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Food for U.S. Manned Space Flight

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FOOD ENGINEERING LABORATORY

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SPACE FEEDING	FOOD PACKAGING	UNITED STATES	SKYLAB
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The food systems which have supported the U.S. manned space flight programs have provided safe, nutritious, acceptable, and convenient food, compatible with the mission. The food systems which supported the Mercury, Gemini, and Apollo Flights and the Skylab and Apollo–Soyuz Missions are briefly described. Also the engineering operational and biological constraints which were imposed in these food systems by the space vehicle and environment are discussed. The appendix, Table A–1, provides an inventory of the foods used by NASA

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20. ABSTRACT (continued)

from Project Mercury (the final flight) through the Apollo–Soyuz Test Flight. Data on portion weight, ingredients, processing procedures, water for reconstitution, and flight usage are included in this table. An addendum covers the foods approved for the Shuttle – Operational Flight Test (OFT) use along with the standard menu.

PREFACE

As a result of experience gained in the development of advanced systems for feeding both the Army and the Air Force under stress, the food research and development organization of the US Army Natick Research and Development Laboratories (NLABS) was called upon to design and implement the feeding requirements for the Project Mercury flights of 1961–1963 and to continue developing foods for subsequent Gemini, Apollo, and Apollo-Soyuz flights and to provide technical assistance in preparing the Skylab food specifications.

Designing space food involved more than developing acceptable nutritious food. Consideration had to be given to weight and volume, the nonavailability of refrigeration, requirements for short-term exposure to temperatures exceeding 55°C, the lack of cooking facilities and concomitant need for ready-to-eat or simple-to-prepare foods, and the fact that the food was to be consumed in a weightless environment. These requirements indicated a need for highly stable "convenience" foods.

Toward this end six different categories of food were developed by the Food Engineering Laboratory of NLABS, namely: semisolid foods which were packaged in aluminum tubes and used on Project Mercury, bite-sized dehydrated foods to be eaten dry; precooked dehydrated foods to be reconstituted before consumption; wet foods thermally stabilized in flexible packages; intermediate moisture foods and radappertized foods (i.e., foods preserved by ionizing radiation). Of the 216 different food components which have been included in the 25 U.S. space flights launched since Project Mercury, 102 were developed by NLABS.

NLABS has kept NASA informed of developments in the new lightweight food and packaging being used in or developed for military rations. Often prototype products of special interest to NASA have been made available to NASA for actual space flight menu use before development for the military is completed. In fact, 44 different military ration items were offered for NASA's consideration for possible Apollo-Soyuz Test Program (ASTP) use. Of these, only five products were from a standard ration in the supply system – these were precooked freeze dehydrated entrees from the Long Range Patrol Food Packet.

Most of the foods offered NASA for ASTP were components of the newest combat ration, the Individual Ready-to-Eat Meal. The flat shape of the flexibly packaged food components of the Individual Ready-to-Eat Meal and their reduced packaging weight made them particularly attractive for ASTP use. The astronauts must have been just as pleased by their flavor and overall quality as were the military personnel who consumed them during service testing. Of the 27 military ration components used on the ASTP, 21 are components of the Individual Ready-to-Eat Meal.

Two compressed cooked vegetable bars – sweet peas and leaf spinach -- also made their debut on space flight menus on the ASTP. These products are not novel to military cooks as compressed peas are in routine procurement (FSN 8915–00–401–8480) and compressed spinach has been service tested by all four Services. The single portion bar, however, is new. When packaged in a "feeder" and rehydrated, the spinach bar will expand to a full portion of leaf spinach – 11 times larger in size than the compressed bar. The pea bar is slightly larger than the spinach bar since the volume ratio of compressed peas to uncompressed reconstituted round peas is only 4 to 1.

Individual servings of irradiation sterilized meat – beef steak, ham, corned beef and smoked sliced turkey – were specially produced at NLABS for the ASTP flight. Irradiation sterilization is entirely new method of food preservation which was being pioneered by the military as a new food preservation process. This is also an excellent example of "spin off" to the space program of a new military sponsored technology not yet approved for military ration use. Of course the flexibly packaged irradiation sterilized products that were supplied NASA were produced and tested thoroughly against very rigid criteria for safety, acceptability and package integrity by the US Army Natick Research and Development Laboratories. The 1975 ASTP flight was not the first time that NASA had expressed its confidence in irradiation sterilized foods. Flexibly packaged radappertized ham (ham sterilized by ionizing radiation) was first used on Apollo 17. It was also carried as a contingency food on Skylab.

Many of the Individual Ready-to-Eat Meal components and three of the radappertized meats used on the ASTP have been furnished NASA for use on the initial Shuttle flight menus – beef steak, corned beef, and smoked turkey slices. All three were included on the first two Shuttle Operational Flight Test (OFT) menus.

The research described in this paper was performed for the National Aeronautics and Space Administration (NASA) under NDPR No. T–9371A. However, this effort benefitted from and drew heavily on all work carried out over the years under the DoD Food RDT& Engineering Program.

This paper is one of two providing information on the foods included on US Space flight menus (1963 through 1975) and provides details on formulations, portion sizes, water requirements, and menu use for 216 space foods. A second paper will provide available nutritional data on each space food.

Acknowledgements

The authors are indebted to Edmund M. Powers, Research Microbiolgist, NLABS, for his contribution to the Microbiology Section, Dr. Norman D. Heidelbaugh, COL USAF (Ret.), now at Texas A&M University, for his helpful comments; and to Rita M. Rapp, Shuttle Support Branch, NASA LBJ Space Center, and Connie R. Stadler, Technology Inc., Houston, Texas for their assistance in completing Table A–1. Our appreciation is also expressed to Jackie Tardif, Joyce Barrett, Barbara Leston, and Judy Tamburro for the exceptionally good typing they provided.

Addendum

Work on this paper was completed before the food systems for the Shuttle Flights were developed. Therefore, an addendum has been added at the end of the paper to briefly describe both the interim food system which NASA is using on the first four Shuttle Flights, and the new Shuttle food system which will be included on fifth Shuttle mission – the first Operational Mission (OPS).

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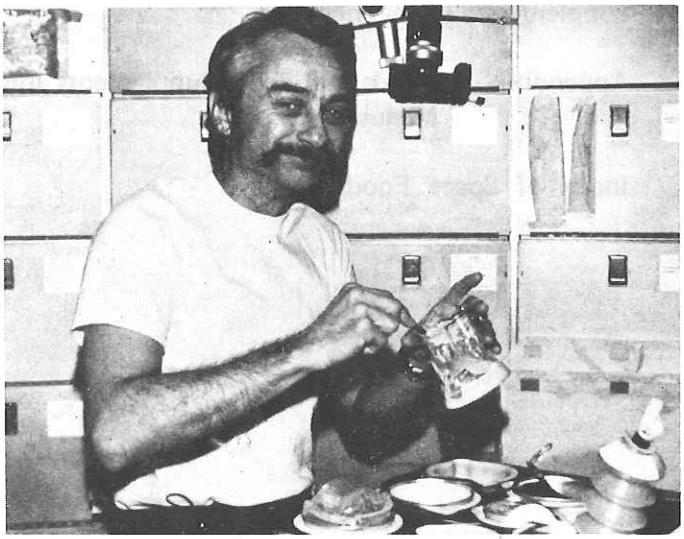
Gemini

Skylab



FOOD FOR U.S. MANNED SPACE FLIGHT

Introduction

The food systems which have supported U.S. manned space flight programs have provided safe, nutritious, acceptable, and convenient food, compatible with the mission. A variety of engineering, operational, and biological constraints have been imposed on the food systems by the space vehicle and environment. The Mercury, Gemini, Apollo and Skylab programs have each had distinctly different food system requirements and with the increased technical sophistication of the flight hardware and mission objectives, the technical sophistication of the supporting food system has also increased. Few background data or experiences were available to support food product development; therefore, every flight was a continuing experiment on what could be eaten and developed to advance the overall technology.

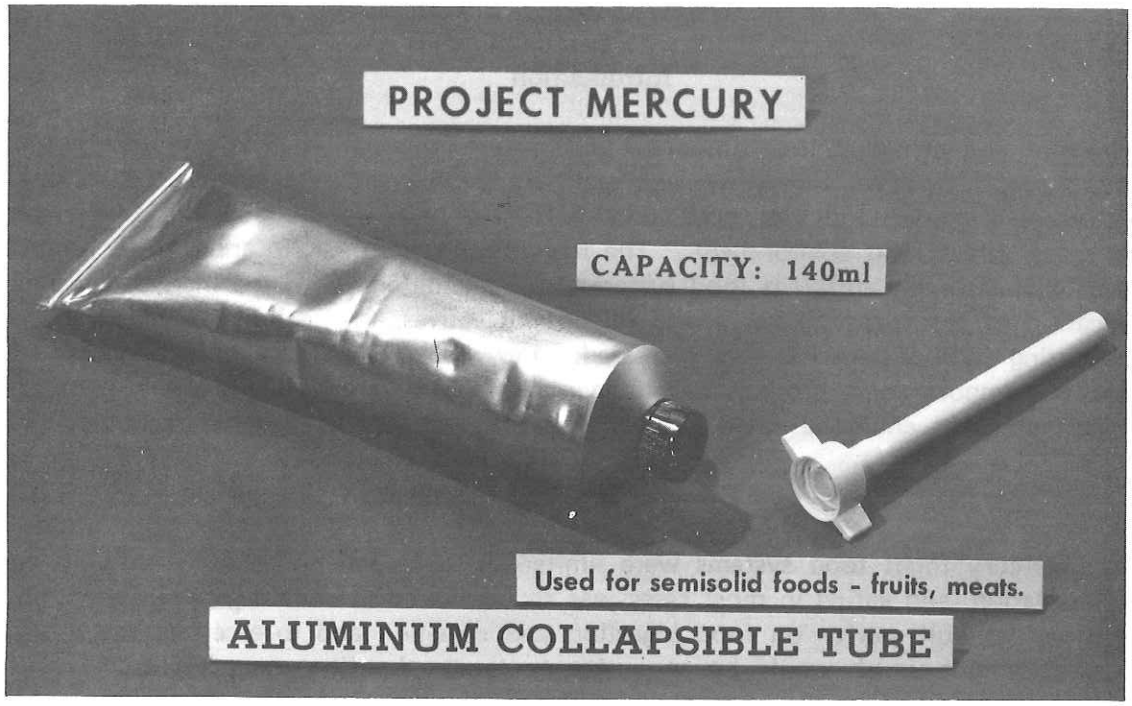
Food Systems for Mercury Flights

The Mercury flight food systems were limited in scope and purpose. The flights were of short duration, and eating in most cases was accomplished to obtain gross information as to the effect of null gravity on food ingestion and digestion and to ascertain the types of food and packaging which would be applicable to longer duration space flight.

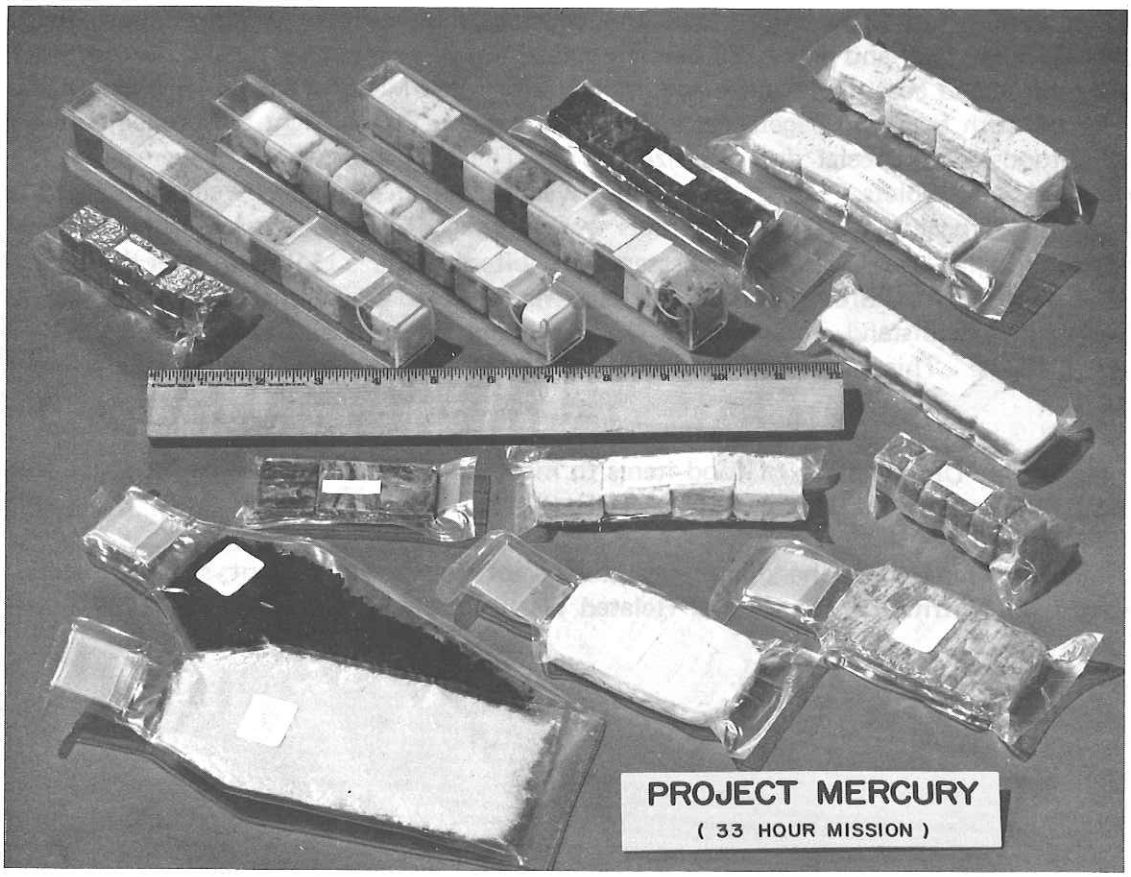
Semi-solid, sterile, tubed foods, fruits, and meat combinations packaged in collapsible aluminum tubes, adaptations of products developed for feeding Air Force pilots flying at high altitudes, were the initial " space" foods.[1] John Glenn (Mercury 6) was the first astronaut to carry food aboard. He consumed 119.5 grams of pureed applesauce (78.7 percent water – approximately 80 kcal [335 kJ]). Beef and vegetables (85 percent water – approximately 60 kcal [271 kJ]), beef and gravy (76 percent water – 130 kcal [544 kJ]) and pureed peaches were also considered acceptable and made available for some Mercury flights. Schirra (Mercury 8) consumed both beef and vegetables and pureed peaches on his flight.[2] Supplementing the semi-solid foods were special dry bite-size foods. The first items supplied were compressed cocoa malted milk tablets. Each round tablet was 2.5 cm in diameter, weighed about 5 gm and supplied 20 kcal (84 kJ). The tablets were packaged in a tube made from kraft with a tear-open string. Several varieties of dessert-type, bite-size cubes (1.9 cm) under development for longer duration Air Force aerospace missions, were selected by astronaut Carpenter (Mercury 7). Designed to withstand storage at 27°C these cubes softened and even melted during his Mercury 7 flight. This prompted the development of bite-size foods including freeze-dried

[1] H.A. Hollender, Development of food items to meet Air Force requirements for space travel, Technical Documentation Report AMRL–TDR 64–38, Wright Patterson AFB, Ohio, 1964.

[2] E.L. Michel, Preparation, handling and storage of foods for present space projects, in **Conference on Nutrition in Space and Related Waste Problems**, NASA SP–70, 1964, 57–63.



Tubed foods were consumed on Mercury Flights through a polystyrene extension tube called a "pontube"



Menu for the final Mercury flight (Mercury 9) consisted of bite-size foods and four rehydratables.

products capable of meeting the more stringent environmental requirements of the Mercury programs which included tempering for three hours at 43°C. Crude fiber content of bite-size foods was reduced to negligible amounts to improve energy density. Also, it was anticipated that the low fiber content of the diet would reduce fecal bulk and the frequency of defecation.

Astronaut Cooper (Mercury 9) selected 10 different types of bite-size foods (a total of 57 bites) and four rehydratable foods (dehydrated products which required addition of water prior to consumption) – orange and grape juice powders and freeze-dried beef pot roast and chicken and gravy. He actually consumed only 696 kcal (2912 kJ) of the 2369 kcal (9912 kJ) available to him at launch.[3] Because of problems with the food container and water dispenser during the flight, he was unable to properly reconstitute the freeze-dried foods and could only eat 1/3 of a package of beef pot roast. Reportedly he tired of the dry bite-size foods which also contributed to his low calorie intake. Dietary control of defecation during Project Mercury was successful; however, it was learned that in flight food and water ingestion must be scheduled in mission timelines along with other activities.[4] The experience gained during Project Mercury in food packaging and in-flight handling led to the evolution of the more sophisticated Gemini and Apollo food systems.

Mercury food packaging was experimental and transient. Aluminum tubes were used for the semi-solid foods; kraft tubes, plexiglass dispensers and three-ply laminates of clear plastic films were used for various food items.[5] No food stowage compartment was provided in Mercury spacecraft, therefore, the food supply was included among other necessities in the astronaut's ditty bag.[6]

The bite-size food concept provided for the Mercury flights was handicapped because of the 43°C three-hour stability requirement which resulted in the need to employ a high melting point (58°C) fat for a coating. These coatings were applied in an effort to control the formation of free-floating crumbs during flight. The coatings proved to be unpalatable and digestibility trials demonstrated that these coatings were poorly absorbed in the gut and could result in a steatorrhea.

[3] A.D. Catterson, E.P. McCutcheon, H.A. Minners, and R.A. Pollard, Aeromedical Observations, in **Mercury Project Summary Including Results of the Fourth Manned Orbital Flight May 15 and 16, 1963,** NASA SP–45, 1963, 315.

[4] C.A. Berry, Aeromedical Preparations, in **Mercury Project Summary Including Results of the Fourth Manned Orbital Flight May 15 and 16, 1963,** NASA SP–45, 1963, 203.

[5] E.A. Nebesky, G.L. Schulz, and F.J. Rubinate, Packaging for space flights, **Activities Report,** 17, 32–36, 1965.

[6] P.A. Lachance, Development of stored food and water systems, **Environmental Biology and Medicine,** Vol. 1, pp 205–228, 1971, with Appendix A – Nutrient composition of space flight foods, M.V. Klicka and M.H. Thomas.

The Food Systems for Gemini Flights

The first manned flight of the Gemini program, Gemini 3, lasted less than five hours, but four experimental meals were aboard to test a new, more complex, all dehydrated food system. The longer planned length of the subsequent missions (2 to 14 days) not only required a much more sophisticated approach but also required careful menu planning to conform to spacecraft stowage, weight, and volume constraints. The nutrient content of the foods and dietary intake were significant parameters of mission success.

The original Gemini food system concept was based on four meals per man per day and was followed only for the four-day mission of Gemini 4. The more critical stowage constraints of Gemini 5 (8 days) and Gemini 7 (14 days) necessitated minimizing food volume, and the consequent reduction permitted only three meals a day. Preferred by the astronauts, this three-meal pattern was adopted for the balance of the Gemini flights and for Apollo and Skylab. Two-, three-, and four-day menu cycles were used on Gemini flights. Except on the Gemini 4 and Gemini 8 missions, the Gemini crew members were provided identical menus which permitted overwrapping of meal pairs. On Gemini 4 and Gemini 8, astronaut preference adjustments necessitated component changes and the overwrapping of a number of individual meals.

Extensive testing at the Aerospace Medical Research Laboratory, Wright Patterson Air Force Base and the School of Aerospace Medicine, Brooks Air Force Base ascertained that diets composed exclusively of dehydrated food could be highly acceptable, digestible, efficiently utilized and capable of maintaining positive nitrogen balance.[7-16] In these studies the technology of freeze-dehydration as a means of food preservation (pioneered for military ration use) was employed to assure acceptable products which would reconstitute in the ambient temperature water available aboard Gemini. These were the first human feeding trials which verified that the feeding of freeze-dehydrated foods was physiologically equivalent to the feeding of routine diets. These studies also verified the acceptability of such foods using ambient temperature water. On Gemini only ambient temperature water was available.

[7] J.E. Vanderveen, K.J. Smith, E.W. Speckmann, G. Kitzes, and A.E. Prince, Protein, energy, and water requirements of man under simulated space stresses, in **Conference on Nutrition in Space and Related Waste Problems**, NASA SP–70, 1964, 373–378.

[8] E.W. Speckmann, K.J. Smith, J.E. Vanderveen, G.M. Homer, and D.W. Dunco, Nutritional acceptability of a dehydrated diet, **Aerosp. Med.**, 36, 256–260, 1965.

[9] K.J. Smith, Nutritional evaluation of a precooked dehydrated and bite-size compressed food diet as a sole source of nutriment for six weeks, **AMRL–TR–66–3**, 30 pp., 1966.

[10] K.J. Smith, E.W. Speckmann, P.A. Lachance, and D.W. Dunco, Nutritional evaluation of a precooked dehydrated diet for possible use in aerospace systems, **Food Technol.**, 20, 101–105, 1966.

Each Gemini meal contained from four to seven servings of food. These were provided in bite-size form (as compressed 1.9-cm cubes or as freeze-dried rectangulars, usually 2.5 cm by 2.9 cm by 1.9 cm high) designed for direct consumption or as rehydratables. The bite-size foods included meats, bread, dessert and confection items. A few bite-size foods, e.g. bacon squares and fruit cake were high enough in moisture content to qualify as intermediate moisture foods – foods in which stability is achieved primarily by adjusting water activity.

The number of bite-size units included in a serving varied in accordance with astronaut preferences and by mission – being either 4, 6 or 8.

The rehydratable foods included dry mixes and freeze-dried products which reconstituted to familiar beverages, puddings, soups, entrees, fruits and vegetables. Approximately 726 grams of packaged food providing up to 2900 kcal (12,000 kJ) were provided for each crew member each day. The volume provided for food stowage was restricted to 2130 cubic centimeters (cm^3) per crew member per day. The three meal per day diet was designed to provide 16–17 percent total calories from protein, 30–32 percent from fat and 50–54 percent from carbohydrate.[17] The uniform shape, high caloric density and flavor variety of the bite-size

[11] B.J. Katchman, G.M. Homer, and D. Dunco, The biochemical, physiological and metabolic evaluation of human subjects wearing pressure suits and on a diet of precooked dehydrated foods, **AMRL–TR–67–8**, 51 pp, 1967.

[12] C.A. Linder and V.R. Must, The effect of repetitive feedings on the acceptability of selected metabolic diets, **AMRL–TR–66–75**, 8 pp, 1967.

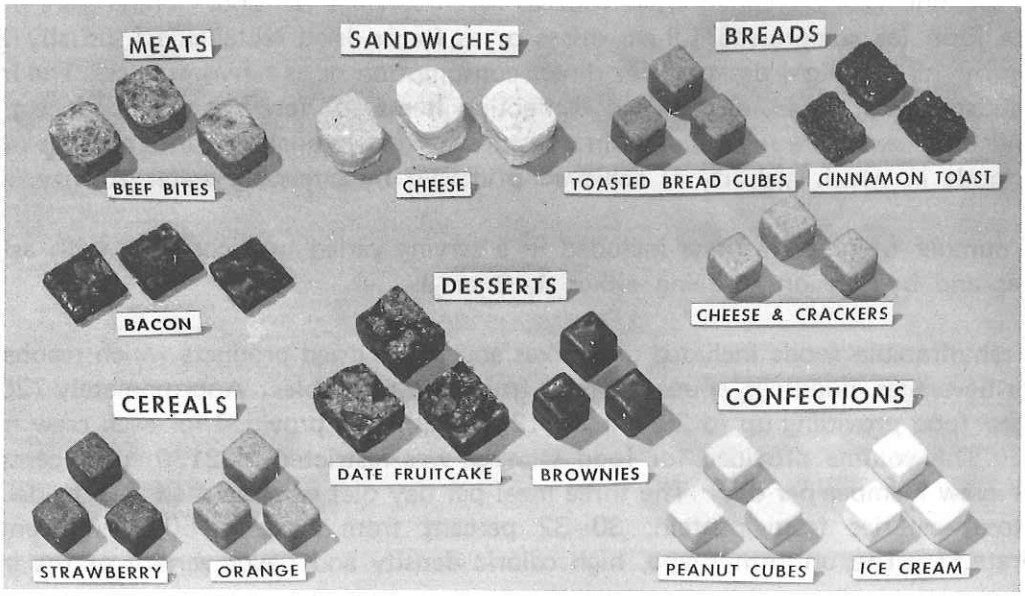
[13] N.D. Heidelbaugh, J.E. Vanderveen, M.V. Klicka, and M.J. O'Hara, Study of man during a 56-day exposure at 258 mm Hg total pressure: VIII. Observations on feeding bite-size foods, **Aerosp. Med.**, 37, 583–590, 1966.

