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Development of Space Foods[1]

MARY V. KLICKA

Ration Design Specialist,
Food Division,
U.S. Army Natick Laboratories,
Natick, Massachusetts

THE FOOD AND Container Divisions of the U. S. Army Natick Laboratories have supported the National Aeronautics and Space Administration (NASA) by developing foods for the six manned Mercury space flights as well as for tests for future flights. Lt. Col. A. A. Taylor and his Air Force co-workers had demonstrated prior to the Mercury flights that man could eat and drink while in a weightless state (1). However, since these data were obtained during periods of less than 1 min. of weightlessness, extreme caution was exercised in the selection of foods for the first space diets.

Initially, the research and development effort for Project Mercury was limited to adaptation of foods developed for Air Force high altitude flights. These foods consisted of semi-solid (comminuted) sterile meat combinations and fruits. They had the consistency of junior baby foods but were seasoned at levels preferred by adults.

The foods were packaged in collapsible aluminum tooth-paste-type tubes with a non-toxic, food-grade organic inside coating. The food was fed into the mouth through a 3½-in. polystyrene "pontube" screwed onto the aluminum tube. The pontube cut open the sealed aluminum tube as it was attached.

Two meat items (beef and vegetables and beef and gravy) and two fruits (applesauce and peaches) were the most popular of the items submitted to the astronauts for evaluation. Consequently, these four items were made available to Astronauts Glenn, Carpenter, and Schirra.

Supplementing the semi-solid foods were special bite-size solid pieces. The first items supplied were compressed cocoa malted milk tablets and fruit flavored D-xylose tablets. Each round tablet was 1 in. in diameter, weighed about 5 gm., and supplied 20 calories. The tablets were packaged in a kraft paper tube with a tear-open string.

Also being developed at this time were a wide assortment of food items for a projected fourteen-day aerospace mission. Requirements were for a variety of acceptable and nutritious precooked dehydrated and bite-sized solid foods.

The food pieces were to be stable under the following conditions: refrigerated storage for six months; three-day storage at 50° to 80°F.; altitude pressure equivalent to 25,000 ft.; relative humidity, 30 to 50 per cent; atmosphere, 100 per cent oxygen.

Two types of bite-size pieces (a total of forty-one varieties) were developed with the cooperation of members of the food industry. One type consisted of coated dessert items, including baked cakes and cookies and combinations of fruits, nuts, and candies. An edible coating afforded protection from exchange of flavors, dehydration, bacterial spoilage, crumbling, and stickiness in handling.

In the second type, a variety of cereals, nuts, dry fruits, and cheese and/or bacon were incorporated into an edible stable food carrier. The carrier was composed chiefly of fat and nonfat milk solids with sugar added in some cases.

Astronaut Carpenter selected several of these items for testing. These softened and even melted during his flight. Therefore, the stability requirement was raised from 80°F. to 100°F. It was also decided to use a ¾-in. cube as a standard size to allow development of a standard dispenser.

Project Mercury

With NASA becoming more interested in the bite-size items being developed for the Air Force, changes were made to meet the more stringent Mercury requirements. These included tempering for 3 hr. at 110°F., followed by submission to a 1-second, 15-G force and a 240-second, 8-G force without benefit of protective packaging.

Preliminary plans for menus for longer Mercury flights began in summer 1962 when NASA requested test diets for 33- and 72-hr. flights. An additional requirement was the minimizing of the fecal residue from the foods.

Also, at this time, NASA expressed increased

[1]This paper describes the consolidated efforts of both the Food and Container Divisions of the U. S. Army Natick Laboratories in supporting the National Aeronautics and Space Administration. Presented at the 46th Annual Meeting of The American Dietetic Association in Philadelphia, on October 17, 1963.

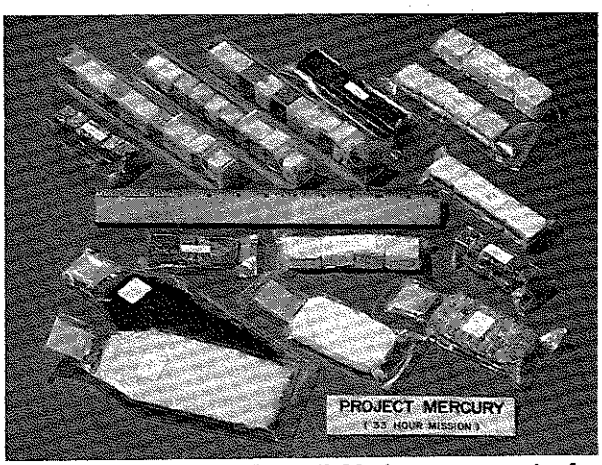

FIG. 1. *Bite-size foods available for astronauts' selection in Project Mercury. Top, left to right: cornflake cubes; three dispensers containing nine varieties of bite-size dessert-type cubes; fruit cake; beef sandwiches, and chicken sandwiches. At the end of the ruler: peanut butter sandwiches. Below the ruler: orange juice, grape juice, bacon squares, cheese sandwiches, chicken and gravy; and rice-cornflake cubes.*