[14] J.E. Vanderveen, N.D. Heidelbaugh, and M.J. O'Hara, Study of man during a 56-day exposure to an oxygen-helium atmosphere at 258 mm Hg total pressure IX, Nutritional evaluation of feeding bite-size foods, **Aerosp. Med.**, 37, 591–594, 1966.

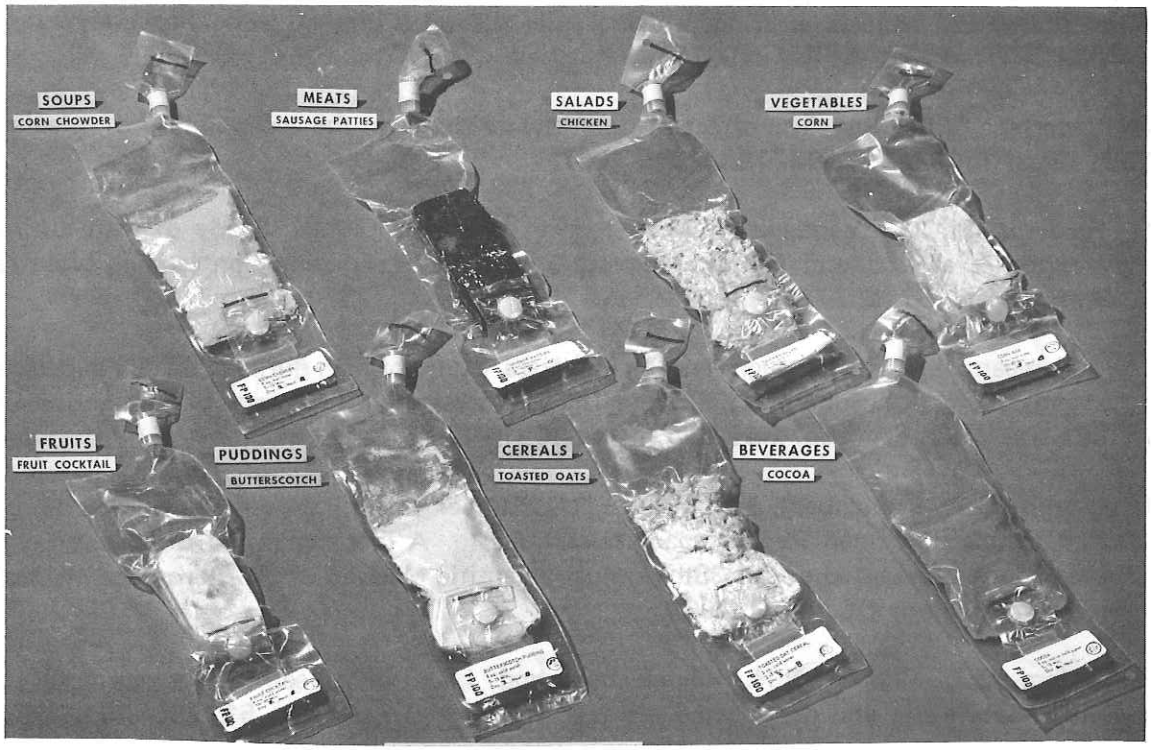
[15] R.E. Chapin, R.S. Kronenberg, M.J. O'Hara, D.C. Loper and J.E. Vanderveen, Nutritional evaluation of foods developed for aerospace operations I. A diet composed of bite-size and rehydratable foods. Presented at the 38th Annual Scientific Meeting of the Aerospace Medical Association, Washington, DC, April 1967.

[16] M.J. O'Hara, R.E. Chapin, N.H. Heidelbaugh, and J.E. Vanderveen, Aerospace feeding: Acceptability of bite-size and dehydrated foods, **J. Am. Dietet. Assoc.**, 51, 246–250, 1967.

[17] C.S. Huber, M.C. Smith, and M.V. Klicka, Space foods, in **Health and Food**, G.G. Birch, L.F. Green, and L.G. Plaskett, Eds., Halsted Press, John Wiley and Sons, New York, 1972, 130–151.



Bite size space foods — Gemini



Rehydratable space foods — Gemini. The tablet attached to each rehydratable package is an anti-microbial agent — 8 quinolinol sulphate — used for waste stabilization.

foods made them ideally suited for the engineering requirements of space flight. However, they were less well liked than the rehydratable products due in part to their texture and dryness.[18,19] Thus, all Gemini menus utilized a combination of bite-size and rehydratable foods with rehydratables supplying at least 50 percent, and as high as 68 percent, of the total number of servings of food supplied.[20-25]

Frequently difficulties in the handling, preparation, or consumption of the foods used were surfaced only through in-flight experience. Every effort was made to solve the problems before the food was offered again.[26,27] However, this dynamic process resulted in variable product formulations and corresponding changes in nutrient content. For example, a number of bite-size foods had to be altered to control crumb problems. Problems occurring in Project

[18] R.A. Nanz, E.L. Michel, and P.A. Lachance, Evolution of a space feeding concept for Project Gemini, **NASA TM X–51697**, 1964.

[19] R.A. Nanz, E.L. Michel, and P.A. Lachance, Evolution of space feeding concepts during the Mercury and Gemini space programs, **Food Technol.**, 21, 1596–1602, 1967.

[20] M.V. Klicka, H.A. Hollender, and P.A. Lachance, Foods for Astronauts, **J. Am. Dietet. Assoc.**, 51, 238–245, 1967.

[21] P.A. Lachance and C.A. Berry, Luncheon in space, **Nutr. Today**, 2 (2), 2–11, 1967.

[22] R.A. Nanz, P.A. Lachance, and M.V. Klicka, Food consumption on Gemini IV, V and VII missions, **NASA Technical Memorandum, NASA TM X–58010**, October 1967.

[23] H.A. Hollender, M.V. Klicka, and P.A. Lachance, Space feeding: Meeting the challenge, **Cereal Sci. Today**, 13, 44–48, 1968.

[24] M.V. Klicka, P.A. Lachance and H.A. Hollender, Space feeding, **Activities Report** 20, 53–72, 1968.

[25] P.A. Lachance, M.V. Klicka, and H.A. Hollender, Space feeding: Cereal products utilized in the US manned space program, **Cereal Sci. Today**, 13, 49–54, 70, 1968.

[26] S.E. Stone, Gemini flight food qualification testing: requirements and problems, **Activities Report**, 17, 37–43, 1965.

[27] H.A. Hollender, M.V. Klicka, and M.C. Smith, Food technology problems related to space feeding, in **COSPAR** Life Science and Space Research, VIII, North – Holland Publ. Co., 1970, 265–279.

Mercury had resulted in the routine application of coatings to the bites to minimize the hazard of crumbs and greasiness or stickiness. Attempts at correction of the problems with these coatings resulted in five different coating changes for some bite-size foods (e.g., sandwiches). These coatings remained in the space food inventory throughout Project Gemini. An in-flight biomedical experiment measuring calcium and nitrogen balance was conducted on the fourteen-day mission of Gemini 7. The primary objective of this experiment was to obtain data on the effects of space flight on the skeletal and muscular systems.[28,29,30-33] In support of this study, fruit flavored beverages and applesauce on the Gemini 7 menus were fortified with calcium lactate to assure the desired supply of approximately 1 gram of calcium per day. Generally 1.1 gram of calcium lactate (201 mg of calcium) was added to a 21-gram (dry weight) serving of beverage powder or 35-gram serving of applesauce. The use of beverages fortified with calcium lactate continued throughout the remaining Gemini missions and for all Apollo missions.

All Gemini food was vacuum-packaged in a clear, 4-ply flexible plastic laminate comprised of an inner and outer layer of polyethylene with fluorohalocarbon and polyester layers between. The rehydratable packages contained a one-way spring loaded valve which was opened by an interfacing water dispenser for rehydration. At the opposite end of the package was the feeding tube comprised of polyethylene tubing. The astronaut consumed the meal through this feeding tube by squeezing the food into his mouth. The meal overwrap was a polyolefin-aluminum foil-polyester film.

The Food Systems for Apollo Flights

The initial Apollo Food System was based on the dehydrated foods perfected for the Gemini program; however, greater attention was focused on astronaut preferences which resulted in greater menu variation. Also hot water (65° ± 5°C) was available for food rehydration

[28] See reference 6.

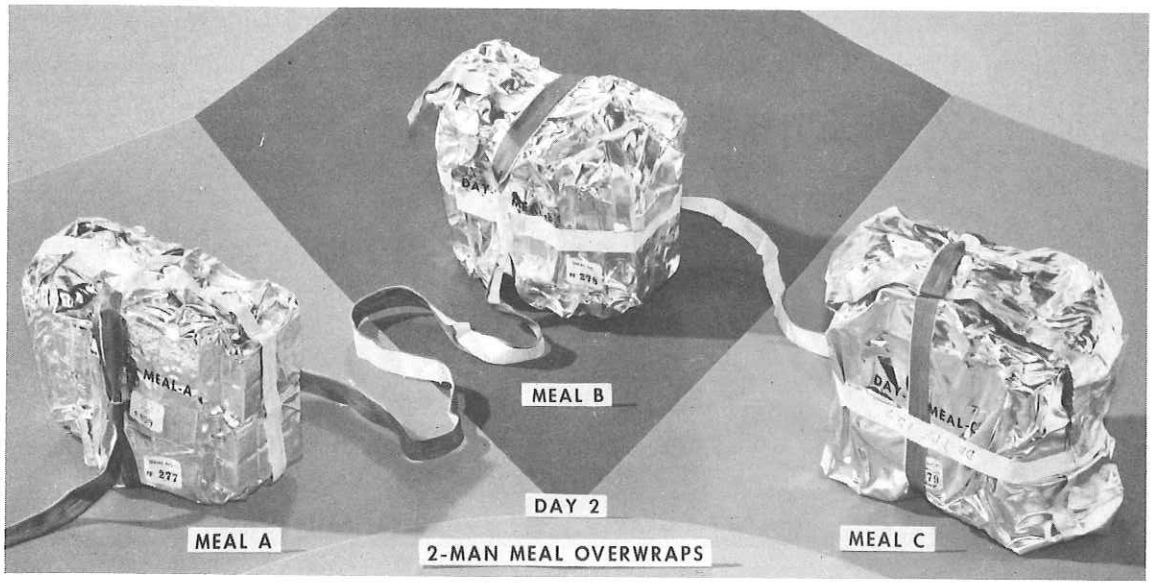
[29] See reference 22.

[30] P.B. Mack, G.P. Vose, F.B. Vogt, and P.A. Lachance, Experiment M–6, bone demineralization, in **Gemini Midprogram Conference**, NASA SP–121, 1966, 407–415.

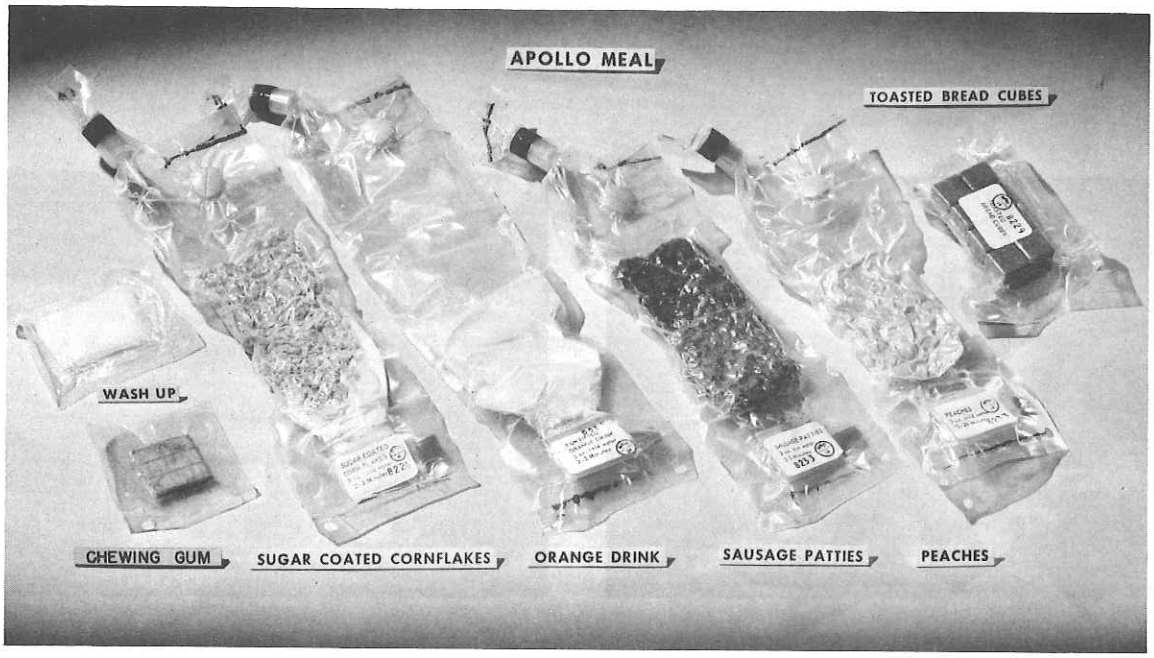
[31] G.D. Whedon, L. Lutwak, W.F. Neuman, and P.A. Lachance, Experiment M–7, calcium and nitrogen balance, in **Gemini Midprogram Conference**, NASA SP–121, 1966, 417–421.

[32] J.M. Reid, L. Lutwak, and G.D. Whedon, Dietary control in the metabolic studies of Gemini 7 space flight, **J. Am. Dietet. Assoc.**, 53, 342–347, 1968.

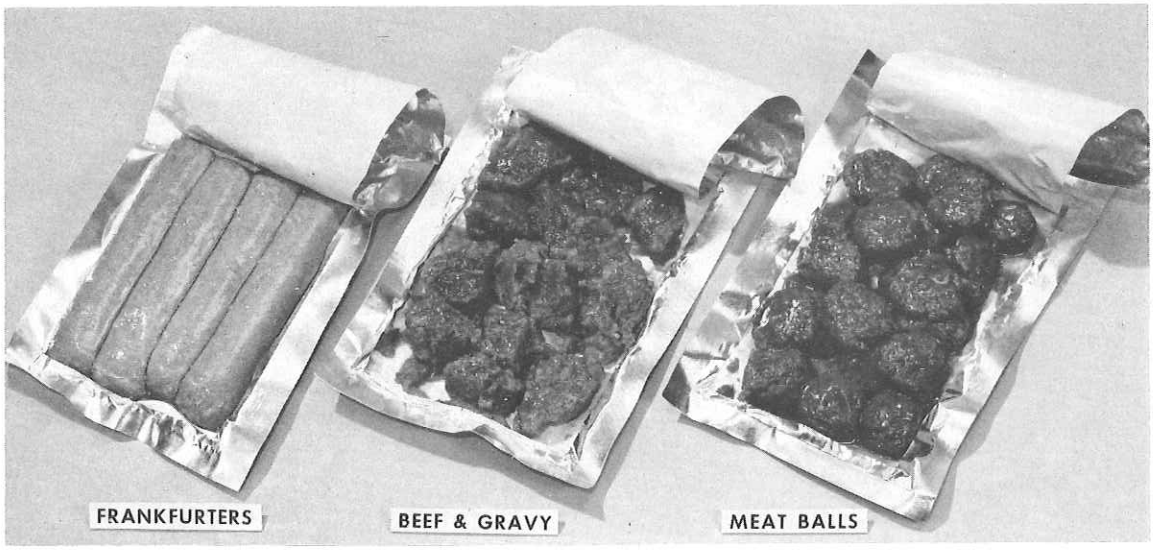
[33] L. Lutwak, G.D. Whedon, P.A. Lachance, J.M. Reid, and H. Lipscomb, Mineral electrolyte and nitrogen balance studies of the Gemini VII 14-day orbital space flight, **J. Clin. Endocrinol. Metab.**, 29, 1140–1156, 1969.



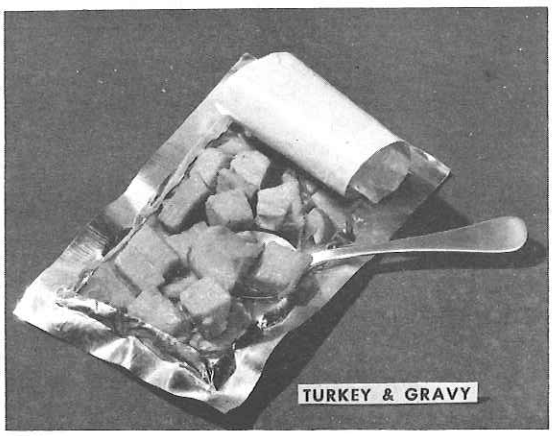
Project Gemini 2-man meal overwraps



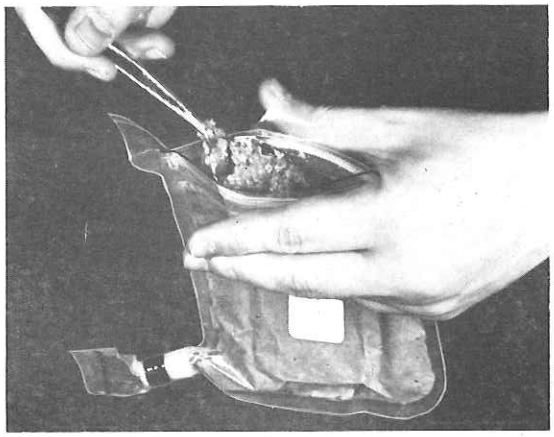
An early Apollo flight meal



Thermostabilized meats — popular with Apollo astronauts



Thermostabilized wet meat product — introduced on Apollo 8 flight menu



"Spoon-bowl" package used for rehydratables following Apollo 8 flight

in the Command Module. Water in the Lunar Module was at ambient cabin temperature. The long interval (almost two years) which occurred between the last Gemini mission (Gemini 12) and the first manned Apollo mission (Apollo 7) due to the spacecraft fire in January 1967 allowed time for improvements in product formulations and resulted in the development of an increased variety of both bite-size and rehydratable foods. USAF C–135 aircraft flying Keplarian trajectories to simulate brief periods of null gravity were used to verify that a conventional spoon could be used to consume most foods in null gravity environments.[34] The use of a spoon began with Apollo 8 with the introduction of flexibly packaged thermostabilized foods – called "wet packs" – to the Apollo menus. The packages for rehydratable foods, excepting beverages, were subsequently redesigned to adapt to the more normal use of a spoon. With each subsequent Apollo mission, the menu variety was improved and increased. Intermediate moisture fruits were introduced on Apollo 9. Intermediate moisture confections were added on later missions. Fresh bread was provided on Apollo 10 when NASA, for the first time, deviated from its requirement for full vacuum-packaging and allowed packaging under a partial pressure of nitrogen. Sandwich spreads (thermostabilized) initially packaged in aluminum tubes and later in rigid aluminum cans accompanied the bread. To control mold on the fresh bread furnished on Apollo missions 12 through 17, the bread was produced using irradiated flour (flour exposed to 50,000 rad of cobalt gamma irradiation).[35] Additionally, for the last three Apollo missions the bread was given a second post baking irradiation treatment (also 50,000 rad). Flexibly packaged radappertized ham (ham sterilized by ionizing radiation) was included on the final Apollo 17 menus.[36]

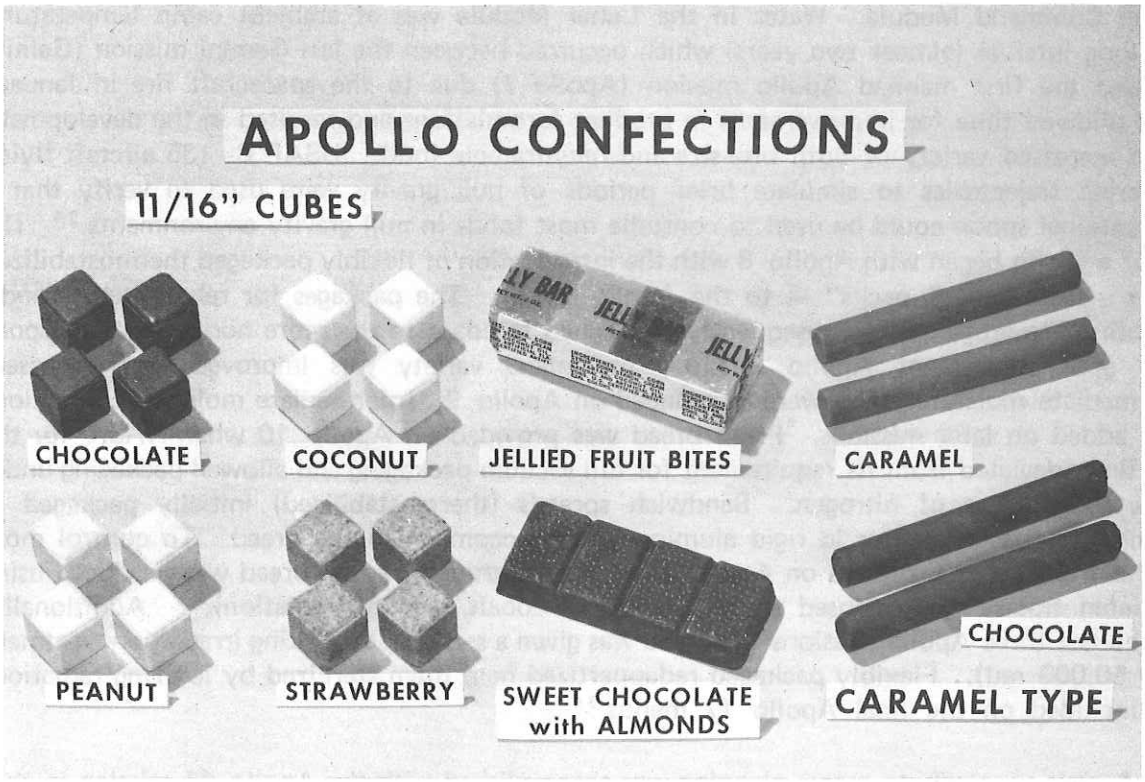
A new approach to menu planning was accomplished with the Apollo 11 mission in that the crew was allowed the flexibility to plan some of their menus in flight. Approximately half of the packaged food supplied was overwrapped into planned one-man meals. The remaining foods were stowed loose, pantry style, in their primary package without assembling (overwrapping) into meals. This gave the crew the option of varying their meal selections.[37]

[34] R.L. Flentge, A.C. Grim, F.F. Doppelt, and J.E. Vanderveen, How conventional eating methods were found feasible for spacecraft, **Food Technol.**, 25, 51–54, 1971.

[35] T.E. Hartung, L.B. Bullerman, R.G. Arnold, and N.D. Heidelbaugh, Application of low dose irradiation to a fresh bread system for space flights, **J. Food Sci.**, 38, 129–132, 1973.

[36] M.V. Klicka, Space foods and their development, in **Encyclopedia of Food Technology**, Johnson, A.H. and Peterson, M.S., (Eds.) The Avi Publishing Co., Inc., Westport, Conn., 1974, 828–840.

[37] M.C. Smith, N.D. Heidelbaugh, P.C. Rambaut, R.M. Rapp, H.O. Wheeler, C.S. Huber, and C.T. Bourland, Apollo food technology, in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 437–468.



Apollo confections

Apollo food storage compartment

The first meal after launch in Apollo consisted of a frozen sandwich, which was prepared and packaged under Apollo system quality control and stowed for easy access in a pocket of each crew member's flight suit.

With few exceptions, all foods used during the Apollo program were analyzed for nitrogen, fat, crude fiber, calcium, phosphorus, iron, sodium, potassium, and magnesium content.

Foods consumed out of planned menu sequence and those which were not included in the programmed menus (snacks) were recorded in flight logs. Furthermore, on all Apollo flights most food residue and unopened food packages were returned; the residue was weighed to provide more information on flight consumption and to verify in-flight logging procedures. Thus NASA was able to determine the nutrient intake of each crew member on each Apollo mission. The average intakes ranged from a low of 1350, 1260, and 1250 kcal (5643, 5267, and 5225 kJ) per day for the Commander, Command Module pilot, and lunar module pilot, respectively, on the Apollo 10 mission to a high of 2903, 2492, and 2572 kcal (12,134, 10,456 and 10,751 kJ) per day for the respective Apollo 15 crew members. Mean caloric intake for the Apollo program was 1877 ± 415 kcal (7854 ± 1735 kJ).[38,39] Flight surgeons at Mission Control in Houston detected cardiac arrhythmias in two crew members during the Apollo 15 mission. These arrhythmias were suspected of being linked to potassium deficits and excessive workloads.[40] Metabolic studies were conducted on Apollo 16 and Apollo 17 and the input and output of various elements, particularly potassium, were carefully examined in the Apollo 16 balance study and a detailed assessment of energy metabolism was made.[41] The metabolic studies on Apollo 17 were designed to determine the effect of space flight on overall body composition and circulating and excretory levels of certain hormonal constituents, thus providing a firmer basis for interpretation of Skylab metabolic experiments.[42]

[38]P.C. Rambaut, M.C. Smith, P.B. Mack and J.M. Vogel, Skeletal response in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein and C.A. Berry, Managing Editors, 1975, 303–322.

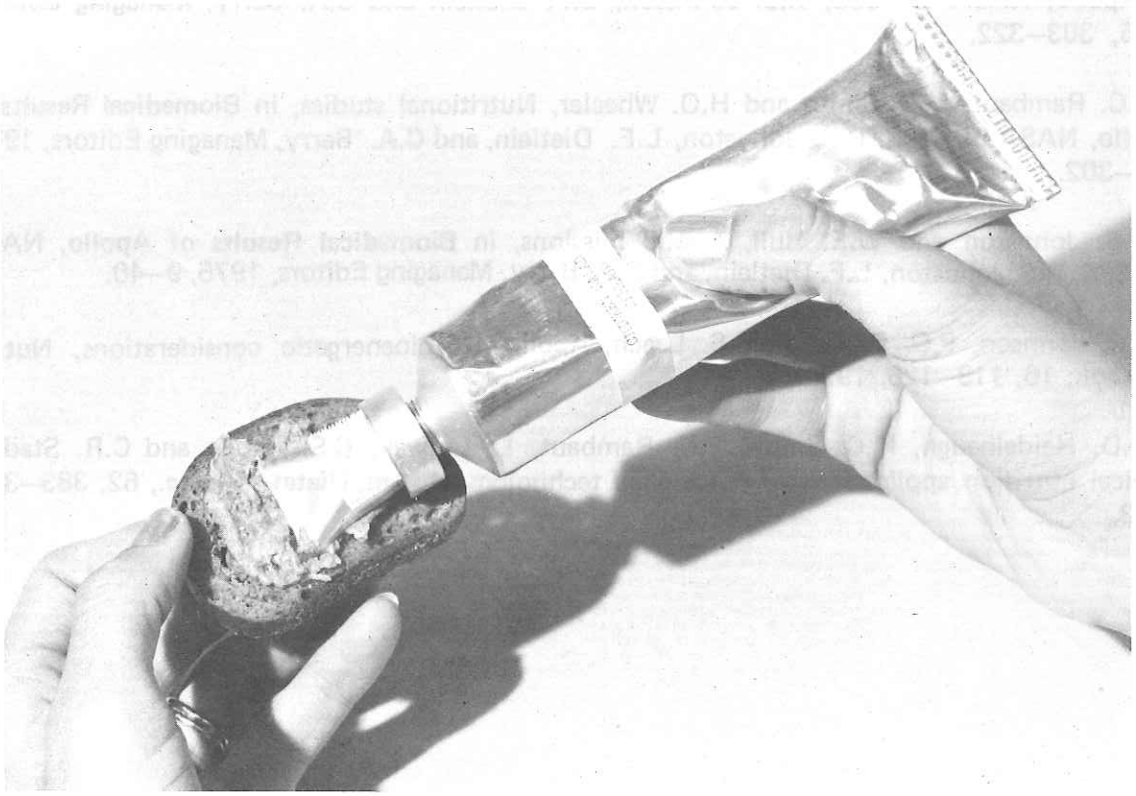
[39]P.C. Rambaut, M.C. Smith and H.O. Wheeler, Nutritional studies, in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 277–302.

[40]R.S. Johnston and W.E. Hull, Apollo missions, in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 9–40.

[41]P.C. Johnson, P.C. Rambaut, C.S. Leach, Apollo 16 bioenergetic considerations, **Nutr. Metabol.**, 16, 119–126, 1974.

[42]N.D. Heidelbaugh, M.C. Smith, P.C. Rambaut, L. Lutwak, C.S. Huber, and C.R. Stadler, Clinical nutrition applications of space food technology, **J. Am. Dietet. Assoc.**, 62, 383–389, 1973.

Apollo meal overwrap



Thermostabilized sandwich spreads used on Apollo menu

For both missions nutrient intake information was obtained for 72 hours before flight and approximately 48 hours after flight. For the Apollo 17 mission a five-day metabolic balance was performed approximately two months before the mission by using the flight menus and collecting urine and fecal wastes. In the analysis of the balance study performed for Apollo 17, mission inflight metabolic data were compared with those obtained during the preflight study. For both Apollo 16 and 17 the potassium intakes were maintained above normal ground-based intakes. To accomplish this, beverage powders were fortified with potassium gluconate. Ten mEq potassium (as 2.35 gm potassium gluconate) added to a serving of the fruit flavored beverages, cocoa, and even black coffee was not detectable by trained taste panels using triangle sampling techniques.[43]

Although package designs were modified and improved, all dehydrated and intermediate moisture foods on the Apollo menus were packaged in the clear, flexible laminate used on Project Gemini. A heat-processable laminated packaging material (modified polyolefin-aluminum foil-polyester) was used for most thermostabilized foods. A nonflammable fluorohalocarbon film was introduced and used as a meal overwrap material in the Apollo program. Thermostabilized salad-type sandwich spreads were packaged in collapsible aluminum tubes (Lunar Module) and in aluminum cans (Command Module).

The Food System for Skylab Missions

A primary purpose of the Skylab missions was to gather physiological information on man's ability to perform during periods of prolonged weightlessness. Nutritional studies designed to assess the effects of space flight on nutrition and musculoskeletal function was one of the life science investigations intensively pursued during the Skylab program. In brief, these experiments consisted of metabolic balance studies designed to quantitate the effects of space flight on the rate of gain or loss of the key chemical constituents from the body plus exhaustive endocrinological investigations probing those changes in control function which accompany or precipitate changes in body composition and fluid and electrolyte metabolism.*

These experiments consisted of a nutrient input/output measurement on all Skylab astronauts commencing 21 days preflight, continuing throughout the inflight phase, and for an 18-day period postflight. Sodium, potassium, calcium, phosphorus, nitrogen, magnesium, energy and water intake were precisely measured within 2%. All fecal material and urine samples were returned to Earth for analysis, and samples of blood were taken preflight, inflight, and postflight.

Another objective of Skylab was to test those environmental conditions crucial to optimal crew performance. A design goal of the Skylab program was to make the living and working

[43] Ibid.

*Results of Skylab medical experiments are reported in "Biomedical Results from Skylab" edited by R.S. Johnston and L.F. Dietlein, NASA SP–377, 1977. (Three specific references are cited under supplemental references for 1977.)

environment comfortable and enjoyable. The type and variety of the food system was recognized by NASA as foremost among the life conditions influencing behavior. The need for accurate physiological data on the one hand and the objective of improving the habitability of the spacecraft on the other hand presented a significant challenge to the development of a food system for Skylab.

Every effort was made to make the food a positive morale factor and to include maximum variety of acceptable foods on the Skylab menus. As a result, 72 baseline foods representing six different categories of foods – thermostabilized, frozen, natural state, beverages, intermediate moisture, and rehydratable – were chosen following preliminary screening by astronauts. Individual menus were developed for each Skylab crew member from these foods, and when finalized, each menu was supported by a minimum of five sets of sensory data representative of crew acceptance.[44,45]

A prime constraint for Skylab food was that each food item had to receive a mean acceptance rating of 6 or above in astronaut taste panels. A 9-point hedonic scale was used for ratings: 9 = like extremely, 6 = like slightly, 5 = neither like nor dislike and 1 = dislike extremely.

Nutritional constraints for the Skylab food system required that each food ingredient be quantified so that no single serving of any one food would vary from any other portion of that food by more than 2 percent in regard to calories, protein, calcium, phosphorus, sodium, magnesium, and potassium. Also the daily menus had to provide a specified quantity of five nutrients: protein, 90 to 125 ± 10 gm, calcium, 750 to 850 ± 16 mg, phosphorus, 1,500 to 1,700 ± 120 mg, sodium, 3,000 to 6,000 ± 500 mg, and magnesium, 300 to 400 ± 100 mg, plus at least 3,945 mg of potassium.[46]

Menus were designed according to 6-day cycles. The menus contained a core set of foods which provided the required levels of nitrogen, calcium, phosphorus, magnesium, potassium, and sodium. This core diet was approximately 300 kcals (1255 kJ) less than the caloric requirement established for Earth. All additional calories were provided by food items, termed "caloric adjustment items," which were low enough in controllable elements so as not to perturb the prescribed intake ranges.

[44] N.D. Heidelbaugh, M.C. Smith, P.C. Rambaut, T.E. Hartung, and C.S. Huber, Potential public health applications of space food safety standards, J. Am. Vet. Med. Assoc., 159, 1462–1469, 1971.

[45] C.R. Stadler, D.D. Sanford, J.M. Reid, and N.D. Heidelbaugh, Skylab menu development, J. Am. Dietet. Assoc., 62, 390–393, 1973.

[46] P.C. Rambaut, N.D. Heidelbaugh, and M.C. Smith, Calcium and phosphorus mobilization in man during weightless flight, Activities Report, 25, 1–7, 1973.

The crew was encouraged to consume completely their nominal menu. A system of negative reporting was employed such that the crew reported at the end of each day any deviation from the nominal menu. The only admissible deviations were the incomplete consumption or omission of an item on the nominal menu, the use of an off/nominal rehydration quantity or the consumption of a caloric adjustment item.

To maintain controlled intakes of the required minerals, in conjunction with these possible deviations, the crew members were also supplied the following mineral supplements: calcium lactate (32 mg calcium), orthophosphate (110 mg phosphorus), magnesium lactate (25 mg magnesium), sodium chloride (197 mg sodium), and potassium gluconate (195 mg potassium).

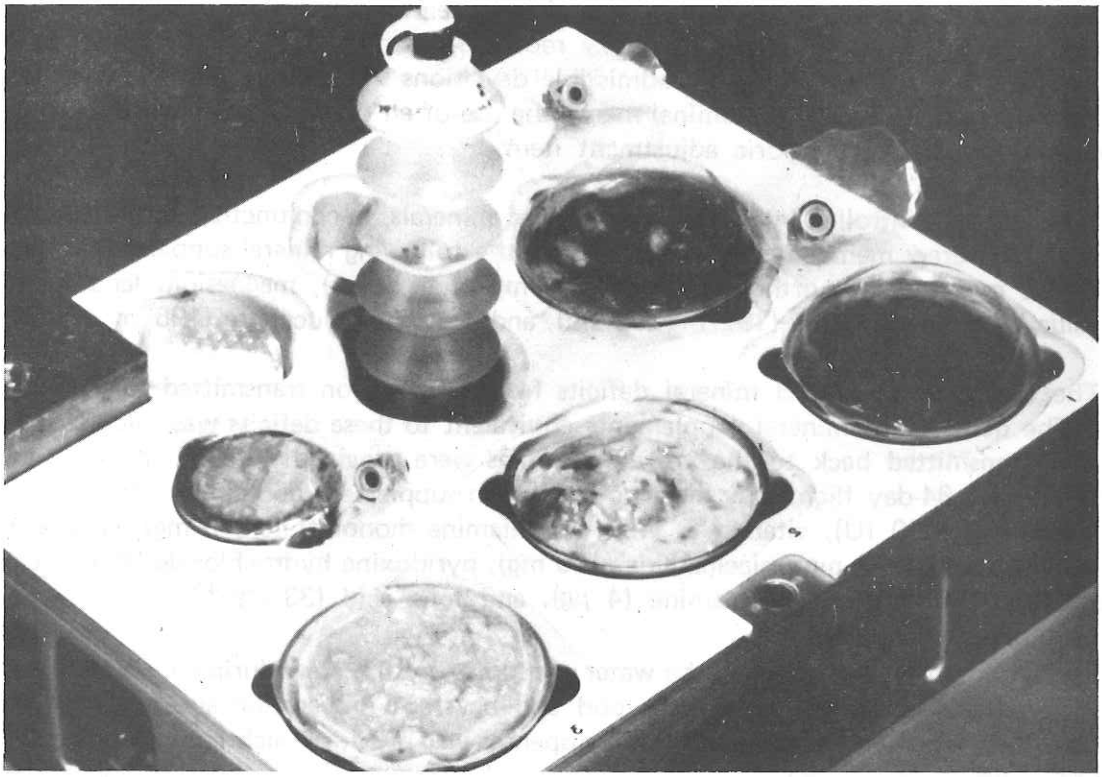
The computer calculated mineral deficits from information transmitted to Earth by the crew. The quantity of mineral supplements equivalent to these deficits was calculated in real time and transmitted back to the crew. Vitamins were provided both by the food and, in the 59-day and 84-day flights, by means of a vitamin supplement containing vitamin A (5000 IU), vitamin D (500 IU), vitamin E (15 IU), thiamine mononitrate (10 mg), riboflavin (10 mg), ascorbic acid (313 mg), niacinamide (100 mg), pyridoxine hydrochloride (2 mg), calcium pantothenate (20 mg), cyancobalamine (4 μg), and folic acid (33 μg).[47]

Special attention was given to the water consumed by the crew during the Skylab mission. The water system dispensed water for food and beverage preparation and drinking with an accuracy of ± 1 percent. A separate drink dispenser was provided each crewman, it contained a recording device for the amount of water dispensed. The water was essentially free of calcium, magnesium, phosphorus, nitrogen, potassium, and sodium.

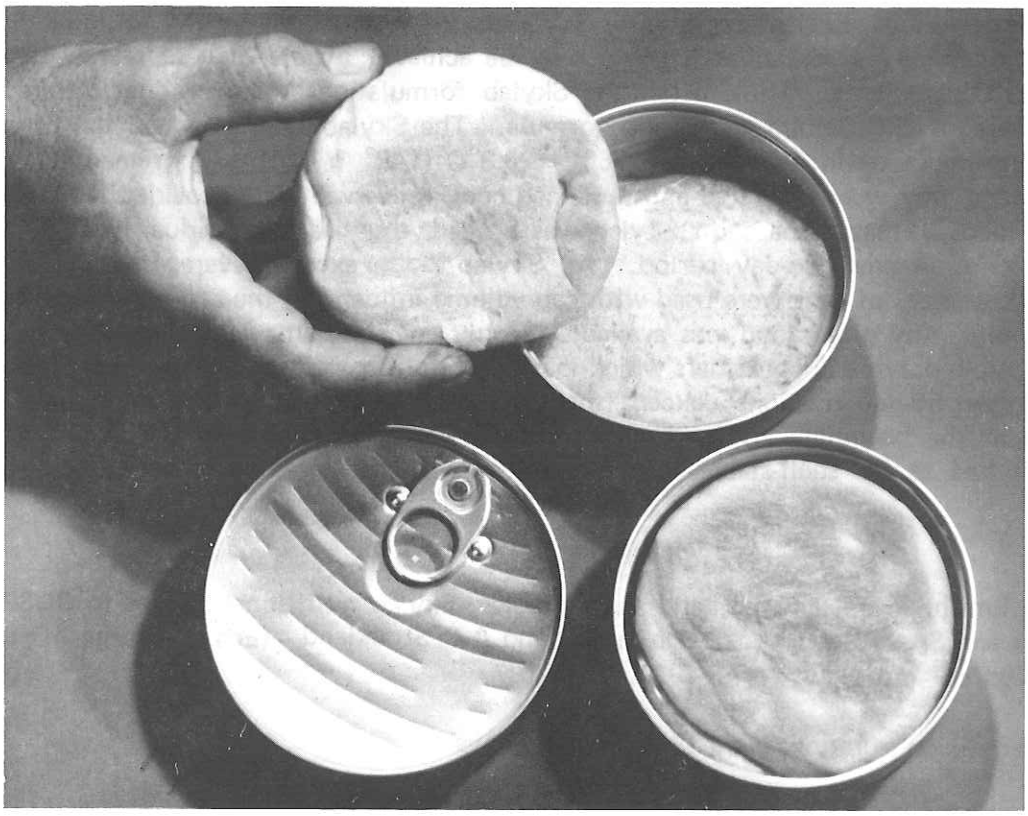
The degree of nutrient control for Skylab foods required the careful formulation of each food. For many rehydratables it could only be achieved by blending separately dehydrated, precooked ingredients. Thus, often the Skylab formulations for a product differed slightly from those of the Gemini or Apollo formula. The Skylab food tray had the capability of heating three foods in each meal to 65° ± 3.3°C (149° ± 6°F). The remaining four wells of the food tray were unheated and remained cool. Silverware was provided for consumption of the food. Freezer space on Skylab was limited, thus, each individual was allowed three frozen items in any two-day period. All Skylab foods, except beverages, were packaged in cans. Three sizes of cans were used with can volume influencing the serving size of the various food items. Any given food was available in only one size can. All beverages were packaged in collapsible polymeric containers which expanded on reconstitution. All food for the planned 28 and two 56-day missions* except that food planned for consumption in the Command Module at the beginning and end of each mission was launched with the Skylab workshop. Thus, it had to be shelf-stable for at least one year under ambient conditions.

[47] M.C. Smith, P.C. Rambaut, and C.R. Stadler, Skylab nutritional studies in **COSPAR Life Sciences and Space Research**, R. Holmquist and A.C. Strickland (Eds.), Volume 15, Pergamon Press, Oxford and New York, 1977, 193–197.

*Actual mission durations were 28, 59, and 84 days.



Skylab food tray



Skylab bread

Skylab packaging – All Skylab foods, except beverages were packaged in easy open cans. Primary package for rehydratables was a clear plastic pouch with a reconstitution valve attached.

Skylab expandable beverage container

Complaints of blandness in the foods on the part of the Skylab 1 crew resulted in the Skylab 2 and 3 crews launching with an assortment of condiments such as hot sauce, horseradish, pepper, and garlic to supplement the catsup already aboard. The Skylab 3 crew launched with a 28-day supply of formulated nutrient-defined, high-density food bars which enabled the extension of their flight from the planned 56-day mission to 84 days.

A flexibly packaged, thermoprocessed fruitcake designed to be nutritionally complete at a 2800 kcal (11,700 kJ) level was included in the Skylab food supply as a contingency food. NASA approved the consumption of some of this cake only on Christmas Day 1973, as a holiday treat.

The Food System for Apollo-Soyuz Mission

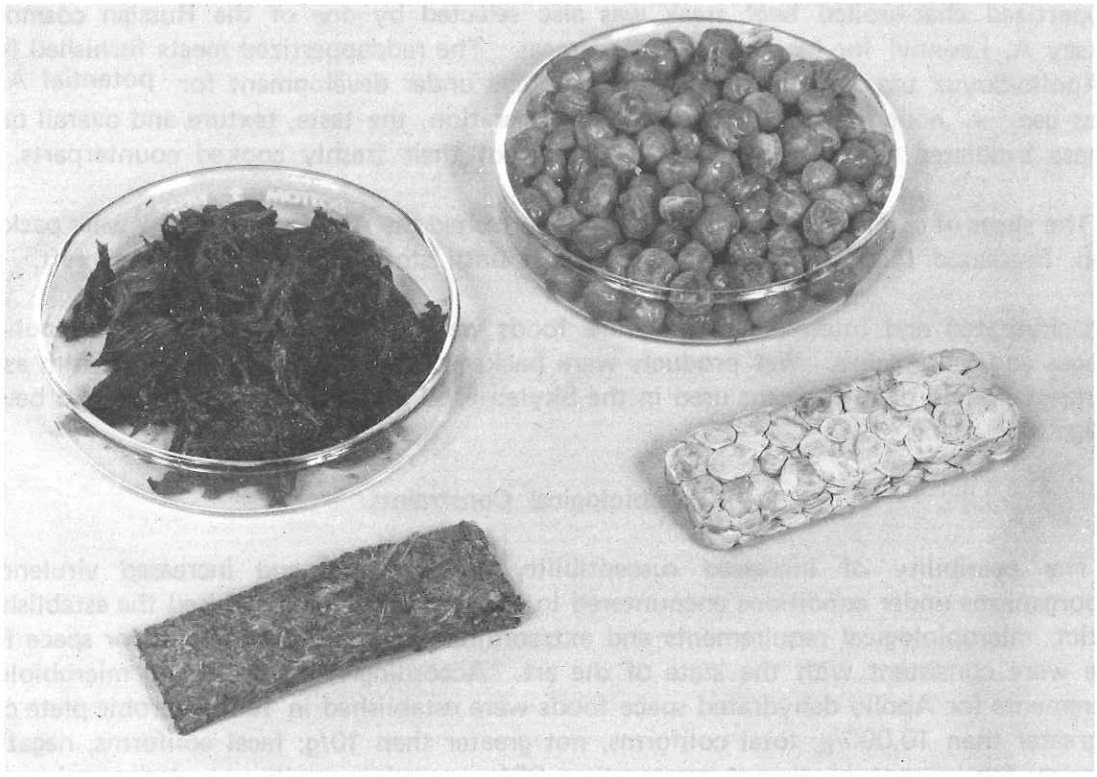
The Apollo-Soyuz food system maximized menu variety and incorporated the most acceptable of the foods developed for Apollo and Skylab within Apollo-Soyuz mission constraints; i.e., no freezer or food warmer, limited weight and volume, and limited supply (about 300 mL per crew member) of hot (49°C) water. As with each previous NASA program several new foods were introduced to the US space food inventory including one completely new food category – freeze-dried, reversibly compressed vegetables. Compressed, freeze-dried pea bars (2.5 cm x 7.6 cm x 1.2 cm), requiring only a quarter of the volume of an equal weight of freeze-dried peas, and spinach bars (2.5 cm x 7.6 cm x 0.5 cm), requiring only 1/11th of the volume of an equal weight of freeze-dried spinach, were included on the menus chosen by astronauts Stafford and Slayton. Both products reconstituted to full half-cup portions which looked and tasted like their frozen counterparts. The technology demonstrated in these vegetables can also be applied to meats, cottage cheese, and fruits, as well as other vegetables.

Developed by the US Army Natick Research and Development Laboratories for use by the Armed Forces under conditions where space, weight and/or volume are critical (e.g. submarine and field feeding), this new class of compressed foods shows potential for wide application to future space feeding.

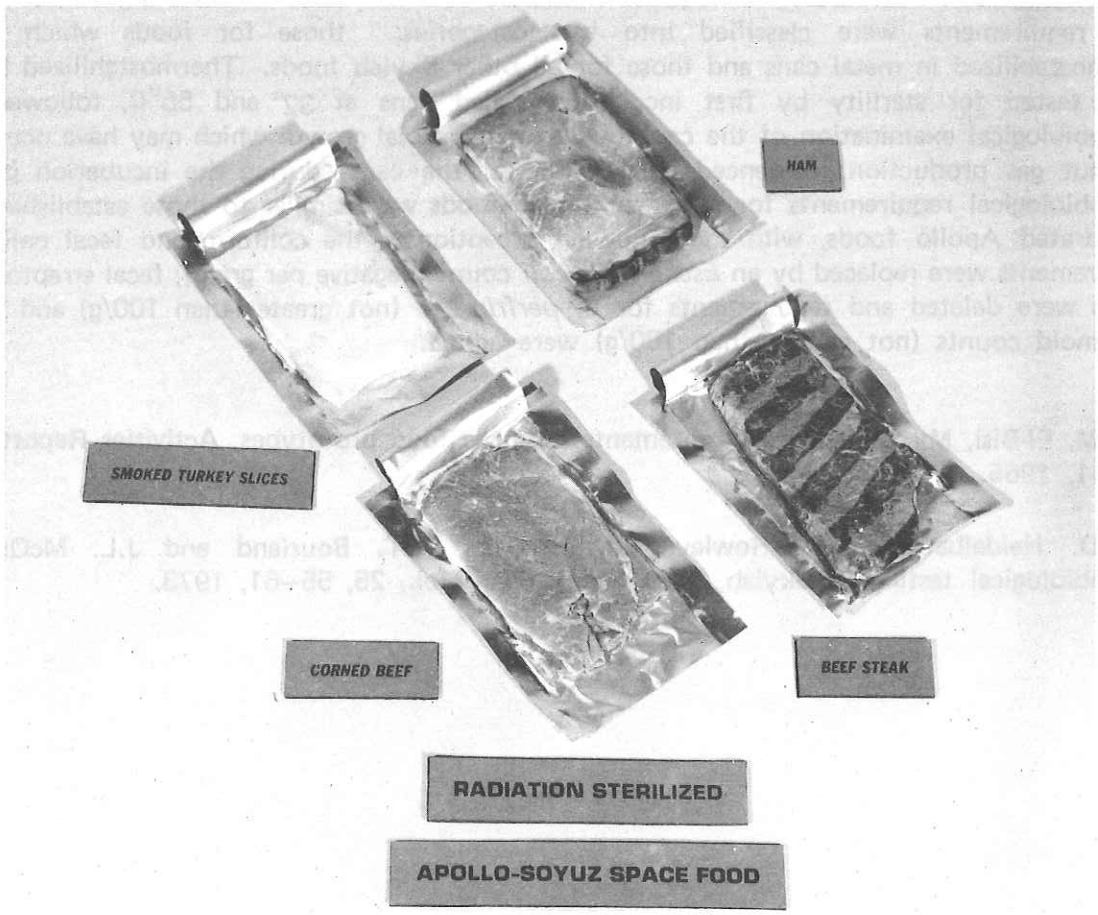
Reconstitution of reversibly compressed, freeze-dried green vegetables which have been given an extended blanch prior to freeze drying, and compressed, precooked, freeze-dried, diced chicken, beef, or pork requires only soaking in hot water. Even products such as compressed shredded carrots and cottage cheese reconstitute quickly in cool water. During reconstitution, these products pick up most of the water removed during dehydration; and also return to their original piece-sizes, shapes, and textures.

Recently, this new compression technology has also been successfully applied to entrees – meat and vegetables or meat and rice combinations, instant puddings, and even sweetened dehydrated drinks. For the military user, the fact that these compressed foods can be eaten dry or reconstituted makes them particularly adaptable to emergency/assault feeding use. The fact that they provide maximum and acceptable nutrition in minimum space and weight will also appeal to those responsible for the logistical support of future space stations.

Four radappertized meats (meats sterilized by ionizing radiation) were included on the Apollo-Soyuz menu: ham slices, corned beef, turkey slices, and a char-broiled beef steak. The



Compressed dehydrated spinach and peas included on Apollo-Soyuz menu — shown dry and rehydrated



Irradiated meats used on Apollo-Soyuz menu

radappertized char-broiled beef steak was also selected by one of the Russian cosmonauts (Aleksey A. Leonov) for his U.S. exchange meal. The raddappertized meats furnished NASA for Apollo-Soyuz use were prototypes of products under development for potential Armed Forces use. Although shelf stable without refrigeration, the taste, texture, and overall quality of these irradiated meats is comparable to that of their freshly cooked counterparts.

The slices of commercially produced bread furnished the Apollo-Soyuz crew were packaged, frozen, irradiated (50,000 rad), and held frozen until stored aboard the space craft.

Dehydrated and intermediate moisture foods were packaged in the Apollo spoon-bowl packages and/or pouches. Wet products were packaged in the flexibly laminated film as used on Project Apollo or in the cans used in the Skylab food system. A modified Apollo beverage package was used.

Microbiological Constraints

The possibility of increased susceptibility to infection and increased virulence of microorganisms under conditions encountered in manned spaceflight required the establishment of strict microbiological requirements and extraordinary production methods for space foods. These were consistent with the state of the art. Accordingly, the following microbiological requirements for Apollo dehydrated space foods were established in 1964: aerobic plate count, not greater than 10,000/g; total coliforms, not greater than 10/g; fecal coliforms, negative in one gram; fecal streptococci, not greater than 20/g; coagulase positive staphylococci, negative in 5 grams; and salmonella, negative in 10 grams.[48]

Skylab food microbiological requirements were established for the first flight in 1973.[49] The requirements were classified into two categories: those for foods which were thermostabilized in metal cans and those for all other Skylab foods. Thermostabilized foods were tested for sterility by first incubating sealed cans at 32° and 55°C, followed by microbiological examination of the cans to detect microbial growth which may have occurred without gas production (evidenced by swelling of the cans) during the incubation phase. Microbiological requirements for all other Skylab foods were similar to those established for dehydrated Apollo foods, with the following exceptions: the coliform and fecal coliform requirements were replaced by an *Escherichia coli* count (negative per gram); fecal streptococci limits were deleted and requirements for *C. perfringens* (not greater than 100/g) and yeast and mold counts (not greater than 100/g) were added.

[48] H.M. El-Bisi, Microbiological requirements of space food prototypes, Activities Report, 17, 54–61, 1965.

[49] N.D. Heidelbaugh, D.B. Rowley, E.M. Powers, C.T. Bourland and J.L. McQueen, Microbiological testing of Skylab foods, Appl. Microbiol., 25, 55–61, 1973.

The aerobic plate count (APC) served as an index of sanitary processing as well as proper storage and transportation of food products. Of the food surveyed in 1968 and 1969, 93% had APCs less than 10,000/g.[50] The yeast and mold requirements supplemented the APC and limited spacecraft contamination. All foods examined had low counts, which were well within test limits.

The presence of coliforms in processed foods is a useful indicator of post processing contamination. Fecal coliforms are a more specific indicator of fecal contamination because of the high incidence of *E. coli* within the group. Recovery of *E. coli* from foods implies that pathogens and other organisms of fecal origin may be present. Of the Apollo foods tested, 98% had less than 10 coliforms/g, and 99% were negative for fecal coliforms. All Skylab foods were negative for *E. coli*. Because *E. coli* is not a perfect indicator, requirements for specific pathogens, namely, salmonellae and coagulase positive staphylococci, were selected. None of the Skylab foods were positive for these two pathogens. Tests for *C. perfringens* were performed on Skylab foods which required warming prior to consumption and in which it was judged that *C. perfringens* might be present. The organism was not found in any of the foods tested.[51]

Microbiological examination of Apollo and Skylab foods demonstrated that all the microbiological requirements were satisfied. However, the microbiological indices and test procedures selected comprised only one segment of the total food safety system. Equally important elements of this safety system which were essential to attainment of the established test limits included strict criteria and procedures for raw materials, storage, processing, transportation, and personnel monitoring.

Problems and Findings of the Various Space Flight Food Experiments

A brief summary of a succession of problems studied in the various flights is provided in Table 1.

[50] E.M. Powers, C. Ay, H.M. El-Bisi, and D.B. Rowley, Bacteriology of dehydrated space foods, Appl. Microbiol., 22, 441–445, 1971.

[51] See reference 49.

TABLE 1

Findings of the Various Space Flight Food Experiments

in Relation to the Basic Problems of Feeding Men in Space

	The Problem(s)	The Findings
MERCURY	a. What effect does null gravity have on food ingestion and digestion?	a. No serious effects.
	b. What packaging is best adapted to space flights?	b. Laminates of clear packaging materials proved to be satisfactory moisture vapor barriers and capable of holding a vacuum.
GEMINI	a. How can storage constraints be met?	a. Compressed dehydrated bite-size foods provide maximum caloric density per cc of space; caloric density can be increased by adding nondairy cream substitute to dehydrated soups, puddings, and cocoa and anhydrous dextrose to beverages.
	b. What is the effect of an all dehydrated diet?	b. No serious effect Dehydrated diet can be highly acceptable, digestible, nutritious, and physiologically equivalent to consuming regular diets.
	c. What difficulties occur in food handling, preparation, and consumption?	c. Dry bite-size foods crumble – corrected through careful formulation and applying appropriate edible coatings; dehydrated fruits and natural fruit juices fuse when vacuum packed in flexible pouch – corrected through reformulation and use of formulated drinks; reconstitution with cabin temperature water requires specially formulated gravies and soups; freeze-dried precooked food mixture reconstitute faster than mixtures of separately dehydrated components.
	d. Are there any nutritional effects?	d. Calcium losses that occurred during early Gemini flights were reduced by providing approximately 1 g of calcium per day in the diets and by maintaining a rigid exercise schedule.
APOLLO	a. What food preferences do astronauts have?	a. Foods most like those consumed on earth are preferred.
	b. Can a spoon be used to consume food?	b. A spoon can be used for all foods except beverages and thin soups.

	c. Are there any metabolic phenomena of interest?	c. Cardiac arrhythmias suspected of being due to potassium deficiences and excessive work loads occurred on Apollo 15; potassium levels on subsequent flight diets were increased.
	d. What microbiological requirements must be met?	d. Aerobic plate counts not greater than 10,000 g; total coliforms not greater than 10 g; fecal coliforms negative in 1 g, fecal streptococci, not greater than 20 g, coagulase positive staphylococci negative in 5 g, and salmonella negative in 10 g.
SKYLAB	a. What physiological effects may occur during prolonged space flight that affect menu planning?	a. Set diets become monotonous; astronauts prefer to have open pantry instead of preplanned rigid diet; complaints of blandness in Skylab may indicate space flight has some effect on ability to taste; caloric intake similar to intake on earth.
	b. What environmental conditions are crucial to crew performance?	b. Normal food, normal methods of eating, freezer space.
APOLLO-SOYUZ	a. What were the findings in regard to reversibly compressed foods?	a. Reversibly compressed dehydrated foods reconstitute to normal appearance, flavor, texture and color. Such foods are acceptable to astronauts, have excellent stability, and provide maximum caloric density per cc of space; thus, they have excellent potential for use in space stations and long term space missions.
	b. How were irradiated foods accepted?	b. The consumption of irradiated ham and bread on Apollo 17 demonstrated the initial astronaut acceptance of irradiated food. The consumption of four irradiated meats – ham, smoked turkey, corned beef and beefsteak – on Apollo-Soyuz clearly showed that these products were well accepted by U.S. astronauts. Even one Russian cosmonaut selected irradiated beefsteak for his U.S. exchange meal. Low dose irradiation helped prevent mold growth on the bakery products and did not adversely affect the flavor of the bread or sweet rolls.

Inventory of U.S. Space Foods

An inventory of the foods included on the final Mercury flight and on the Gemini, Apollo, Skylab, and Apollo-Soyuz menus is provided in Appendix A, Table A–1, Foods and Food Supplements Included on U.S. Space Flight Menus. In view of the transient and experimental nature of many of the earliest space foods, Project Mercury 6, 7 and 8 menus are not included in this table. For convenience and to facilitate planning future space flight or space station menus, the 220 foods have been grouped into 11 major menu use categories – entrees, soups, fruits and vegetables, bread and crackers, cereals, spreads, condiments, desserts, beverages, confections, nuts and snacks and high-density food bars. As appropriate, each category of food is subclassified by type of food, namely bite-size, rehydratable, thermo-stabilized, natural form, irradiated, frozen, intermediate moisture and baked (natural form). The foods are listed alphabetically under each subclassification. The unit weight or portion size, principal ingredients and processing procedures cited in Table A–1 reflect those cited in the latest production guides, specifications, or product descriptions.

Conclusions

The foods used on US space flights have been comprised of a wide variety of natural foods which have been specially processed and/or packaged to adapt them to null gravity consumption and other mission constraints. However, a 28-day supply of nutritionally defined formulated foods was also utilized on the final Skylab mission. Called *high density food bars*, 9 different flavored or formulated products were launched with the Skylab 3 crew. These supplemental bars were consumed every third day in lieu of the planned Skylab menus composed of conventional foods and made it possible for NASA to extend the planned 56-day mission to 84 days.

However, if the following observations made by Edward G. Gibson, a crew member of the final 84-day Skylab flight, are heeded, nutritionally defined formulated foods such as these will not be utilized extensively in planning future diets for routine space missions: "We experienced hunger on two different occasions because of the types of diet we were on. In order to extend our mission from 56 to 84 days, we supplemented our meals with high density food bars every third day. During those days, we had the same amount of minerals and number of calories as we had on other days, but the amount of food was greatly reduced so we ended up fairly hungry on every third day . . . Another effect of the food was from the Mineral Balance experiment M071. It was a worthwhile experiment, but it certainly did have its impact on the food system. In the future, we'd like to see a food system where there would be more flexibility of choice in what one wants to eat, when one wants to eat it, and how one wants to season it. An open pantry versus a preplanned rigid diet such as we had would be an optimum situation from the crew operational standpoint".[52]

[52] E.G. Gibson, Skylab 4 crew observations in **Biomedical Results from Skylab**, R.S. Johnston, and L.F. Dietlein, Eds. 1977, 27.

The comments of Dr. Joseph P. Kerwin, the Scientist Pilot in Skylab 2 and the first U.S. physician astronaut in space, are also of interest to the planners of future space diets. These are: "To me, the most astonishing thing was our ability and desire to peck in the groceries, and there's a long preflight history to that. We fought and scratched with the Principal Investigators on that diet for 4 or 5 years. We finally settled on an in-flight diet estimation, which kind of went like this: We had several 6-day periods of food intake measurement prior to the flight. These data were taken and were modified by certain standard height/weight/surface area tables, and so forth, to get a best estimate of our average caloric intake, and then we subtracted 300 kilocalories from that. Most of us were certain that even that amount of food was going to be too great. And lo and behold! We discovered that after a few days of decreased appetite in flight we were able to eat all our food. Indeed, as the missions progressed the amount of food the crew was allowed to eat increased and their exercise increased, they were essentially eating the same amount of food as they ate on the ground. That to me is a mystery. I still don't understand how in an environment in which certainly muscular work is reduced, the caloric demand and the relationship between caloric intake and body weight remain just about the same as they do on the ground, I think that's a very interesting problem that we haven't yet been able to solve".[53]

[53] J.P. Kerwin, Skylab 2 crew observations and summary, in **Biomedical Results from Skylab**, R.S. Johnston, and L.F. Dietlein, Eds. 1977, 28.

ADDENDUM

MAIN ASPECTS OF FOOD SYSTEMS FOR SHUTTLE FLIGHTS

FOODS

Appetizing, wholesome, nutritious convenience foods, light in weight and low in volume. Types of foods include: thermostabilized, rehydratable, irradiated, natural form, and intermediate moisture.

FOOD PACKAGING

Operational missions, OPS, (beginning with the fifth shuttle mission) will use one package for rehydratable foods and beverages. It will have an injection molded base with a thermoformed flexible lid. It will use a needle-septum concept for reconstitution. The Orbital Flight Tests, OFT, (first four shuttle missions) are using the types of packaging and water dispensing systems used in Apollo, Skylab, and Apollo-Soyuz Test Project missions.

FOOD PREPARATION

OPS missions will use a galley system having a food preparation area, a semi-automatic rehydration unit and a convection oven. A hot water heater will be a component of the galley facility. The OFT missions, having no galley or water heater, use a portable food warmer to heat reconstituted foods and beverages.

RESTRAINTS

The food lockers, located near the spacecraft electronic gear, may reach temperatures above 32°C (90°F). This limits the type of foods which can be used. Food package design and hardware must still function in zero gravity; liquids must still be fully contained at all times.

MENUS

Menu is a standard menu instead of the personal preference menu used on earlier missions. A pantry is provided to supplement the menu. The menu provides 3000 kilocalories per day. A 6-day menu cycle will be used for the OPS missions; a 4-day menu cycle on the OFT missions.

ADDENDUM

The Food Systems for Shuttle Flights[54,55,56]

When the space shuttle Orbiter Columbia was launched on its first flight into space on 12 April 1981 and landed safely 54½ hours later, a new and important advance in man's exploration of space was initiated. Columbia's second flight, 12–14 November 1981 confirmed the reusability of the Space Shuttle Orbiter, a basic objective of this space shuttle project. This new spacecraft is designed to transport into Earth orbit a crew of seven for 30 days and a payload of 30 tons. It will have its own unique food system. That system insofar as it has been designed and developed is briefly summarized opposite.. The requirements of this system are different from those of previous U.S. space missions.

Goal. The goal of the work on the shuttle food system, as for previous missions, is to provide crew members with appetizing, safe, nutritious, and convenient food that is light in weight and low in volume. This objective must be achieved within many of the same biological, operational and engineering constraints which influenced development of the feeding systems for earlier missions. However, the improved environmental conditions in the Shuttle Orbiter, principally the elimination of the oxygen enriched atmosphere used on previous spacecraft and a nominal ambient cabin pressure of 15 psi, have allowed NASA to relax some of the food packaging constraints imposed on earlier flights. They have also supported NASA's consideration of cost effective alternatives to the custom order mositure-vapor and gas-barrier packaging films and intensive packages used on earlier missions.

According to Bourland *et al.*[57] the new space food system will be introduced on the fifth shuttle mission – the first Operational Mission (OPS). The changes will include a redesigned package for rehydratables and a new galley. The new rehydration package will have an injection molded base with a thermoformed flexible lid and will use a needle-septum concept for rehydration. One package will be used for both rehydratable foods and beverages. Automated production and more readily available materials will reduce the cost of space food packaging. The galley system has a food preparation area, a semi-automatic rehydration unit and a convection oven. The time required to add water to the packages has been reduced to 3–5 minutes. Foods for space flights are purchased in lots and held at 4°C (40°F) until one to two months before a scheduled flight when they are transferred to flight packages.

[54] C.T. Bourland, M.F. Foley, R.M. Rapp, and R.L. Sauer, Space shuttle food processing and packaging, J. Food Protect., Vol. 44, 313–315, April 1981.

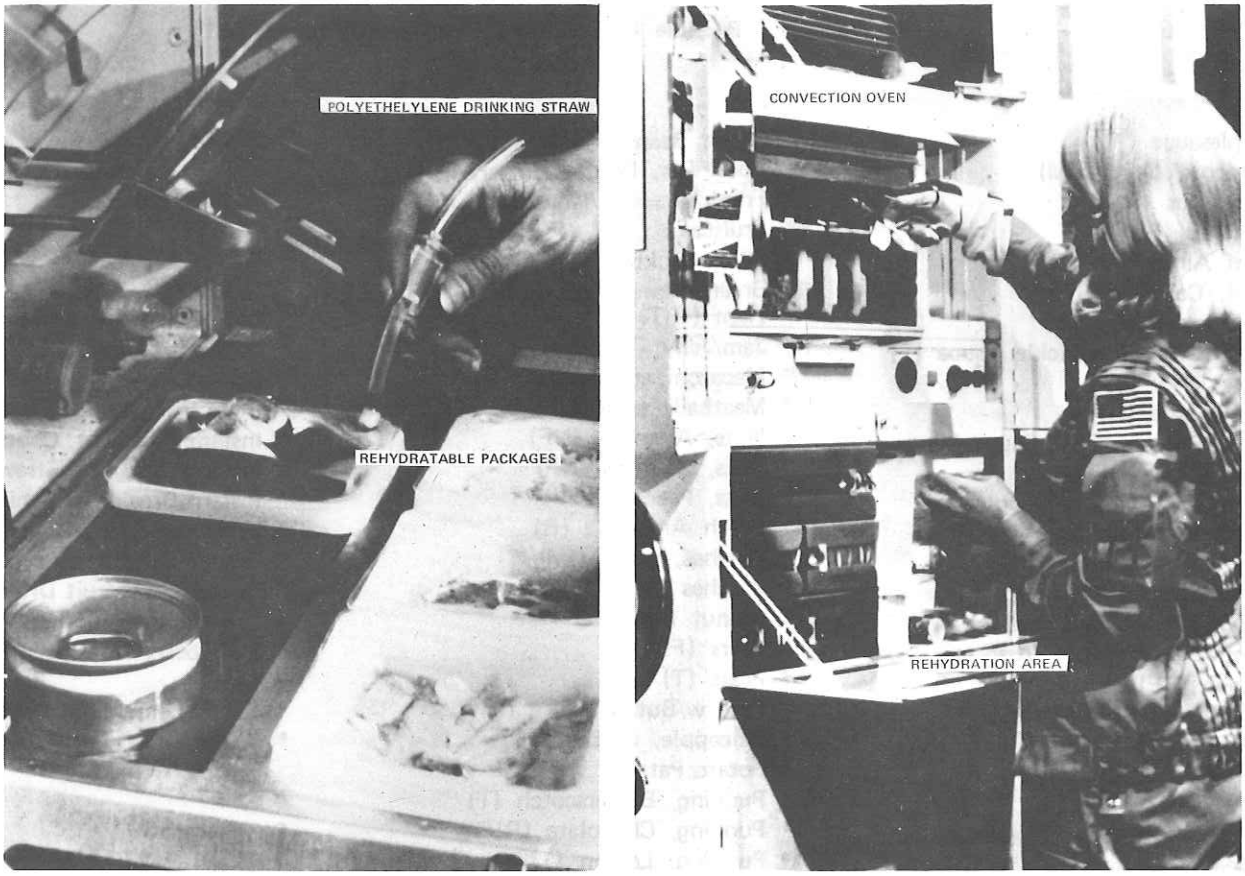
[55] C.R. Stadler, C.T. Bourland, R.M. Rapp, and R.L. Sauer, Food System for Space Shuttle Columbia, J. Am. Dietet. Assoc., Vol. 80, 108–114, February 1982.

[56] R.L. Sauer and R.M. Ropp, STS–1 Medical Report, NASA TM–58240, S.L. Pool, P.C. Johson, Jr., and J.A. Mason, Editors, 54–57, October 1981.

[57] See reference 54.

SHUTTLE OFT FOOD SYSTEMS

A composite photograph of the STS–1 food system is shown. From the top, left to right; a locker tray packed with overwrap meals, various sizes of flexible foil retort pouches, food being placed in the food warmer; center row: beef with vegetables in a spoon-bowl package, food being eaten from a spoon-bowl package aboard Columbia, Skylab beverage package, bottom row: meal assembled on the serving tray clipped to the mid-deck lockers, utensils used on STS–1, and the OFT water dispensing unit.



Shuttle Galley

The fact that the lockers used for the storage of food aboard the Orbiter are located near the spacecraft electronic gear and may reach temperatures above 32.2°C (90°F) does, however, limit the types of foods which can be used on shuttle missions. The types of foods planned for the space shuttle include: thermostabilized, rehydratable, irradiated, natural form, and intermediate moisture.

The first four missions, called the Orbital Flight Tests (OFT), are being flown without a galley and thus are using an interim shuttle food system. The food packages used on Apollo, Skylab, and Apollo-Soyuz Test Project missions are being used with this interim system. Although a hot water heater will be a component of the galley, hot water is not available for the OFT; therefore, a portable food warmer is being used to heat food for these missions. The list of foods and beverages approved for OFT shuttle flight use is furnished as Table 1. Those foods preceded by an asterisk are identical to or very similar to foods used on earlier space programs – those described in Appendix A, Table A–1.

The shuttle menu will provide 3000 kilocalories per day. It will be a standard menu instead of the personal preference type menu used on previous flights. Diversified crews and projected flight frequencies have dictated this approach. A pantry will be provided to supplement the menu. Individual crew members will have a voice in the selection of pantry components. Table 2 provides the standard OFT menu. Table 3 provides the list of foods supplied in the pantry which can be used as snacks or as substitutes for menu items. These pantry foods also serve as the contingency food supply.

Table 1. Baseline OFT Shuttle Food and Beverage List

* Applesauce (T)
* Apricots, Dried (IM)
* Asparagus (R)
  Bananas (FD)
  Beef Almondine (R)
* Beef, Corned (I)(T)
* Beef and Gravy (T)
* Beef, Ground w/Pickle Sauce (T)
* Beef Jerky (IM)
* Beef Pattie (R)
* Beef, Slices w/BBQ Sauce (T)
* Beef Steak (I)(T)
  Beef Stroganoff w/Noodles (R)
* Bread, Seedless Rye (I)(NF)
  Broccoli au Gratin (R)
* Breakfast Roll (I)(NF)
  Candy, Chocolate Coated
  Candy, Life Savors, Assorted Flavor (NF)
  Cauliflower w/Cheese (R)
* Cereal, Bran Flakes (R)
* Cereal, Cornflakes (R)
* Cereal, Granola (R)
  Cereal, Granola w/Blueberries (R)
  Cereal, Granola w/Raisins (R)
* Cheddar Cheese Spread (T)
* Chicken ala King (T)
  Chicken and Noodles (R)
  Noodles and Chicken (R)
* Chicken and Rice (R)
  Chili Mac w/Beef (R)
* Cookies, Butter
* Cookies, Pecan (NF)
* Cookies, Shortbread (NF)
* Crackers, Graham (NF)
* Eggs, Scrambled (R)
  Food Bar, Almond Crunch (NF)
  Food Bar, Chocolate Chip (NF)
  Food Bar, Granola (NF)
  Food Bar, Granola/Raisin (NF)
  Green Beans and Broccoli (R)
  Food Bar, Peanut Butter/Granola (NF)
* Frankfurters (Vienna Sausage) (T)
* Fruitcake
* Fruit Cocktail (T)
  Green Beans, French w/Mushrooms (R)
* Ham (I)(T)
* Jam/Jelly (T)
* Macaroni and Cheese (R)
* Meatballs w/BBQ Sauce (T)
* Nuts, Almonds (NF)
  Nuts, Cashews (NF)
* Nuts, Peanuts (NF)
* Peach Ambrosia (R)
* Peaches, Dried (IM)
* Peaches (T)
* Peanut Butter
* Pears (FD)
* Pears (T)
  Peas w/Butter Sauce (R)
* Pineapple, Crushed (T)
* Potato Pattie
* Pudding, Butterscotch (T)
* Pudding, Chocolate (R)(T)
* Pudding, Lemon (T)
* Pudding, Vanilla (R)(T)
  Rice Pilaf (R)
* Salmon (T)
* Sausage Pattie (R)
  Shrimp Creole (R)
* Shrimp Cocktail (R)
* Soup, Cream of Mushroom (R)
  Spaghetti w/Meatless Sauce (R)
* Strawberries (R)
* Tomatoes, Stewed (T)
* Tuna (T)
* Turkey and Gravy (T)
* Turkey, Smoked/Sliced (I)(T)
  Turkey, Tetrazzini (R)
  Vegetables, Mixed Italian (R)

Beverages

  Apple Drink
* Cocoa
* Coffee, Black
* Coffee w/Cream
* Coffee w/Cream and Sugar
* Coffee w/Sugar
* Grape Drink
* Grapefruit Drink
* Instant Breakfast, Chocolate
  Instant Breakfast, Strawberry
  Instant Breakfast, Vanilla
* Lemonade
* Orange Drink
* Orange-Grapefruit Drink
* Orange-Pineapple Drink
* Strawberry Drink
* Tea
* Tea w/Lemon and Sugar
* Tea w/Sugar
  Tropical Punch

Condiments

BBQ Sauce
Catsup
Mustard
Pepper
Salt
Hot Pepper Sauce
Mayonnaise

Abbreviations

T — Thermostablized
IM — Intermediate Moisture
R — Rehydratable
I — Irradiated
FD — Freeze-Dried
NF — Natural Form

NOTE: Assuming no food warming capability on the Orbiter

*Foods are identical to or similar to those on earlier space programs.

Table 2. Shuttle – Standard OFT Menu

Meal	Day 1[1], 5		Day 2, 6		Day 3, 7		Day 4, 8	
A	Peaches	(T)	Applesauce	(T)	Dried Peaches	(IM)	Dried Apricots	(IM)
	Beef Pattie	(R)	Beef Jerky	(NF)	Sausage	(R)	Breakfast Roll (I)	(NF)
	Scrambled Eggs	(R)	Granola	(R)	Scrambled Eggs	(R)	Granola w/Blueberries	(R)
	Bran Flakes	(R)	Breakfast Roll (I)	(NF)	Cornflakes	(R)	Vanilla Inst. Brkfst	(B)
	Cocoa	(B)	Choc. Inst. Brkfst	(B)	Cocoa	(B)	Grapefruit Drink	(B)
	Orange Drink	(B)	Orange-Grapefruit Drk	(B)	Orange-Pineapple Drink	(B)		
B	Frankfurters	(T)	Corned Beef (T)	(I)	Ham (T)	(I)	Ground Beef w/	(T)
	Turkey Tetrazzini	(R)	Asparagus	(R)	Cheese Spread	(T)	Pickle Sauce	
	Bread (2X) (I)	(NF)	Bread (2X) (I)	(NF)	Bread (2X) (I)	(NF)	Noodles & Chicken	(R)
	Bananas	(FD)	Pears	(T)	Green Beans & Broccoli	(R)	Stewed Tomatoes	(T)
	Almond Crunch Bar	(NF)	Peanuts	(NF)	Crushed Pineapple	(T)	Pears	(FD)
	Apple Drink (2X)	(B)	Lemonade (2X)	(B)	Shortbread Cookies	(NF)	Almonds	(NF)
					Cashews	(NF)	Strawberry Drink	(B)
					Tea w/Lemon & Sugar (2X)	(B)		
C	Shrimp Cocktail	(R)	Beef w/BBQ Sauce	(T)	Cream of Mushroom Soup	(R)	Tuna	(T)
	Beef Steak (T)	(I)	Cauliflower w/Cheese	(R)	Smoked Turkey (T)	(I)	Macaroni & Cheese	(R)
	Rice Pilaf	(R)	Gr. Beans w/Mushrooms	(R)	Mixed Italian Vegetables	(R)	Peas w/Butter Sauce	(R)
	Broccoli au Gratin	(R)	Lemon Pudding	(T)	Vanilla Pudding (T)	(R)	Peach Ambrosia	(R)
	Fruit Cocktail	(T)	Pecan Cookies	(NF)	Strawberries	(R)	Chocolate Pudding (T)	(R)
	Butterscotch Pudding	(T)	Cocoa	(B)	Tropical Punch	(B)	Lemonade	(B)
	Grape Drink	(B)						

NOTE: [1] Day 1 (launch day) consists of Meal B and C only and the last day consists of Meal A only

Abbreviations

T — Thermostabilized
IM — Intermediate Moisture
R — Rehydratable
I — Irradiated
FD — Freeze-Dried
NF — Natural Form
B — Beverage (Rehydratable)

Table 3. Contingency/Pantry Baseline

Food Classification and Name	OFT Use STS–1*	STS–2	STS–3
Beverages			
Apple Drink	8	8	10
Coffee (B)	12	10	–
Coffee (C&S)	8	10	–
Grapefruit Drink	6	6	10
Lemonade	8	8	10
Orange Drink	8	8	10
Strawberry Drink	–	–	10
Tea	10	10	–
Tea w/Lemon & Sugar	–	–	10
Snacks			
Apricots	4	4	2
Bananas, FD	2	–	–
Beef Jerkey (Dried Beef)	4	4	4
Bread	4	4	–
Chocolate Covered Candies (M&M's)	–	–	4
Cookies, Butter	–	–	3
Cookies, Pecan	–	–	3
Cookies, Shortbread	4	4	–
Food Bar, Chocolate Chip	–	–	5
Food Bar, Granola/Raisin	4	4	5
Peaches, Dried	2	2	2
Pears, FD	2	–	–
Nuts, Almonds	2	4	2
Nuts, Cashews	2	4	2
Nuts, Peanuts	4	4	2
Peanut Butter	4	4	2
Soda Crackers	4	4	4

Food Classification and Name	OFT Use STS–1*	STS–2	STS–3
Thermostabilized			
Beef Steak	4	8	4
Corned Beef	4	4	–
Frankfurters	–	–	2
Ham	4	4	4
Meatballs/Barbecue Sauce	–	–	2
Pudding, Butterscotch	2	–	–
Pudding, Lemon	2	–	–
Salmon	2	2	–
Turkey, Smoked	4	2	2
Rehydratables			
Asparagus	3	2	–
Beef Pattie	2	2	2
Chicken & Rice Soup	–	–	4
Chicken Tetrazinni	–	–	2
Eggs, Scrambled	–	–	2
Green Beans/Broccoli	3	2	–
Green Beans/Mushrooms	2	2	–
Peach Ambrosia	3	2	–
Peas/Butter Sauce	–	–	2
Potato Pattie	–	–	2
Rice Pilaf	–	–	2
Sausage Pattie	3	2	–
Strawberries	3	2	–
Vegetables, Italian	2	2	2

*STS – Shuttle Transportation System

List of References

Berry, C.A., Aeromedical Preparations, in **Mercury Project Summary Including Results of the Fourth Manned Orbital Flight May 15 and 16, 1963**, NASA SP–45, 1963, 203.

Catterson, A.D., E.P. McCutcheon, H.A. Minners, and R.A. Pollard, Aeromedical Preparations, in **Mercury Project Summary Including Results of the Fourth Manned Orbital Flight May 15 and 16, 1963**, NASA SP–45, 1963, 315.

Chapin, R.E., R.S. Kronenberg, M.J. O'Hara, D.C. Loper, and J.E. Vanderveen, Nutritional evaluation of foods developed for aerospace operations I. A diet composed of bite-size and rehydratable foods. Presented at the 38th Annual Scientific Meeting of the Aerospace Medical Association, Washington, DC, April 1967.

El-Bisi, H.M., Microbiological requirements of space food prototypes, **Activities Report**, 17, 54–61, 1965.

Flentge, R.L., A.C. Grim, F.F. Doppelt, and J.E. Vanderveen, How conventional eating methods were found feasible for spacecraft, **Food Technol.**, 25, 51–54, 1971.

Gibson, E.G., Skylab 4 crew observations, in **Biomedical Results from Skylab**, R.S. Johnston and L.F. Dietlein, Eds. 1977, 22–26.

Hartung, T.E., L.B. Bullerman, R.G. Arnold, and N.D. Heidelbaugh, Application of low dose irradiation to a fresh bread system for space flights, **J. Food Sci.**, 38, 129–132, 1973.

Heidelbaugh, N.D., D.B. Rowley, E.M. Powers, C.T. Bourland and J.L. McQueen, Microbiological testing of Skylab foods, **Appl. Microbiol.**, 25, 55–61, 1973.

Heidelbaugh, N.D., M.C. Smith, P.C. Rambaut, T.E. Hartung, and C.S. Huber, Potential public health applications of space food safety standards, **J. Am. Vet. Med. Assoc.**, 159, 1462–1469, 1971.

Heidelbaugh, N.D., M.C. Smith, P.C. Rambaut, L. Lutwak, C.S. Huber, and C.R. Stadler, Clinical nutrition applications of space food technology, **J. Am. Dietet. Assoc.**, 62, 383–389, 1973.

Heidelbaugh, N.D., J.E. Vanderveen, M.V. Klicka, and M.J. O'Hara, Study of man during a 56-day exposure at 258 mm Hg total pressure: VIII. Observations on feeding bite-size foods, **Aerosp. Med.**, 37, 583–590, 1966.

Hollender, H.A., Development of food items to meet Air Force requirements for space travel, Technical Documentation Report **AMRL–TDR 64–38**, Wright Patterson AFB, Ohio, 1964.

Hollender, H.A., M.V. Klicka, and P.A. Lachance, Space feeding: Meeting the challenge, **Cereal Sci. Today**, 13, 44–48, 1968.

Hollender, H.A., M.V. Klicka, and M.C. Smith, Food technology problems related to space feeding, in **COSPAR** Life Science and Space Research, VIII, North – Holland Publ. Co., 1970, 265–279.

Huber, C.S., M.C. Smith, and M.V. Klicka, Space foods, in **Health and Food**, G.G. Birch, L.F. Green, and L.G. Plaskett, Eds., Halsted Press, John Wiley and Sons, New York, 1972, 130–151.

Johnson, P.C., P.C. Rambaut, C.S. Leach, Apollo 16 bioenergetic considerations, **Nutr. Metabol.**, 16, 119–126, 1974.

Johnston, R.S. and W.E. Hull, Apollo missions, in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 9–40.

Katchman, B.J., G.M. Homer, and D. Dunco, The biochemical, physiological and metabolic evaluation of human subjects wearing pressure suits and on a diet of precooked dehydrated foods, **AMRL–TR–67–8**, 51 pp, 1967.

Kerwin, J.P., Skylab 2 crew observations and summary, in **Biomedical Results from Skylab**, R.S. Johnston and L.F. Dietlein, Eds. 1977, 27–29.

Klicka, M.V., Space foods and their development, in **Encyclopedia of Food Technology**, A.H. Johnson, and M.S. Peterson, (Eds.) The Avi Publishing Co., Inc., Westport, Conn., 1974, 828–840.

Klicka, M.V., H.A. Hollender, and P.A. Lachance, Foods for Astronauts, J. Am. Dietet. Assoc., 51, 238–245, 1967.

Klicka, M.V., P.A. Lachance, and H.A. Hollender, Space feeding, **Activities Report** 20, 53–72, 1968.

Lachance, P.A., Development of stored food and water systems, **Environ. Biol. Med.**, Vol. 1, pp 205–228, 1971, with Appendix A – Nutrient composition of space flight foods, M.V. Klicka, and M.H. Thomas.

Lachance, P.A. and C.A. Berry, Luncheon in space, **Nutr. Today**, 2 (2), 2–11, 1967.

Lachance, P.A., M.V. Klicka, and H.A. Hollender, Space feeding: Cereal products utilized in the US manned space program, **Cereal Sci. Today**, 13, 49–54, 70, 1968.

Linder, C.A., and V.R. Must, The effect of repetitive feedings on the acceptability of selected metabolic diets, **AMRL–TR–66–75**, 8 pp, 1967.

Lutwak, L., G.D. Whedon, P.A. Lachance, J.M. Reid, and H. Lipscomb, Mineral electrolyte and nitrogen balance studies of the Gemini VII 14-day orbital space flight, **J. Clin. Endocrinol. Metabol.**, 29, 1140–1156, 1969.

Mack, P.B., G.P. Vose, F.B. Vogt, and P.A. Lachance, Experiment M–6, bone demineralization, in **Gemini Midprogram Conference**, NASA SP–121, 1966, 407–415.

Michel, E.L., Preparation, handling and storage of foods for present space projects, **Conference on Nutrition in Space and Related Waste Problems**, NASA SP–70, 1964, 57–63.

Nanz, R.A., P.A. Lachance, and M.V. Klicka, Food consumption on Gemini IV, V and VII missions, **NASA TM X–58010**, October 1967.

Nanz, R.A., E.L. Michel, and P.A. Lachance, Evolution of a space feeding concept for Project Gemini, **NASA TM X–51697**, 1964.

Nanz, R.A., E.L. Michel, and P.A. Lachance, Evolution of space feeding concepts during the Mercury and Gemini space programs, **Food Technol.**, 21, 1596–1602, 1967.

Nebesky, E.A., G.L. Schulz, and F.J. Rubinate, Packaging for space flights, **Activities Report**, 17, 32–36, 1965.

O'Hara, M.J., R.E. Chapin, N.D. Heidelbaugh, and J.E. Vanderveen, Aerospace feeding: Acceptability of bite-size and dehydrated foods, **J. Am. Dietet. Assoc.**, 51, 246–250 1967.

Powers, E.M., C. Ay, H.M. El-Bisi, and D.B. Rowley, Bacteriology of dehydrated space foods, **Appl. Microbiol.**, 22, 441–445, 1971.

Rambaut, P.C., N.D. Heidelbaugh, and M.C. Smith, Calcium and phosphorus mobilization in man during weightless flight, **Activities Report**, 25, 1–7, 1973.

Rambaut, P.C., M.C. Smith, P.B. Mack, and J.M. Vogel, Skeletal response in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 303–322.

Rambaut, P.C., M.C. Smith, and H.O. Wheeler, Nutritional studies, in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 277–302.

Reid, J.M., L. Lutwak, and G.D. Whedon, Dietary control in the metabolic studies of Gemini 7 space flight, **J. Am. Dietet. Assoc.**, 53, 342–347, 1968.

Speckmann, E.W., K.J. Smith, J.E. Vanderveen, G.M. Homer, and D.W. Dunco, Nutritional acceptability of a dehydrated diet, **Aerosp. Med.**, 36, 256–260, 1965.

Smith, K.J., Nutritional evaluation of a precooked dehydrated and bite-size compressed food diet as a sole source of nutriment for six weeks, **AMRL–TR–66–3**, 30 pp., 1966.

Smith, K.J., E.W. Speckmann, P.A. Lachance, and D.W. Dunco, Nutritional evaluation of a precooked dehydrated diet for possible use in aerospace systems, **Food Technol.**, 20, 101–105, 1966.

Smith, M.C., N.D. Heidelbaugh, P.C. Rambaut, R.M. Rapp, H.O. Wheeler, C.S. Huber, and C.T. Bourland, Apollo food technology, in **Biomedical Results of Apollo**, NASA SP–368, R.S. Johnston, L.F. Dietlein, and C.A. Berry, Managing Editors, 1975, 437–468.

Smith, M.C., P.C. Rambaut, and C.R. Stadler, Skylab nutritional studies in **COSPAR Life Sciences and Space Research**, R. Holmquist, and A.C. Strickland, (Eds.), Volume 15, Pergamon Press, Oxford and New York, 1977, 193–197.

Stadler, C.R., D.D. Sanford, J.M. Reid, and N.D. Heidelbaugh, Skylab menu development, **J. Am. Dietet. Assoc.**, 62, 390–393, 1973.

Stone, S.E., *Gemini flight food qualification testing:* requirements and problems, **Activities Report**, 17, 37–43, 1965.

Vanderveen, J.E., N.D. Heidelbaugh, and M.J. O'Hara, Study of man during a 56-day exposure to an oxygen-helium atmosphere at 258 mm Hg total pressure IX, Nutritional evaluation of feeding bite-size foods, **Aerosp. Med.**, 37, 591–594, 1966.

Vanderveen, J.E., K.J. Smith, E.W. Speckmann, G. Kitzes, and A.E. Prince, Protein, energy, and water requirements of man under simulated space stresses, in **Conference on Nutrition in Space and Related Waste Problems**, NASA SP–70, 1964, 373–378.

Whedon, G.D., L. Lutwak, W.F. Neuman, and P.A. Lachance, Experiment M–7, calcium and nitrogen balance, in **Gemini Midprogram Conference**, NASA SP–121, 1966, 417–421.

Addendum

C.T. Bourland, M.F. Foley, R.M. Rapp, and R.L. Sauer, Space shuttle food processing and packaging, **J. Food Protect.**, Vol. 44, 313–315, April 1981.

R.L. Sauer and R.M. Ropp, STS–1 Medical Report, NASA TM–58240, S.L. Pool, P.C. Johson, Jr., and J.A. Mason, Editors, 54–57, October 1981.

C.R. Stadler, C.T. Bourland, R.M. Rapp, and R.L. Sauer, Food System for Space Shuttle Columbia, **J. Am. Dietet. Assoc.**, Vol. 80, 108–114, February 1982.

Supplemental References

Prior to 1963

Taylor, A.A. and B. Finkelstein, Preventive medicine aspects of flight feeding, **Am. J. Public Health**, 48, 604–609, 1958.

Finkelstein, B. and A.A. Taylor, Food, nutrition and the space traveler, **Am. J. Clin. Nutr.**, 8, 793–800, 1960.

Finkelstein, B., Nutrition research for the space traveler, **J. Am. Dietet. Assoc.**, 36, 313–317, 1960.

Taylor, A.A., B. Finkelstein, and R.E. Hayes, Food for space travel, **US AF Report, ARDC–TR–60–8**, Andrews AFB, 1960.

Thomas, M.H. and D.H. Calloway, Nutritional evaluation of dehydrated foods, **J. Am. Dietet. Assoc.**, 39, 105–116, 1961.

Schuetze, C.E., W.E. McMahon, L.M. Adams, and W.M. Barnes, Encapsulation of foods, **Technical Documentary Report No. MRL–TDR–62–53**, Wright Patterson Air Force Base, 19 pp., 1962.

Roth, N.G. R.B. Wheaton, and H.H. Morris, Control of waste putrefaction in space flight, **Developments in Industrial Microbiology**, 3, NY, Plenum Press, 1962, p. 35.

1963

Lachance, P.A. and J.E. Vanderveen, Problems in space foods and nutrition: foods for extended space travel and habitation, **Food Technol.**, 17, 567–572, 1963.

1964

Calloway, D.H., Nutritional aspects of gastronautics, **J. Am. Dietet. Assoc.**, 44, 347–352, 1964.

Hollender, H.A., Discussion: Preparation, handling and storage of foods for present space projects, in **Conference on Nutrition in Space and Related Waste Problems**, NASA SP–70, 65–69, 1964.

Finkelstein, B., Food, in **Bioastronautics Data Book**, Webb, P., Ed., NASA SP–3006, 1964, pp. 191–199.

Finkelstein, B. and J.J. Symons, Feeding concepts for manned space stations, **J. Am. Dietet. Assoc.**, 44, 353–357, 1964.

Klicka, M.V., Development of space foods, **J. Am. Dietet. Assoc.**, 44, 358–361, 1964.

Roth, N.G. and J.J. Symons, Handling and storage of food for long flights, in **Conference on Nutrition in Space and Related Waste Problems**, NASA SP–70, 1964, 85–91.

Webb, P., **Bioastronautics Data Book**, NASA SP–3006, 1964.

1965

Calloway, D.H., Nutritional criteria of primary concern to space flight, **Activities Report**, 17, 7–10, 1965.

Finkelstein, B., Pre-flight space feeding, **Activities Report**, 17, 11–13, 1965.

Hawley, R.L. and F. Parker, Observations on simulated space feeding experiments, **Activities Report**, 17, 44–53, 1965.

Hollender, H.A., Technology of space foods, **Activities Report**, 17, 19–31, 1965.

Hollender, H.A. and M.V. Klicka, Development of dehydrated and bite size food items, **AF Technical Report** AMRL–TR–65–160, 1965.

Link, M.M., Space medicine in project Mercury, NASA SP–4003, 1965.

Miller, S.A., H.A. Dymsza, S.R. Tannenbaum, and S.A. Goldblith, Metabolic studies of energy dense compounds for aerospace nutrition, **AF Technical Report** AMRL–TR–64–121, 1965.

Tuomy, J.M., Development of dehydrated meat and fish salads for military use, **Food Technol.**, 19, 46–50, 1965.

1966

Bustead, R.L. and J.M. Tuomy, Food quality design for Gemini and Apollo space program, Presented at 20th Annual Conference of American Society for Quality Control, June 1966.

Heidelbaugh, N.D., Space flight feeding systems: Characteristics, concepts for improvement and public health implications, **J. Am. Vet. Med. Assoc.**, 149, 1662–1671, 1966.

Smith, K.J., E.W. Speckmann, and R.L. Hein, Selected bibliography on the sustenance of man in aerospace systems, AMRL–TR–65–234, 70 pp, 1966.

Klicka, M.V., and H.A. Hollender, Developing space foods, **Industry**, 32, 26–27 and 61, 1966.

Klicka, M.V., H.A. Hollender, and P.A. Lachance, Development of space foods, **Svenska Ekonomiforestandarinnors.** Tidskrift No. 1 (Sweden), 1966.

Lachance, P.A., Nutritional aspects of space feeding, **Nutrition Needs**, 29 (4), Dec. 1966.

Margen, S. and D.H. Calloway, Clinical study of minimum protein and caloric requirements for man, **Annual Report** to NASA on NASA Grant NGR–05–003–068 and contract NAS 9–3966, Sept. 1966.

1967

Heidelbaugh, N.D. and M.A. Rosenbusch, A method to manufacture pelletized formula foods in small quantities. **USAF School of Aerospace Medicine Tech. Report SAM–TR–67–75**, 1967.

Katchman, B.J., G.M. Homer, J.P. Murphy, C.A. Linder, and V. Must, The biochemical, physiological and metabolic evaluation of human subjects in a life support systems evaluator and on a liquid food diet, **AMRL–TR–67–72**, 55 pp. 1967.

Lachance, P.A. and R.A. Nanz, The acceptability of food items developed for space flight feeding, **Food Technol.**, 21, 1361–1367, 1967.

Must, V.K., C.A. Linder, D.W. Dunco, K.J. Smith, and E.W. Speckmann, Comparison of organoleptic acceptability of liquid and fresh diets, **AMRL–TR–65–179**, 9 pp, 1967.

Webb, P., Weight loss in men in space, **Science**, 155, 558–560, 3 Feb. 1967.

1968

Heidelbaugh, N.D., J.E. Vanderveen, and H.G. Iger, Development and evaluation of liquid formula foods for aerospace feeding systems, **Aerosp. Med.**, 39, 138–143, 1968.

1969

El-Bisi, H.M. and E.M. Powers, The microbiological wholesomeness of space foods, **Technical Report 70–41–FL**, US Army Natick Laboratories, Natick, Mass, June 1969.

Fischer, C.L., P.C. Johnson, and C.A. Berry, Red blood cell mass and plasma volume changes in manned space flight, **J. Am. Med. Assoc.**, 200, 579–583, 1969.

Mehrlich, F.P. and M.V. Klicka, Food in space, **Activities Report**, 21, 155–168, 1969.

Smith Jr., M.C., and C.A. Berry, Dinner on the moon, **Nutr. Today**, Autumn, 37–42, 1969.

1970

Flentge, R.L. and R.L. Bustead, Manufacturing requirements of food for aerospace feeding, **USAF School of Aerospace Medicine, Technical Report, SAM–TR–70–23**, Brooks AF Base, 1970.

Hollender, H.A. and M.V. Klicka, Feeding man in space, **Proceedings of the Seventh Annual Working Group on Extraterrestrial Resources**, NASA SP–229, 1970, 36–49.

Huber, C.S., Long term space mission requirements, **Aerospace Food Technology**, NASA SP–202, 145–149, 1970.

Klicka, M.V., Space food development: A review, **Activities Report**, 22, 63–78, 1970.

Lachance, P.A. and M.V. Klicka, The use of meat with an extended shelf life in the nutrition of the astronaut, in **Proceedings of the Meat Industry Research Conference**, University of Chicago, 26–27 March 1970.

Smith, M.C., The Apollo food program, **Aerospace Food Technology**, NASA SP–202, 5–13, 1970.

1971

Bourland, C.T., C.S. Huber, and N.D. Heidelbaugh, The relative effectiveness of 8-hydroxyquinoline sulfate and alkyl dimethyl benzl ammonium chloride in the stabilization of aerospace food waste, **J. Food Milk Technol.**, 34, 478–481, 1971.

Brodinsky, R.L., L.A. Rancitelli, W.A. Huller, and L.S. Dewey, Calcium, potassium and iron loss by Apollo 7, 8, 9, 10 and 11 astronauts, **Aerosp. Med.**, 42, 621–626, 1971.

Heidelbaugh, N.D. and M.C. Smith, Potential applications of space food processing environment controls for the food industry, Proceedings Food Engineering Forum: Environment and the Food Processor, **Am. Soc. Agr. Eng.**, St. Joseph, Michigan, 95–105, 1971.

Smith, M.C., C.S. Huber, and N.D. Heidelbaugh, Apollo 14 food system, **Aerosp. Med.**, 42, 1185–1192, 1971.

1972

Berry, C.A., and M. Smith, What we've learned from space exploration, **Nutr. Today**, 4–11 and 29–32, Sept-Oct 1972.

Bush, W.H., Skylab food system project: Support and management, **Activities Report**, 33–39, 1972.

Rambaut, P.C., C.T. Bourland, N.D. Heidelbaugh, C.S. Huber, and M.D. Smith, Some flow properties of foods in null gravity, **Food Technol.**, 26, 58–63, 1972.

Smith, M.C., P.C. Rambaut, N.D. Heidelbaugh, R.M. Rapp, and H.O. Wheeler, Food and nutrition studies for Apollo 16, **NASA TM–X–58096**, MSC–07195, Oct. 1972.

1973

Bannerot, R.B., J.E. Cox, C.K. Chen, and N.D. Heidelbaugh, Heating of foods in space vehicle environments, **Am. Soc. of Mechanical Engineers Publication** 73–WA/HT–15, 1973.

Heidelbaugh, N.D., P.C. Rambaut, and M.C. Smith, Incorporation of nutritional therapy in space food systems, **Activities Report**, 25, 7–23, 1973.

Heidelbaugh, N.D., D.B. Rowley, E.M. Powers, C.T. Bourland, and J.S. McQueen, Microbiological testing of Skylab foods, **Appl. Microbiol.**, 25, 55–61, 1973.

Heidelbaugh, N.D., M.C. Smith, and P.C. Rambaut, Food safety in NASA nutrition programs, **J. Am. Vet. Med. Assoc.**, 163, 1065–1070, 1973.

Heidelbaugh, N.D., M.C. Smith, P.C. Rambaut, and C. Leach, Space food processing environment controls and safety standards, **AICHE Chemical Engineering Progress Symposium Series No. 132, 69, 87–90, 1973.**

Huber, C.S., N.D. Heidelbaugh, R.M. Rapp, and M.C. Smith, Nutrition systems for pressure suits, **Aerosp. Med.**, 44, 905–909, 1973.

Rambaut, P.C., N.D. Heidelbaugh, J.M. Reid, and M.C. Smith, Caloric balance during simulated and actual space flight, **Aerosp. Med.**, 44, 1264–1269, 1973.

1974

Bannerot, R.B., J.E. Cox, C.K. Chen, and N.D. Heidelbaugh, Thermal preparation of foods in space vehicle environments, **Aerosp. Med.**, 45, 263–268, 1974.

Bourland, C.T., N.D. Heidelbaugh, C.S. Huber, P.R. Kiser, and D.B. Rowley, Hazard analysis of *clostridium perfringens* in the Skylab food system, **J. Milk Food Technol.**, 37, 624, 628, 1974.

Leach, C.S., P.C. Rambaut and P.C. Johnson, Adrenal cortical responses of the Apollo 17 crew members, **Aerosp. Med.**, 45, 529–534, 1974.

Smith, M.C., R.M. Rapp, C.S. Huber, P.C. Rambaut, and N.D. Heidelbaugh, Apollo experience report – Food Systems, **NASA TN D–7720**, July 1974, 66 pp.

Vogel, J.M., P.C. Rambaut, and M.C. Smith, Bone mineral measurements from Apollo experiments M–078, **NASA TMX–58110**, Jan. 1974.

1975

Heidelbaugh, N.D., Industrial applications of space food technology, Underwood-Prescott Memorial Lecture, 1975, MIT Press.

1977

Bourland, C.T., R.M. Rapp, and M.C. Smith, Space shuttle food system, **Food Technol.**, 31, 40–45, 1977.

Michel, E.L., J.A. Rummel, C.F. Sawin, M.C. Buderer, and J.D. Lem, Results of Skylab medical experiment M 171 – metabolic activity, in **Biomedical Results from Skylab**, R.S. Johnston, and L.F. Dietlein, (Eds.) (NASA SP–377), 1977, 372–387.

Rambaut, P.C. and M.C. Smith, Nutrition support of space shuttle crews, **Nutr. Today**, 12, 6–11 and 28–30, 1977.

Rambaut, P.C., M.C. Smith, C.S. Leach, G.D. Whedon, and J. Reid, Nutrition and responses to zero gravity, **Federation Proceedings**, 36, 1678–1682, 1977.

Vogel, J.M., M.W. Whittle, M.C. Smith, and P.C. Rambaut, Bone mineral measurement – experiment M 078, in **Biomedical Results from Skylab**, R.S. Johnston, and L.F. Dietlein, (Eds.) (NASA SP–377) 1977, 183–190.

Whedon, G.D., L. Lutwak, P.C. Rambaut, M.W. Whittle, M.C. Smith, J. Reid, C. Leach, C.R. Stadler, and D.D. Sanford, Mineral and nitrogen metabolic studies – experiment M 071, in **Biomedical Results from Skylab**, R.S. Johnston, and L.F. Dietlein, (Eds.) (NASA SP–377), 1977, 164–174.

1978

Heidelbaugh, N.D., Space food systems in **Encyclopedia of Food Science**, M.S. Peterson, and A.H. Johnson (Eds.), the AVI Pub. Co., Westport, Conn., 1978, 700–702.

Appendix

Table A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Entrees									
Bite Size									
Bacon square or wafer	5 ± 0.5	Lean bacon	Slice, fry, compress, package under vacuum immediately.		1 (1)	9 (18)	11 (32)	3 (8)	1 (2)
Bacon and egg bite	6.0 ± 0.4	Whole eggs 75, hard cooked chopped eggs 12, bacon fat 9, ground fried bacon. Coating: high melting point fat.	Combine ingredients, cook, form freeze, freeze dry, apply coating, freeze dry again.			5 (10)			
Barbecued beef bite	3.6 ± 0.4	Cooked diced beef 27, seasoning mix (tomato soup, catsup, relish, onion, vinegar, starch, butter, Worcestershire sauce, spices) 25, water 24, cooked ground beef 13, beef stock 10, gelatin. Coating: water, vegetable oil, sodium caseinate, glycerine, gelatin.	Prepare beef, hydrate gelatin, prepare gravy, combine all ingredients, heat to 82°C, form, freeze, freeze dry, apply coating, freeze dry again.				2 (5)		
Beef bite	4.2 ± 0.4	Cooked ground beef 28, water 24, cooked diced beef 18, beef stock 17, beef stock fat 7, seasoning mix, ground fresh onions, gelatin. Coating: water, vegetable oil, sodium caseinate, glycerine, gelatin.	Prepare beef, hydrate gelatin, prepare gravy, combine all ingredients, heat to 82°C, form, freeze, freeze dry, apply coating, freeze dry again.			1 (2)	3 (7)		

[a]Reported to nearest whole number.

[b]Total flights and, in parenthesis, number of astronauts per flight: 1 Mercury (1), 10 Gemini (2), 11 Apollo (3), 3 Skylab (3) and 1 Apollo-Soyuz (3). Note: Only the last of the six Mercury flights is covered in this table.

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Bite Size (cont'd)									
Beef stew bite	3.5 ± 0.4	Cooked diced beef 34, water 27, beef stock 13, potatoes 10, seasoning, milk, carrots, peas, onions, gelatin. Coating: water, vegetable oil, sodium caseinate, glycerine, gelatin.	Prepare beef and vegetables hydrate gelatin, make gravy, add and cook vegetables, add meat and gelatin, heat to 82°C, form, freeze, freeze dry, apply coating, freeze dry again.				1 (2)		
Chicken bite, creamed	3.4 ± 0.4	Cooked diced chicken 25, water 20, ground cooked chicken 22, chicken stock 16, gravy mix 12, butter, flour, gelatin. Coating: water, vegetable oil, sodium caseinate, glycerine, gelatin.	Prepare poultry, hydrate gelatin, prepare gravy, combine all ingredients, heat to 82°C, form, freeze, freeze dry, apply coating, freeze dry again.			3 (6)	2 (3)		
Turkey bite	2.9 ± 0.4	Water 38, cooked ground turkey 20, cooked diced turkey 19, turkey, stock 14, seasoning 8, gelatin. Coating: water, vegetable oil, sodium caseinate, glycerine, gelatin.	Prepare poultry, hydrate gelatin, prepare gravy, combine all ingredients, heat to 82°C, form, freeze, freeze dry, apply coating, freeze dry again.				5 (11)		
Rehydratable									
Beef and gravy (regular)	35 ± 1.5	Cooked beef 68, beef stock 14, Seasoning mix.	Cook and dice meat, combine with gravy, form, freeze, freeze dry.	90		7 (13)			

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Beef and gravy (textured)	35 ± 1.5	Beef cooked 74, beef stock 18, seasoning mix.	Combine 3 parts shredded raw beef and 1 part raw beef emulsion, cook, dice, combine with gravy, form, freeze, freeze dry.	90			4 (10)		
Beef and vegetables (regular)	22 ± 1.5	Cooked beef 28, beef stock 18, water 17, potatoes 12, carrots 12, peas 9, seasoning mix.	Cook and dice meat and vegetables, combine with gravy, form, freeze, freeze dry.	90		8 (16)			
Beef and vegetables (textured)	22 ± 1.5	Cooked beef 35, beef stock 18, potatoes 12, carrots 12, water 10, peas 9, seasoning mix.	Combine 3 parts shredded raw beef and 1 part raw beef emulsion, cook and dice meat, dice and cook vegetables, combine with gravy, form, freeze, freeze dry.	90			5 (11)		
Beef Hash (regular)	29 ± 1.5	Raw beef 48, potatoes 30, water 17, seasoning mix, gelatin.	Hydrate gelatin, cook meat with seasoning and remaining water, combine meat, diced cooked potatoes and gelatin, form, freeze, freeze dry.	90			4 (10)		
Beef Hash (blend)	48.3 ± 0.9	Dry meat sauce 84, dry potatoes 16. (Meat sauce: ground beef 53, water 42, seasoning mix).	Prepare and freeze dry meat sauce, peel, dice, cook and freeze dry potatoes. Blend dry ingredients.	135				3 (6)	
Beef Patties	34 ± 2.8	Raw beef 91, water 6, pregelatinized corn meal, salt, black pepper, onion powder.	Grind beef, combine with other ingredients, form pattie, deep fat fry, freeze, freeze dry.	45					1 (2)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Beef pot roast (regular)	27 ± 1.5	Cooked beef 50, beef stock 23, water 23, seasoning mix.	Cook and dice meat, combine with gravy, form, freeze, freeze dry.	90	1 (1)	8 (16)			
Beef pot roast (textured)	27 ± 1.5	Cooked beef 56, beef stock 23,water 17, seasoning mix.	Combine 3 parts shredded raw beef and 1 part raw beef emulsion, cook and dice meat, combine with gravy, form, freeze, freeze dry.	90			5 (12)		
Beef stew (military formula)	30 ± 1.0	Cooked diced beef 39, water 32, diced raw potatoes 16, carrots, peas gravy mix, vegetable oil	Combine gravy mix and water, add vegetables and oil, cook, add beef and heat to 82°C, pan, freeze, freeze dry.	90			6 (16)		
Canadian bacon and applesacue	29 ± 1.5	Canadian bacon 50, applesauce 38, cooked white sauce 12.	Dice bacon, combine with sauce, form, freeze, freeze dry.	60		5 (10)	8 (23)		
Chicken and gravy (regular)	24.5 ± 1.5	Water 47, cooked diced chicken 46, seasoning mix 7.	Cook and dice chicken, prepare gravy, add chicken, heat to 82°C, form, freeze, freeze dry.	90	1 (1)	9 (18)			
Chicken and gravy (textured)	24.5 ± 1.5	Cooked diced chicken 52, water 41, seasoning mix 7.	Combine 3 parts shredded raw chicken and 1 part raw chicken emulsion, cook, dice, combine with gravy, form, freeze, freeze dry.	90			4 (10)		
Chicken and gravy (blend)	34.2 ± .68	Chicken 50, dehydrated chicken gravy 50.	Cook, dice and freeze dry chicken, prepare and freeze dry gravy, combine dry ingredients.	90				3 (5)	

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Chicken and rice (military formula)	33 ± 1.0	Water 42, cooked diced chicken 38, instant rice 10, vegetable oil, pimientos, soup and gravy base, salt.	Combine all ingredients except chicken, bring to a boil, soak 5 minutes, add chicken, heat to 82°C, pan, freeze, freeze dry.	90			8 (22)		
Chicken and rice (blend)	47.6 ± .95	Freeze-dried chicken 34, freeze-dried rice 41, sauce base 22, pimientos. (Sauce base: hydrolyzed cereal solids, pregelatinized starch, chicken flavor, flow agent, powdered chicken fat, seasonings.)	Cook, dice and separatelv freeze dry chicken, rice and pimientos, uniformily blend sauce base ingredients, combine dry ingredients.	120				2 (4)	
Chicken and vegetables (regular)	21 ± 1.5	Water 28, cooked diced chicken 24, potatoes 17, peas 16, carrots 10, seasoning mix, salt.	Cook, dice chicken, prepare gravy, add diced and cooked vegetables, heat to 82°C, form, freeze, freeze dry.	90		3 (6)			
Chicken and vegetables (textured)	21 ± 1.5	Cooked diced chicken 28, water 23, potatoes 17, peas 16, carrots 10, seasoning mix, salt.	Combine 3 parts shredded raw chicken and 1 part raw chicken emulsion, cook and dice chicken, dice and cook vegetables, combine with gravy, form, freeze, freeze dry.	90			5 (11)		
Chicken Salad (regular)	41.0 ± 2.0	Cooked diced chicken 66, mayonnaise 13, cooked celery 13, bacon 6, pregelatinized corn meal.	Combine ingredients, form, freeze, freeze dry.	90		7 (14)			

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Chicken salad (textured)	41.0 ± 2.0	Cooked diced chicken 71, mayonnaise 11, cooked celery 11, bacon 5, pregelatinized corn meal.	Combine 3 parts shredded raw chicken and 1 part raw chicken emulsion, cook, dice and chill chicken, combine with other ingredients, form, freeze, freeze dry.	90			7 (15)		
Chicken stew (military formula)	30.2 ± 1.0	Water 32, cooked diced chicken 29, potatoes raw 21, gravy mix 6, carrots 5, peas, vegetable oil.	Combine all ingredients except chicken, heat to 85°C, add chicken, heat to 82°C, pan, freeze, freeze dry.	90			8 (20)		
Eggs, scrambled	34.5 ± .69	Whole eggs, low fat milk (BF 2%), egg whites (desugared), butter, non-fat dry milk solids, salt, algin.	Combine ingredients, heat to coagulate eggs, pan, freeze, freeze dry.	90			6 (17)	3 (9)	1 (2)
Macaroni and Cheese	44.0 ± .88	Dehydrated macaroni 64, cheese sauce mix 36. (Sauce mix: nonfat dry milk, creaming agent, starches, cheese powders, seasonings).	Cook and freeze dry macaroni, prepare and freeze dry cheese sauce, blend dry ingredients.	105				3 (8)	1 (1)
Pork and escalloped potatoes (military formula)	34.4 ± 1.0	White sauce (cooked) 38, raw diced potatoes 34, raw diced pork 26, pimientos, green peppers, dehydrated onions.	Combine ingredients and cook until meat and vegetables are tender, pan, freeze, freeze dry.	90			8 (22)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]			
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Pork and escalloped potatoes (blend)	36.8 ± .74	Freeze-dried cooked pork 35, freeze-dried cooked potatoes 38, sauce base 25, freeze-dried pimientos 2.	Cook and freeze dry sauce base combine dry ingredients.	135				3 (4)	
Salmon salad	42 ± 2.0	Canned salmon 81, mayonnaise 15, cooked chopped onion, pregelatinized corn meal.	Combine, form, freeze, freeze dry.	105		5 (9)	8 (21)		
	46.7 ± .9							3 (5)	
Sausage patties	20.0 ± 1.5	Pork loin, trimmed 76, water 20, corn meal, salt, shortening, salt, rosemary, sugar, black pepper.	Blend and cook all ingredients except pork, grind pork, combine and form pattie, deep fat fry, freeze, freeze dry.	45		7 (12)	10 (24)		1 (2)
	30.0 ± 0.6							3 (8)	
Shrimp cocktail (regular)	31. ± 2.0	Cooked shrimp 65, tomato catsup 19, seafood sauce 16.	Combine ingredients, form, freeze freeze dry.	60		9 (17)	11 (25)		1 (2)
Shrimp cocktail (blend)	18.75 ± .47	Freeze-dried shrimp 67, dehydrated cocktail sauce 33.	Cook and freeze dry shrimp, freeze dry sauce, combine.	60				3 (7)	
Spaghetti and meat sauce (regular)	21 ± 1.5	Raw beef 44, water 28, spaghetti, 25 seasoning mix (starch, salt, oleo stock, onion powder, monosodium glutamate, black pepper, citric acid).	Prepare sauce, add meat and cook at 82°C, add spaghetti, pan, freeze, freeze dry.	60		9 (17)	4 (10)		
Spaghetti and meat sauce (military formula)	34.4 ± 1.0	Raw ground beef 51, tomato paste 19, water 14, raw spaghetti (vermicilli) 13 and seasoning mix.	Cook spaghetti, drain, prepare sauce, add beef and cook at 82°C, add tomato paste and heat to 82°C, pan freeze and freeze dry.	90			6 (16)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Spaghetti and meat sauce (blend)	50 ± 1.0	Freeze-dried ground beef 40, freeze-dried cooked spaghetti 40, dry spaghetti sauce 20.	Cook and freeze dry beef, spaghetti and sauce, combine dry ingredients.	150				3 (7)	
Tuna Salad	42 ± 2.0	Canned tuna 73, mayonnaise 13, pickle relish 10, pregelatinized corn meal, salt.	Combine ingredients, form, freeze and freeze dry.	90		8 (16)	10 (25)		
Veal and barbecue sauce	46.5 ± .9	Dehydrated veal 69, dehydrated barbecue sauce base 29, brown sugar, pregelatinized starch, powdered barbecue salt.	Cook, dice and freeze dry veal, prepare and freeze dry sauce ingredients, combine.	150				3 (8)	
Thermostabilized									
Beef and gravy	140 ± 5	Diced beef (cooked) 70, gravy 30 (Gravy: Water, tomato paste, soup and gravy base, flour, oil, onions, salt).	Dice and cook beef, prepare gravy, pouch, heat process.				6 (18)		1 (2)
Beef and potatoes	100 ± 5	Fried beef chunks 54, dehydro-frozen potatoes 35, water 10, salt.	Fry beef to 20% shrink, pouch, heat process.				3 (7)		
Beef slices and barbecue sauce	140 ± 5	Cooked beef slices 55, sauce 45 (Sauce: water, tomato paste, brown sugar, vinegar, oil, seasonings and spices.)	Cook beef, slice, prepare sauce pouch, heat process.						1 (3)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]			
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Thermostabilized (cont'd)									
Beefsteak	140 ± 5	Beef chunks 96, ice, salt, pepper.	Mix, stuff into forms, cook, slice, sear for grilled appearance, pouch, heat process.				3 (9)		
Chicken a la king	140 ± 5	Cooked, diced chicken 30, gravy 70 (Gravy: chicken broth, milk, peas, pimientos, mushrooms, flour, chicken fat, seasonings).	Cook chicken, prepare sauce, combine ingredients, pouch, heat process.						1 (1)
Chili with meat	190 ± 3.8	Water 44, beef rounds 22, beef flanks 20, tomato paste, starch, chili pepper, potato flour, salt, onion powder, sugar, cumin, oregano, vegetable oil, garlic powder, oleoresin, paprika, liquid caramel color.	Grind meat, cook with remaining ingredients, can, heat process.					3 (7)	
Frankfurters	135 ± 5	Beef 42, pork 35, ice 19, salt, sodium erythrobate, sodium nitrite and seasoning.	Put ingredients through emulsilator, stuff casings, cook, pouch, heat process.				7 (19)		1 (1)
Ham and potatoes	105 ± 5	Cooked ham chunks 67, dehydrofrozen potatoes 33.	Cure ham, cook, dice, pouch, heat process.				3 (8)		
Hamburgers with gravy	158 ± 7	Hamburger patties (beef, water, salt, cornmeal, onion powder, pepper) 93 and gravy 7.	Prepare and fry patties, prepare gravy, pouch, heat process.				3 (9)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Thermostabilized (cont'd)									
Ham slices	120 ± 5	Ham	Cure ham, cut into chunks, stuff into casings, cook, slice, pouch, heat process.				1 (3)		
Hot dogs in tomato sauce	200 ± 4	Cow beef 23, flanks beef 23, regulars pork 23, leans pork 23, ice 5, salt, sugar, frank seasoning, sodium erythorbate, sodium nitrite, garlic powder.	Prepare sausage, can, heat process.					1 (2)	
Meatballs and barbecue sauce	140 ± 5	Cooked meatballs 60, sauce 40 (Meatballs: beef, water, bread crumbs, egg whites, salt, onion, pepper. Sauce: water, tomato paste, brown sugar, vinegar, oil, seasonings and spices).	Prepare and cook meatballs, prepare sauce, pouch, heat process.				5 (15)		1 (2)
Salmon		Salmon, salt (commercial item)	Standard commercial method — can, heat process.				7 (21)		
Sandwich spreads		Tuna (or ham or chicken), water wine vinegar, sweet pickles, modified food starch, waxy maise, vegetable oil, sucrose, dehydrated celery, salt, dehydrated green peppers, flavorings, titanium dioxide, propylene glycol monostearate with monoglycerides, dehydrated red pepper, locust bean gum.	Commercial high temperature short time heat process in tubes or cans.						
Tuna, ham or chicken salad	148 or 210 ± 5						6 (18)		
Tuna salad	85 ± 1.7						1 (3)	3 (4)	1 (1)
Chicken salad	85 ± 1.7								1 (1)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Thermostabilized (cont'd)									
Tuna in water	99	Tuna, vegetable oil, salt	Standard commercial method – can, heat process						1 (1)
Turkey and gravy (Apollo)	140 ± 5	Cooked diced turkey 70, gravy 30, (Gravy: water, chicken base, starch, flour, oil, salt, onion salt).	Prepare turkey, prepare gravy, pouch, heat process.				9 (25)		1 (3)
Turkey and gravy (Skylab)	190 ± 4.0	Cooked diced turkey 72, gravy 28	Dice the turkey, add gravy, can, heat process.					2 (5)	
Natural Form									
Beef dried, sliced	47 ± 0.9	Sliced dried beef (called "jerky" on menu)	Commercial item.					2 (4)	
Beef jerky	30 ± 0.5	Beef tenderloin (specially produced)	Seasoned, smoked, dried, sliced				1 (3)		1 (1)
Cheese slice	60 ± 1.0	Processed cheese.	Commercial processed cheese				1 (3)		1 (3)
Irradiated									
Beef steak	100 ± 20	Fresh sirloin strips 91, pumped with solution of salt and sodium tripolyphosphate 9.	Trim and charbroil meat, bake to 74 ± 3°C, vacuum package, freeze to -40 ± 5°C, irradiate, dose = 37 to 42 kJ/kg (3.7 to 4.3 M rad).						1 (3)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]				Apollo-Soyuz
					Mercury	Gemini	Apollo	Skylab	
Irradiated (cont'd)									
Corned beef	80 ± 10	Fresh trimmed briskets 91, pumped with solution of water, salt, sodium tripolyphosphate curing salts and spices 9.	Trim beef, mix with cure, stuff into casings, cook in water, slice, package under vacuum, freeze to -40°C, irradiate, dose = 25 to 29 kJ/kg (2.5 to 2.9 M rad)						1(1)
Ham	95 ± 5	Fresh raw pork ham 87, water, salt, sodium tripolyphosphate, salt and curing salts 13.	Trim fresh pork ham, cut into chunks mix with cure, stuff into forms, smoke to an internal temp of 68°C and a 95% yield based on gross weight of ham, slice, vacuum package, freeze to -40 ± 5°C, irradiate, dose = 37 to 42 kJ/kg (3.7 to 4.3 M rad).				1 (3)		1 (1)
Turkey	90 ± 10	Turkey breast marinated in a curing solution of water, salt, sodium tripolyphosphate and curing salts.	Cure breasts overnight, smoke in smokehouse, bake to 87 ± 3°C, slice, package under vacuum, freeze to -40 ± 5 °C, irradiate, dose = 37 to 42 kJ/kg (3.7 to 4.3 M rad).						1 (3)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Frozen									
Beef, prime rib	170 ± 3	Sliced roast beef.	Roast to 66°C, infrared sear of surface slice 3/8" thick, freeze.					3 (9)	
Filet mignon	170 ± 3	Trimmed beef tenderloins.	Seal in can, cook in water bath to 66°C, water cool to 3°C, remove from can, slice, flame-sear, can, freeze.					3 (9)	
Lobster Newburg	200 ± 4	Cooked lobster meat pieces 40, newburg sauce 60. (Sauce: water 69, nonfat milk 9, margarine 8, piementos, egg yolk, flour, starch, sherry wine, salt, carboxyl methyl cellulose, pepper, paprika.)	Prepare sauce, cook lobster, combine ingredients, freeze.					3 (5)	
Pork loin w/ dressing	200 ± 4	Roasted boneless pork loin 35, gravy 35, dressing 30 (Gravy: pork stock, starch, flour, salt, pork, monosodium glutamate, pork fat; Dressing: dry bread cubes, pork stock, minced onions, pepper, beef soup base, sage, poultry seasoning, monosodium glutamate, pork fat).	Roast the pork, boil gravy, bake dressing and mix these ingredients, freeze.					3 (8)	

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Soups									
Rehydratable									
Cream of chicken	27.5 ± 2.0	Freeze dried chicken powder 28, powdered shortening 28, confectioner hard butter 9, chicken fat 9, salt 7, monosodium glutamate 7, spices, nucleotides and BHA.	Cook, freeze dry and grind chicken, make past of spices and drum dry and blend with other dry ingredients. Melt butter and chicken fat and blend into dry ingredients, mold into bar 2 x 1 x ¾ inches in size.	150			10 (26)		
Cream of tomato	35.0 ± 1.5	Tomato juice 59, milk 20, margarine 9, sour cream, flour, sugar, tomato paste, salt, celery salt, onion powder, white pepper, lecithin.	Combine tomato products, sugar and spices and heat to 66°C. Prepare white sauce and blend in tomato mixture and sour cream, heat to 60°C, freeze, freeze dry, comminute.	150			5 (12)		
Corn chowder	56 ± 1.5	Dehydrated cream style corn 58, coffee creaming agent 38, chicken soup and gravy base.	Blend dry ingredients, add water, cook, freeze dry, comminute.	150		4 (8)	6 (14)		
Lobster bisque	39 ± 1.5	Condensed tomato soup 33, chicken broth 22, condensed pea and ham soup 17, whipping cream 16, confectioners hard butter, creaming agent, sherry wine flavoring, cornstarch and chicken flavoring.	Make roux of butter, cornstarch and chicken flavor; heat, add broth and soups, whipping cream and creaming agents, heat to 86°C for 5 minutes, cool to 54°C, add sherry and flavoring, freeze, freeze dry, comminute.	150			4 (11)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]			
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Pea	49 ± .9	Dehydrated pea soup 55, creaming agent 43, pregelatinized waxy maize starch.	Blend dry ingredients, add water cook, freeze, freeze dry, comminute.	150		4 (8)	9 (23)	3 (5)	1 (3)
Potato	48 ± 9	Dehydrated potatoes 48, creaming agent 48, chicken flavor, salt, celery salt, onion powder, white pepper.	Blend dry ingredients, add water cook, freeze, freeze dry, comminute.	135		6 (12)	9 (20)	3 (6)	1 (3)
Romaine	15 ± .5	Chicken broth, spinach, mushrooms, modified starch, hydrolyzed plant protein, partially hydrogenized soybean oil, salt, carrots, monosodium glutamate, dried onions, sugar, garlic powder, lactose, sodium caseinate, dipotassium phosphate, natural flavorings and spices, tumeric, disodium inosinate, disodium guanylate, atrificial color.	Mix ingredients and heat to 84-97°C, can, seal, retort to 121 C for 55 minutes, freeze dry, package.	90			2 (6)		
Turkey – rice	25.1 ± .5	Freeze-dried turkey 46, freeze-dried rice 17, soup base 36, parsley flakes, white pepper.	Blend dry ingredients.	135			5 (14)	3 (4)	1 (2)
Seafood (crab) mushroom	15 ± .5	Seafood, partially hydrogenated soybean oil, modified starch, mushrooms, salt, chicken broth, white cheese, sherry, butter lactose, dried onion, sodium caseinate, sugar, dipotassium phosphate, tarragon, vinegar, monosodium glutamate, herb and spice, disodium inosinate, disodium guanylate.	Mix ingredients and heat to 84-97°C, can, seal, retort to 121°C for 55 minutes, freeze dry package.	90			1 (3)		1 (3)

TABLE A--1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Fruits and Vegetables									
Rehydratable									
Applesauce	35.0 ± 1.5	Apple powder 57, sugar 43, malic acid.	Peel, blanch and press apples, freeze dry, grind, blend.	210		8 (16)	6 (16)		
Asparagus	8.4 ± 0.2	US Grade "A" asparagus (seasoned cooking water to contain 1% salt with 0.6 g MSG per lb of aspaagus).	Freeze dry.	60				3 (9)	
Beans, green	20.5 ± 0.4	Dehydrated canned green beans 34, dehydrated sauce base 59, dehydrated mushrooms 7 (Sauce base: creaming agent, nonfat milk solids, starch, freeze-dried powdered mushrooms, chicken flavor, lemon peel, onion powder, pepper).	Freeze dry green beans and mushrooms, mix and grind sauce base, combine.	90				3 (7)	
Cranberry – applesauce	35.0 ± 1.5	Apple powder, sugar, dehydrated cranberry, malic acid.	Peel, blanch, press, freeze dry apples, grind, blend.	60			2 (6)		
Cranberry-orange	30 ± 1.5	Frozen cranberry-orange sauce.	Freeze dry, granulate.	60			3 (8)		
Corn, cream style	22.5 ± 2.0 37.5 ± 0.5	Cream style corn – US fancy, canned.	Form, freeze, freeze dry.	90 150		4 (8)		3 (9)	1 (2)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Fruit cocktail	21 ± 2.0	Fresh peaches 40, fresh pears 36, sugar 11, frozen pineapple 10, canned maraschino cherries.	Form, freeze, freeze dry.	90		7 (14)	11 (30)		1 (1)
Peaches	19 ± 2.0	Frozen peaches (8 parts fruit plus 1 part sugar).	Form, freeze, freeze dry.	90		9 (18)	11 (32)		1 (3)
Peach ambrosia with pecans	36.1 ± 0.7	Chopped pecans 42, freeze-dried chopped peaches 30, freeze-dried chopped canned pineapple 15, freeze-dried chopped (sodium bisulfited) bananas 8, freeze-dried chopped, erythrobic acid treated pears 5.	Freeze dry each fruit, combine.	60			4 (11)	3 (6)	1 (3)
Pears	26 ± 2.0	Frozen pears (8 parts fruit plus 1 part sugar).	Form, freeze, freeze dry.	90					1 (2)
Peas, compressed	23.0 ± 0.5	Freeze-dried peas.	Sulfite, slit, blanch, freeze peas, spray water to bring moisture level to 11-12% compress, re-dry to 2% moisture.	150					1 (2)
Peas, creamed	27 ± 2.0	Peas 59, sauce base 41 (Sauce base: nonfat milk solids, creaming agent, waxy maize starch, dried butter powder, tapioca starch, chicken flavor, salt, garlic salt, celery salt, white pepper, turmeric powder).	Freeze dry canned peas, mix and blend sauce base, combine	90		3 (2)			
	34 ± 0.7			105				3 (8)	

(Note: Compressed vegetables require excess water)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Potatoes, mashed	36.0 ± 0.6	Potatoes 76, milk 20, butter 5, salt, antioxidant.	Cook potatoes, mash, combine	120				3 (7)	1 (2)
Potatoes, mashed, sweet	48 ± 0.9	Instant sweet potato flakes 81, sauce mixture 19 (Sauce mixture: dried butter powder 62, sugar 24, salt 12, white pepper).	Blend, combine.	60				1 (1)	
Potato pattie	33 ± 3	Potato shoestring 69, water 21, corn meal 7, salt, shortening, minced onions, white pepper, MSG.	Blend, cook, form, deep fat fry, freeze, freeze dry.	75					1 (2)
Potato salad (regular)	25.5 ± 1.5	Cooked diced potatoes 75, vinegar 6, fried bacon 6, diced cooked onion, mayonnaise, pregelatinized starch, salt, sugar, bacon fat, pepper.	Combine all ingredients, freeze dry.	75		8 (16)	1 (1)		
Potato salad (blend)	33 ± 0.7	Freeze dried potatoes 45, sauce base 27, vegetable protein chips (bacon flavored) 27. (sauce base: water, vinegar, vegetable oil, mayonnaise, hydrolyzed cereal solids, pregelatized starch, spices, antioxidant).	Dice, cook, freeze, freeze dry potatoes, combine sauce base ingredients, heat, pass through colloid mill, freeze, freeze dry, combine dry ingredients.	90				3 (7)	1 (1)
Spinach bar, compressed	6.0 ± 0.5	Spinach	Blanch, freeze, freeze dry, spray with moisture to bring moisture up to 12%, compress, re-dry to 2% moisture.	150					1 (1)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]				Apollo-Soyuz
					Mercury	Gemini	Apollo	Skylab	
Rehydratable (cont'd)									
Strawberries	23.4 ± 0.4	Sugar 59, dehydrated strawberries 41.	Combine, form, freeze, freeze dry.	45				3 (9)	1 (3)
Intermediate Moisture									
Apricots	38 ± 2.0 62 ± 1.5	Blenheim variety dried apricots, less than 25% moisture No. 2 size (1-1/4 to 1-3/8 inch diameter) US Grade A.	Sulfite, sun dry.				7 (20)	3 (8)	1 (3)
Peaches	37 ± 2.0 62 ± 1.5	Freestone or Clingstone variety, US Grade A, moisture content 25 ± 5%.	Sulfite, sun dry.				7 (18)		1 (3)
Pears	33 ± 2.0	Bartlet variety, US Grade A, moisture content 25 ± 5%.	Sulfite, sun dry.				5 (14)		
Thermostabilized									
Applesauce	195 ± 4	US Fancy Grade A thermostabilized applesauce.	Can, heat process.					3 (5)	1 (2)
Cranberry sauce	229 ± 4	Grade A cranberries, cranberry pectin, corn syrup, sugar.	Can, heat process.						1 (3)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Thermostabilized (cont'd)									
Peaches	200 ± 4	Drained thermostabilized diced yellow cling peaches 60, syrup recovered from drained peaches 40.	Can, heat process.				4 (12)	3 (8)	
Pears	200 ± 4	Drained thermostabilized diced pears 60, syrup recovered from drained pears 40.	Can, heat process.					3 (9)	
Pineapple	200 ± 4	Grade A drained fruit cocktail 60, recovered syrup (25% corn syrup, 75% sucrose) 40.	Can, heat process.					3 (6)	1 (3)
Mixed fruit	200 ± 4	Drained fruit cocktail 60, recovered syrup (25% corn syrup, 75% sucrose) (Grade A) 40.	Can, heat process.				4 (12)		
Tomatoes, stewed	190 ± 3.8	Commercial stewed tomatoes (tomatoes, tomato juice, sugar, dextrose, salt, dried onions, dried celery, dried peppers, spice, calcium salt) 99, starch gel 1.	Can, heat process.					2 (6)	1 (2)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
BREAD AND CRACKERS									
Bite Size									
Cheese cracker cube	5.5 ± 0.5	Basic cheese flavored cracker cube mix 86, liquid dextrin 7, sorbitol 7. Coating: water 80, gelatin 7, glycerine, starch, sodium caseinate, liquid dextrin, hydroxypropyl cellulose, lecithin.	Mix, compress, apply gelatin-glycerine starch coating, freeze dry.				9 (24)		
Sandwich, beef	3.1 ± 0.5	Rye bread, beef, beef broth, water, shortening, gravy mix, gelatin. Coating: water 76, sodium caseinate 9, oil 9, glycerine, gelatin.	Prepare filling, make sandwiches, soak in gelatin coating, cut into bite size pieces, apply protein – fat coating, freeze, freeze dry.		1 (1)	8 (15)	7 (16)		
Sandwich, cheese	4.1 ± 0.5	Rye bread, dehydrated cheese, water, gelatin. Coating: water 76, sodium caseinate 9, oil 9, glycerine, gelatin.	Prepare filling, make sandwiches, soak in gelatin coating, cut into bite size pieces, apply protein – fat coating, freeze, freeze dry.		1 (1)	9 (18)	5 (12)		
Sandwich, chicken	2.8 ± 0.5	Rye bread, chicken, water, gravy mix, gelatin, shortening. Coating: water 76, sodium caseinate 9, oil 9, glycerine, gelatin.	Prepare filling, make sandwiches, soak in gelatin coating, cut into bite size pieces, apply protein – fat coating, freeze, freeze dry.		1 (1)	2 (4)	2 (3)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Bite Size									
Toast, cinnamon	2.1 ± 0.4	Enriched firm textured white bread, gelatin – cinnamon coating (water 74, sugar 16, gelatin, cinnamon).	Slice bread 3/8" thick, cut into bites, toast, soak in coating, freeze, freeze dry.			8 (16)	1 (1)		
Toast, plain	2.7 ± 0.4	Enriched firm textured white bread, fat – gelatin coating (high melting point fat, gelatin solution, salt, butter flavor).	Slice bread 3/8" thick, cut into bites, toast, soak in coating, freeze, freeze dry.			1 (2)			
Toasted bread cube, plain	5.9 ± 0.5	Toasted crumbs 60, shortening 17, dehydrated egg albumen 7, malt syrup 6, sucrose 5, sorbitol 5. Coating: water 80, gelatin 7, glycerine, starch, sodium caseinate, liquid dextrin, hydroxypropyl cellulose, lecithin.	Mix, compress, apply gelatin – glycerine – starch coating, freeze dry.			10 (20)	3 (8)		
Toasted bread cube, cinnamon flavored	5.9 ± 0.5	Toasted crumbs 58, shortening 16 sucrose 13, dehydrated egg albumen 8, sorbitol, flavoring. Coating: water 80, gelatin 7, glycerine, starch, sodium caseinate, liquid dextrin, hydroxypropyl cellulose, lecithin.	Mix, compress, apply gelatin – glycerine starch coating, freeze dry.				10 (24)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Natural Form									
Bread		(Proprietary formulas)					8 (24)		1 (3)
Cheese or	30 ± 1.0	Flour, water, cheese tang, liquid sugar, salt, yeast, vegetable shortening, powdered milk, verv, fermatrol, yellow color, dykon, potassium bromate, calcium iodate.	Commercial bread making process. After baking and packaging bread was frozen then irradiated (50,000 rads) while frozen, using cobalt 60 irradiator.						
Rye, seedless or	30 ± 1.0	Wheat flour, rye flour, shortening, milk solids, sugars, salt, safflower oil, yeast, eggs, dough improvers, mold improvers, mold inhibitors.	Commercial bread making process. After baking and packaging bread was frozen then irradiated (50,000 rads) while frozen, using cobalt 60 irradiator.						
White	30 ± 1.0	Wheat flour, shortening, milk product, sugars, salt, safflower oil, yeast, eggs, dough improvers, mold inhibitors.	Commercial bread making process. After baking and packaging bread was frozen then irradiated (50,000 rads) while frozen, using cobalt 60 irradiator.						
Breakfast roll	70	Cinnamon nut bun dough, flour, egg or egg product, yeast, butter, emulsifier, nonfat dry milk, salt, shortening, sugar. Topping and fillings: sugar, salt, shortening, butter, corn syrup, egg or egg product, flour, condensed milk, vanilla powder, almond extract.	Commercial baking process. After baking and packaging rolls were frozen and irradiated (50,000 rads).						1 (2)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Natural Form (cont'd)									
Crackers, biscuits (4 biscuits)	10.9 ± 0.2	Same as MIL–C–1324 Class 3 except hydrogenated soybean oil used instead of cottonseed or peanut oil.	Baked.					3 (9)	1 (3)
Crackers, cheddar cheese (12 crackers)	48 ± 0.75	White crackers 52, hydrogenated shortening 12, spray-dried cheese 10, malto dextrin 6, dehydrated egg albumen, water, cheese flavoring concentrated smoky cheddar cheese flavoring. Coating: water 80, gelatin 7, starch, sodium caseinate, liquid dextrin, hydroxypropyl cellulose, lecithin.	Crumb the crackers, mix crumbs with other ingredients, press into bite-size wafer, coat at 160° ± 5°F, freeze dry.						1 (3)
Thermostabilized									
Bread, white	60 ± 3.6	Enriched bread flour 50, water 25, shortening 10, sugar, salt, active dry yeast, lactic acid, potassium sorbate.	Combine yeast and water, add to bread flour, mix, ferment, punch down sponge, combine other ingredients and add to sponge, ferment, sheet dough, cut into disks, place two 35 gram disks in can, separated by a perforated fluorohalocarbon disk, crimp cans. Proof 30 minutes at 36°C (96°F), bake 30 minutes in 149°C (300°F) oven, cool, evacuate can to achieve internal pressure between 4.6 and 6.2 psia., seal can.					3 (9)	
Frozen									
Cake, coffee	64.0 ± 6.0	Dough 69, raisins 14, cinnamon-sugar filling 9, cinnamon topping 8.	Bake product, freeze.					3 (4)	

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Frozen (cont'd)									
Roll, prebuttered	53.0 ± 3.0	Roll: Flour 44, water 31, bread base (enriched bleached flour sugar, hydrogenated shortening with mono and diglycerides, and BHT, nonfat dry milk, salt, potato flour and yeast food) 15, sugar, shortening, whole egg, salt, compressed yeast. Butter: 10 ± 1.0 g butter applied to each roll.	Bake, slice in half, butter, freeze.					2 (3	
CEREALS									
Bite Size									
Apricot Cereal Cube	6.2 ± 0.5	Sugar coated cornflake 60, shortening 17, powdered apricots 11, dehydrated egg albumen 7, sorbitol 7. Coating: water 91, gelatin 9.	Mix, compress, apply gelatin coating, freeze dry.			6 (12)	6 (15)		
Orange (or lemon) flavored cereal bar	6.2 ± 0.5	Sugar coated cornflake 71, shortening 18, dehydrated egg albumen 7, water, orange (or lemon) flavoring. Coating: water 91, gelatin 9.	Mix, compress, apply gelatin coating, freeze dry.						
Strawberry cereal	6.2 ± 0.5	Sugar coated cornflakes 60, shortening 17, freeze-dried strawberries 11, dehydrated egg albumen 7, sorbitol. Coating: water 91, gelatin 9.	Mix, compress, apply gelatin coating, freeze dry.			8 (15)	3 (6)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for *Reconstitution* (ml)	Flights Using Food (Astronauts Selecting Food)[b]				Apollo-Soyuz
					Mercury	Gemini	Apollo	Skylab	
Rehydratable									
Bran flakes	43.5 ± 0.5	40% bran flakes (bran flakes with other parts of wheat, sugar, salt, malt flavoring with vitamin A, sodium ascorbate, ascorbic acid, thiamine (B_1), riboflavin (B_2), niacinamide, vitamin D, pyridoxine (B_6), folic acid, iron, BHA and BHT) 69, nonfat, dry milk solids 23, sugar 8.	Mix.	60					1 (1)
Corn flakes, sugar coated	36.8 ± 1.5	Sugar coated corn flakes (milled corn, sugar, salt, malt flavorings with vitamin A, sodium ascorbate, ascorbic acid (B_2), niacinamide, vitamin D, pyridoxine (B_6), folic acid, iron phosphate, BHA and BHT) 82, nonfat dry milk 18.	Mix.	60		4 (7)	11 (31)		
	40 ± 0.5	Sugar coated corn flakes 75, nonfat dry milk 25.	Mix.	60				3 (8)	
Granola	50	Granola (oatmeal 39, honey 20, sliced almonds 14, wheat germ 7, brown sugar 7, vegetable oil 6, sesame seeds 5, vanilla) 75, nonfat dry milk 25.	Heat oats at 177°C for 10 minutes, blend dry ingredients, add oil, honey, vanilla. Mix and heat at 177°C for 25 minutes, cool, mix with milk solids, package.	60					1 (2)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. *Portion Size* (Grams)	Ingredients *in Descending* Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable									
Grits, instant	33.7 ± 0.5	Degerminated white corn grits, salt, sodium carboxymethylcellulose, niacin, iron, BHA, thiamine, riboflavin.	Blend grits, salt, vegetable gum and cook, drum dry, add vitamins, iron, BHA and salt.	165			2 (4)		
Natural cereal (Heartland)	50 ± 0.5	Heartland Natural Cereal (rolled oats, brown sugar, defatted wheat germ, vegetable oil, corn syrup, salt, pure vanilla powder, lecithin) 75, nonfat dry milk 25.	Mix.	60					1 (1)
Spiced fruit cereal	35 ± 0.5	Spiced Apple Jacks (sugar, corn, wheat, oat flour, salt, dried apples, apple flavor, corn syrup, cinnamon, hydrogenated vegetable oil, sodium bicarbonate, oil of cassia, certified colors with vitamin A, sodium ascorbate, ascorbic acid, thiamine (B_1), riboflavin (B_2), niacinamide, vitamin D, pyridoxine (B_6), folic acid, iron phosphate, BHA and BHT) 75, nonfat dry milk solids 25.	Mix.	60			4 (11)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]				
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable									
Raisin spice cereal	56 ± 0.5	Raisin spice cereal (rolled oats, sugar, raisins coated with hydrogenated vegetable oil, natural spice flavorings, salt and vegetable gum) 91, dehydrated creaming agent 9.	Mix.	150			1 (3)		1 (1)
Rice Krispies	34 ± 6.5	Rice Krispies (rice, sugar, salt, malt flavoring, niacinamide, iron phosphate, riboflavin, sodium ascorbate, ascorbic acid, thiamine vitamin D, pyridoxine, folic acid, BHA and BHT) 60, nonfat dry milk 33, sugar 7.	Mix dry ingredients.	105				3 (6)	
Toasted oat cereal	24.0 ± 1.5	Oat cereal (oat flour, wheat starch, sugar, salt, calcium carbonate, sodium phosphate, sodium ascorbate artificial color, niacin, iron, gum acacia, vitamin A palmitate, pyridoxine, riboflavin, thiamine, vitamin D, vitamin B_{12} and BHT) 62, nonfat dry milk 35, sugar.	Mix dry ingredients.	90		4 (8)	2 (6)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Spreads									
Thermostabilized									
Cheese spread	42.5 ± 0.5	Cheddar cheese, butter and/or plastic cream, water, salt, coloring, emulsifiers, stabilizers.	Thermally processed.				5 (15)		
Jam – Fruit	28 ± 0.5	US Grade "A" fruit jam (blackberry)	Jam cooking.					3 (9)	
Peach	42.5 ± 0.5	(Strawberry, apple and peach flavors used on Apollo).					7 (19)		1 (3)
Strawberry	42.5 ± 0.5								1 (3)
Peanut butter	42.5 ± 0.5	US No. 1 shelled, roasted peanuts 91, dextrose 4, peanut oil 2, hydrogenated vegetable oil 2, (to each pound add: 40,000 I.U. Vitamin A, 10 mg thiamin, 500 mg ascorbic acid).	Ground to smooth peanut butter				5 (13)		1 (1)
	40 ± 0.8							3 (6)	
Condiments (Normal moisture, heat filled, flex pack)									
Catsup	17.0 ± 0.5	Tomato catsup Fed. Spec. JJJ-C-91F.	Commercial process, repack in pouch, pasteurize.				5 (15)	3 (5)	1 (1)
Mustard	7.0 ± 0.3	Commercial formula.	Repackage commercial item.				5 (15)		1 (3)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Desserts									
Bite Size									
Brownie cube	6.5 ± 0.5	Cake portion: sugar, pecans, shortening, whole eggs, flour, cocoa, vanilla, salt, leavening. Coating: water, shortening, sugar, sodium caseinate, glycerine, gelatin, cocoa, preservatives.	Mix, bake, crumb, compress, apply coating, dry to 7.5 - 9.0% moisture.		1 (1)	10 (20)	10 (24)		
Chocolate cube	6.0 ± 0.5	Chocolate, cocoa butter, sugar. Coating: zein, accetylated mono-, glycerides, citric acid, BHA, BHT.	Mix, plasticize, mold, apply coating.				2 (6)		
Coconut cube	7.5 ± 0.5	Nonfat milk solids, dessicated coconut, powdered sugar, vegetable fat, lecithin, coconut flavor. Coating: zein, acetylated monoglycerides, citric acid, BHA, BHT.	Mix, plasticize, mold, apply coating.			5 (10)	1 (3)		
Cookie cube, sugar	6.0 ± 0.5	Sugar cookie mix 85 (sugar 33, flour 33, eggs 10, shortening 10, margarine 10, cream, vanilla, salt, chemical leavening), egg albumen 7, water. Coating: water, gelatin.	Mix, compress, apply coating. freeze dry.				10 (27)		
Fruit cube, apricot	7.0 ± 0.5	Nonfat milk solids, powdered sugar, vegetable fat, freeze-dried apricots (14%), citric acid, lecithin. Coating: zein, acetylated monoglycerides, citric acid, BHA, BHT.	Mix, plasticize, mold, apply coating.		1 (1)	3 (6)			

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Bite Size (cont'd)									
Fruit cube, pineapple	6.8 ± 0.5	Nonfat milk solids, powdered sugar, vegetable fat, freeze-dried pineapple (20%), citric acid, lecithin. Coating: zein, acetylated monoglycerides, citric acid, BHA, BHT.	Mix, plasticize, mold, apply coating.		1 (1)	1 (2)			
Fruit cube, strawberry	7.0 ± 0.5	Nonfat milk solids, powdered sugar, vegetable fat, freeze-dried, strawberries (10%), citric acid, lecithin. Coating: zein, acetylated monoglycerides, citric acid, BHA, BHT.	Mix, plasticize, mold, apply coating.		1 (1)	3 (6)	3 (7)		
Fruitcake, date	13.2 ± 1.7	Dates 27, pecans 24, eggs 18, cherries 11, sugar 11, flour 8 vanilla, salt. Coating: water, *gelatin. Starch (rice or potato)* wafer.	Mix, bake, cut, apply coating apply starch wafer, freeze, freeze dry.		1 (1)	9 (18)	9 (20)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Bite Size (cont'd)									
Fruitcake, pineapple	12.5 ± 1.7	Pineapple 27, pecans 24, eggs 18, cherries 11, sugar 11, flour 8, vanilla, salt. Coating: water, gelatin. Starch wafer.	Mix, bake, cut apply coating, apply starch wafer, freeze, freeze dry.		1 (1)	9 (18)	8 (23)		
Gingerbread cube	7.0 ± 0.5	Cake portion: molasses, flour, water, shortening, sugar, eggs, cinnamon, salt, leavening, spices. Coating: water, shortening, sugar, sodium caseinate, glycerine, gelatin, dextrin, flavors, preservatives.	Mix, bake, crumb, compress, apply coating, dry to 7.5 to 9.0% moisture.			9 (18)	4 (8)		
Graham cracker cube	6.0 ± 0.5	Basic graham cracker cube mix 86, liquid dextrin 7, sorbitol 7. Coating: water 91, gelatin 9.	Mix, compress, apply coating, freeze dry.				6 (16)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Bite Size (cont'd)									
Ice cream cube, vanilla	5.0 ± 0.3	Water 61, sugar 15, coconut fat 12, nonfat milk solids 11, gelatin, emulsifier. Coating: water, gelatin.	Mix, heat, homogenize, freeze, freeze dry, grind, compress, apply coating.				1 (1)		
Peanut cube	8.4 ± 0.5	Chopped peanuts, nonfat milk solids, powdered sugar, vegetable fat, lecithin, vanilla flavor. Coating: zein, acetylated monoglycerides, citric acid, BHA, BHT.	Mix, plasticize, mold, coat with zein, acetylated monoglycerides and antioxidants.			5 (9)	2 (4)		
Rehydratable									
Pudding, apricot	70 ± 1.5	Instant vanilla pudding mix 48, powdered apricot 22, dehydrated creaming agent 22, pregelatinized starch 6, sugar.	Mix until blended.	180		8 (16)			
Pudding, banana	70 ± 1.5	Instant banana pudding mix 82, dehydrated creaming agent 12, pregelatinized starch 6.	Mix until blended.	180		5 (10)	6 (25)		
Pudding, butterscotch	70 ± 1.5	Instant butterscotch pudding mix 66, dehydrated creaming agent 31, pregelatinized starch.	Mix until blended.	120		8 (16)	11 (32)		
Pudding, chocolate	70 ± 1.5	Instant chocolate pudding mix 64, dehydrated creaming agent 31, pregelatinized starch 5.	Mix until blended.	120		9 (18)	11 (30)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Thermostabilized									
Cake, cherry nut	130 ± 5	Candied cherries 25, sugar 22, flour 17, nuts 15, shortening 8, whole eggs 8, water, baking powder, salt, oil of almonds.	Prepare cake batter, add cherries and nuts, pouch, heat process.						1 (2)
Cake, chocolate nut	130 ± 5	Sugar 23, flour 18, nuts 14, chocolate drops 14, shortening 10, eggs 10, water, corn syrup, salt, baking powder, vanilla.	Prepare cake batter, add nuts and chocolates, pouch, heat.						1 (2)
Fruitcake	85 ± 5	Sugar 19, raisins 16, pecans 14, candied cherries 10, candied pineapple 9, shortening 8, wheat flour 7, soy flour 7, whole eggs 7, water, baking powder, salt, spices. Fortified w/added vitamins and minerals.	Combine ingredients using creaming method of preparation, pouch, heat process.				1 (3)	1 (3)	
Pudding, butterscotch	144 ± 5	Water, sugar, concentrated skim milk, vegetable oil, modified food starch, salt, caramel, carrageenan, sodium stearoyl – 2 lactylate, disodium phosphate, artificial flavor and color, BHA, BHT.	Heat process with high-temperature, short-time equipment then aseptically can.				1 (2)	3 (9)	
Pudding, chocolate	135 ± 5	Water, sugar, hydrogenated vegetable oil, modified food starch, cocoa, nonfat milk solids, sodium caseinate, salt, carrogeenan, sodium stearoyl-2-lactylate, vegetable gum, artificial flavors, BHA, BHT.	Heat process with high-temperature short-time equipment then aseptically can.						1 (1)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]			
					Mercury	Gemini	Apollo	Skylab	Apollo Soyuz
Thermostabilized (cont'd)									
Pudding, lemon	152 ± 7	Water, sugar, modified food starch, vegetable oil, citric acid, carrageenan, sodium citrate, potassium citrate, salt, polysorbate 60, malic acid, concentrated lemon juice, natural flavor, artificial color, BHA, BHT.	Hot fill.				4 (9)	3 (7)	
Pudding, vanilla	142 ± 5	Water, sugar, concentrated skim milk, vegetable oil, modified food starch, salt, carrageenan, sodium stearoyl-2 lactylate, disodium phosphate, artificial flavor, artificial color, BHA, BHT.	Hot fill.				4 (11)		1 (2)
Baked (Natural Form)									
Brownies, chocolate coated	50 ± 5	Brownie 71, chocolate coating 29 (Brownie: sugar 26, flour 19, shortening 19, nuts 16, whole eggs 12, cocoa, dextrose, chemical leavening, flavoring. Coating: enriched sweet chocolate candy MIL–C–10928 fortified with vitamins).	Mix, bake, enrobe.						1 (2)
Cookie, butter	27.0 ± 0.5	Cake flour 45, salt-free butter 29, sugar 17, hydrolyzed cereal solids 7, vanilla 2.	Commercial baking process.					1 (2)	

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Baked (Natural Form) (cont'd)									
Cookie, Oatmeal chocolate coated	40 ± 5	Oatmeal cookie 60, chocolate coating 40. Cookie: sugar 34, oatmeal 30, shortening 17, water 10, flour 14, eggs, dextrose, soda, salt. Coating: enriched sweet chocolate candy (MIL-C-10928) fortified with vitamins.	Mix, bake, enrobe.						1 (1)
Cookie, pecan	61.7 ± .5	Enriched flour, corn flour, sugar, shortening, whole egg solids, pecans, leavening and artificial flavor.	Commercial baking process.						1 (1)
Cookie, shortbread	30.2 ± .5	Enriched flour, corn flour, sugar, shortening, egg products, whey solids, salt, leavening and artificial flavor.	Commercial baking process.						1 (1)
Cookie, vanilla wafer	23.1 ± 1.5	Flour, shortening (minimum A.O.M. 60 hrs.), sugar, corn flour, invert syrup, salt, leavening and artificial flavor and emulsifier.	Combine ingredients, bake.					3 (5)	
Graham crackers	59.2 ± 1.0	Enriched wheat flour, graham flour, rye flour, sugar, shortening, honey, salt, leavening and artificial flavor.							1 (1)

TABLE A-1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]			
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Frozen									
Ice cream vanilla	100 ± 2	Water 57, fresh sweet cream butter fat 14, cane sugar 14, milk solids, nonfat 9, corn syrup solids 6, stabilizers, antioxidants, vanilla flavoring.	Freeze.					3 (9)	
Beverages									
Rehydratable									
Citrus beverage	21.0 ± 0.5	Instant Replay – lime.	Commercial item.	150			3 (9)		
Cocoa	42 ± 1.5	Sugar 45, creaming agent 35, nonfat dry milk 10, cocoa powder 10, salt, ethyl vanillin.		150		8 (16)	11 (31)		
	54 ± 1.1			190				2 (5)	1 (3)
Coffee (black)	2.50	Freeze dried coffee.	Dry blend of three commercial products.	240			9 (18)	1 (1)	1 (1)
Coffee w/cream & sugar	12.5	Sugar 48, dry creaming agent 32, instant coffee 20.	Dry blend.	240			2 (2)		1 (1)
Coffee w/sugar	8.5	Sugar 71, instant coffee 29.	Dry blend.	240			2 (2)	2 (4)	

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Grape drink	21.0 ± 0.5	Sugar, tartaric acid, citric acid, cellulose gum, artificial flavor, ascorbic acid, gum arabic, artificial color, hydrogenated coconut oil, natural grape flavor, Vitamin A.	Dry Mix.	150			9 (24)		
	31.5 ± 0.4			240				3 (7)	1 (1)
Grapefruit juice crystals	21.0 ± 0.5	Freeze-dried grapefruit juice, corn syrup solids, sugar, citric acid, natural grapefruit flavor, calcium phosphate, cellulose gum, sodium citrate, ascorbic acid, sodium bisulfite.	Dry Mix.	150			1 (3)		
	27.6 ± 0.5			240					1 (3)
Grapefruit drink	21.0 ± 0.5	Sugar, citric acid, gum arabic, monosodium phosphate, natural grapefruit flavor, calcium phosphate, ascorbic acid, artificial flavor, cellulose gum, hydrogenated coconut oil, naringin Vitamin A, artificial color, BHA.	Dry Mix.	150		10 (20)	11 (27)		
	33.8 ± 0.4			240				3 (8)	1 (3)
Grape punch	21.0 ± 0.5	Sugar, citric acid, calcium phosphate, Vitamin C, gum arabic, artificial color, artificial grape flavor.	Dry Mix.	150			7 (19)		
Instant breakfast	55.8 ± 1.0	Chocolate flavored instant breakfast 62, nonfat dry milk 38.	Dry Mix.	240			2 (6)	3 (7)	

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b] Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Lemonade	21.3 ± 0.4	Sugar, citric acid, dehydrated lemon juice, corn syrup, dextrose, corn starch, salt, tricalcium phosphate, ascorbic acid, vegetable stabilizer, lemon oil, US Certified artificial color.	Dry mix.	150			1 (2)	3 (9)	1 (2)
Orange drink	21.0 ± 0.5	Sugar, citric acid, natural flavor, gum arabic, monosidium phosphate, potassium citrate, calcium phosphate, ascorbic acid, cellulose gum, hydrogenated coconut oil, artificial flavor, Vitamin A, BHA.	Dry mix.	150		9 (18)	11 (32)		
	31.5 ± 0.4			240				3 (9)	1 (2)
Orange grapefruit drink	21.0 ± 0.5	Sugar, citric acid, gum arabic, cellulose gum, natural orange and grapefruit flavors, carrageenan, sodium citrate, calcium phosphate, Vitamin C, hydrogenated vegetable oil, naringin, artificial flavor, Vitamin A, artificial color and BHA.	Dry mix.	150		9 (18)	11 (31)		
Orange juice	21.0 ± 0.5	Freeze-dried orange juice, corn syrup solids, sugar, citric acid, natural orange flavor, calcium phosphate, cellulose gum, sodium citrate, ascorbic acid, sodium bisulfite.	Dry mix.	150	1 (1)	1 (2)	6 (18)		
	27.6 ± 0.5			240					1 (3)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Rehydratable (cont'd)									
Orange – pineapple drink	21.0 ± 0.5	Sugar, citric acid, vegetable gums, natural flavors, hydrogenated vegetable oil, calcium phosphate, vitamin C, artificial flavors, vitamin A, artificial color, BHA.	Dry mix.	150			4 (10)		
	33.6 ± 0.5			240					1 (2)
Pineapple – grapefruit drink	21.0 ± 0.5	Sugar, citric acid, gum arabic, cellulose gum, sodium citrate, calcium phosphate, vitamin C, hydrogenated vegetable oil, artificial flavor, natural flavors, vitamin A, US certified color.	Dry mix.	150		4 (8)	10 (28)		
Strawberry drink	31.5 ± 0.4	Sugar, citric acid, potassium citrate, monosodium phosphate, artificial flavor, malic acid, ascorbic acid, tricalcium phosphate, gum arabic, artificial color, hydrogenated coconut oil, vitamin A.	Dry mix.	240				3 (5)	1 (3)
Tea	1.1 ± 0.5	Unflavored cold water soluble tea.	Commercial instant tea.	150			1 (3)		
Tea w/lemon & sugar	8.2 ± 1.5	Sugar 92, instant tea 6, lemon crystals.	Dry mix.	150		4 (8)			
	20.0 ± 0.5			240				3 (6)	1 (2)

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]				
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Confections, Nuts, Snacks									
Almonds	45 ± 0.5	US Fancy Grade almonds, salt.	Combine ingredients, dry roast.						1 (2)
Caramel sticks	40.8 ± 0.5	Corn syrup, sucrose, partially hydrogenated oil, sodium caseinate, caramel or chocolate flavors, water glycerine, starch, salt, vegetable monoglycerides, citric acid, artificial flavoring and artificial color.	Commercial heat processing, high speed mixing, extrusion, coating, tempering.				6 (16)		
Chocolate bar, sweet, enriched	28.4 ± 1.4	Sugar, added fat (45° ± 1°C m.p.), chocolate liquor (54% fat), nonfat milk solids, emulsifiers, salt, vanillin, Vitamins (A, C, B_1 and B_6).	Candy process.				6 (16)		
Food bar, apple	54.4	Dried apples, dried apple powder, sugar, corn syrup solids, citric acid, ascorbic acid, artificial color, vegetable gum.	Homogenize ingredients, spread in thin layers and dry to moisture content of 13% or less, laminate into layers until ¼" in height, cut into bars.				1 (3)		
Food bar, apricot	53.0	Dried apricots, dried apple powder sugar, corn syrup solids, citric acid, ascorbic acid, artificial color, vegetable gum.	Homogenize ingredients, spread in thin layers and dry to moisture content of 13% or less, laminate into layers until ¼" in height, cut into bars.				2 (6)		
Food bar, cherry	62.0	Grade A canned cherries, dried apple powder, sugar, corn syrup solids, citric acid, ascorbic acid artificial color, vegetable gum.	Homogenize ingredients, spread in thin layers and dry to moisture content of 13% or less, laminate into layers until ¼" in height, cut into bars.				2 (4)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Flights Using Food (Astronauts Selecting Food)[b]			
					Mercury	Gemini	Apollo	Skylab	Apollo-Soyuz
Confections, Nuts, Snacks (cont'd)									
Food bar, lemon	57.4	Dried apple powder, sugar, corn syrup solids, citric acid, ascorbic acid, artificial color, vegetable gum.	Homogenize ingredients, spread in thin layers and dry to moisture content of 13% or less, laminate, cut into bars.				1 (3)		
Hard candy (lemon drops)	61.8 ± 1.5	Sugar, corn syrup, citric acid, lemon oil, artificial color,	Candy process.					1 (1)	
Mints	37.1 ± 1.0	Cane sugar, natural mint, cream of tartar.	Candy process.					2 (2)	
Peanuts, dry, roasted	45 ± 0.5	Virginia-type peanuts, (US medium grade, aflatoxin negative) 2 + 1% moisture, cleaned, spices and salt added.	Dry roasted, sifted for crumbs.					3 (4)	1 (2)
Peanut butter flavored chocolate bar	42.5 ± 2.5	Proprietary formula (corn syrup solids, sucrose, vegetable oil, wheat gelatin, soy isolate, nonfat dry milk, white chocolate, peanut butter, Post Frosted Rice Krinkles, salt, artificial flavors and colors, emulsifiers and stabilizers, vitamin and mineral mix (sodium iron pyrophosphate, sodium ascorbate, vitamin A palmitate, niacin, riboflavin and thiamin)	Combine sugars, protein, nonfat milk, flavorings, salt and vitamin mix. Add liquified oil and emulsifier and mix. Add peanut butter and cereal and mix, sheet, cool, cut into 1" x 3" 24 gm bars. Prepare coating from chocolate, shortening and vitamin mix, coat bars.				2 (6)		
Pecans	15.8 ± 0.5	USDA Grade No. 1 pecans.	Wash in shell pecans in 60-65°C water then immerse 10-15 seconds in a 2000 ppm chlorine solution; crack, remove contents and package.				5 (15)		

TABLE A–1

FOODS AND FOOD SUPPLEMENTS INCLUDED ON US SPACE FLIGHT MENUS (cont'd)

Food Classification and Name	Unit Wt. Portion Size (Grams)	Ingredients in Descending Order (Percent)[a]	Processing Procedures	Water for Reconstitution (ml)	Mercury	Flights Using Food (Astronauts Selecting Food)[b] Gemini	Apollo	Skylab	Apollo-Soyuz
Confections, Nuts, Snacks (cont'd)									
Starch jelly candy	56.7 ± 2.8	Corn syrup solids, sugar, starch, mono and diglycerides.	Candy process.				6 (16)		
High Density Bars									
Chocolate chip bar		Cornflakes 26, powdered shortening 21, shortening 14, chocolate flavoring 12, powdered sugar 8, nonfat dry milk, chocolate chips, sodium caseinate, calcium caseinate, cocoa, water, corn sirup solids.	Mix, compress, coat.						
Chocolate	55.5							1 (3)	
Raspberry	53.5							1 (3)	
Vanilla	54.5							1 (3)	
Crispy bar		Rice Krispies 28, powdered shortening 23, shortening 15, chocolate flavoring 12, powdered sugar 9, nonfat dry milk, sodium caseinate, calcium caseinate, water, corn sirup solids.	Mix, compress, coat.						
Chocolate	54.5							1 (3)	
Raspberry	53.5							1 (3)	
Vanilla	54.5							1 (3)	
Flake bar		Cornflakes 28, powdered shortening 23, shortening 15, chocolate flavoring 12, powdered sugar 9, nonfat dry milk, sodium caseinate, calcium caseinate, water, corn sirup solids	Mix, compress, coat.						
Chocolate	54.5							1 (3)	
Raspberry	53.5							1 (3)	
Vanilla	54.5							1 (3)	
Survival bar	75.	Shortening 52, dessert powder 35, chocolate flavoring 7, sodium caseinate, sugar, water	Mix, compress, coat.					1 (3)	

Index of Space Foods (from Appendix)