interest in testing, during Mercury flights, precooked dehydrated foods requiring rehydration. A large variety of these foods were being developed at that time for the Gemini flights. It was believed that experience with such foods during the Mercury tests would contribute much to the later development of these foods. Therefore, four dehydrated products (two meats and two fruit juices) were included in the 33-hr. Mercury menu proposed for Astronaut Cooper's flight.

In addition, nine new varieties of bite-size pieces had been developed and accepted by NASA: compressed fried bacon squares; four bite-size freeze-dehydrated sandwiches (beef, peanut butter, cheese, and chicken); three fruit cubes; and specially formulated fresh fruit cake pieces. The fruit cubes were prepared by incorporating crushed, freeze-dehydrated fruits into a basic sweetened carrier.

Astronaut Cooper initially selected ten bite-size items from the first Mercury menu shown in Figure 1. Changes in his final selection were: substitution of an additional package each of beef and peanut butter sandwiches for the cheese and chicken sandwiches; substitution of two additional fruit cake packages for the cornflake and rice-cornflake cubes; reduction in the variety but not the number of dessert-type cubes.

This final menu provided 2394 calories of which 16 per cent were derived from protein; 41 per cent from fat; and 43 per cent from carbohydrate. However, Cooper actually consumed only about one-fourth of the calories furnished. He reportedly ate two pieces of fruit cake; ten bite-size dessert cubes (one dispenser); one bacon square; one peanut butter sandwich; and one-third package of pot roast.

Transparent packaging was required to enable

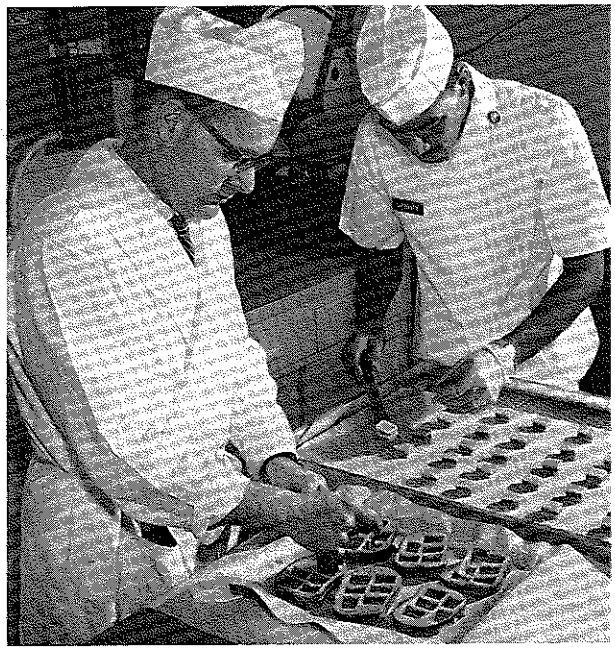

FIG. 2. *Cutting bite-size, gelatin-soaked sandwiches.*

the astronaut readily to identify the foods and to see the amount of water added to foods requiring reconstitution. NASA's requirement for transparency added to the difficulty of packaging, as the flexible packaging material which provides the best protection is a laminate which incorporates an aluminum foil. After much testing, a transparent film laminate was found which provided adequate heat sealability and the very low water vapor permeability needed to protect extremely hygroscopic foods against moisture pick-up and oxidation. It was found that considerable stress may be exerted on the package seals due to pressures applied while kneading items, such as puddings, during reconstitution and forcing the reconstituted food into the mouth. Therefore, for Mercury packages, the Container Division found it necessary to reinforce the reconstitution pouch to make certain it did not burst as the astronaut squeezed for the last few bites.

For the items to be reconstituted, a package was designed with an inclosed aseptic tube which extends to admit water and through which the food is fed directly into the mouth. For the sandwiches, bacon, and fruit cake, a pull-tab arrangement was provided for dispensing the product without breakage or crumbling. For the bite-size pieces, a dispenser was made of 1/16-in. Plexiglas with a pull-tab and closure-flap of polyethylene.

Prior to the actual flight, sets of the packaged foods were subjected to vibration tests ranging from 5 to 2000 cycles per second with force up to 10 G's, acceleration tests of 20 G's for 2 min., and 15 G's shock for 11 milliseconds. With these menus, work was concluded on foods for Project Mercury.

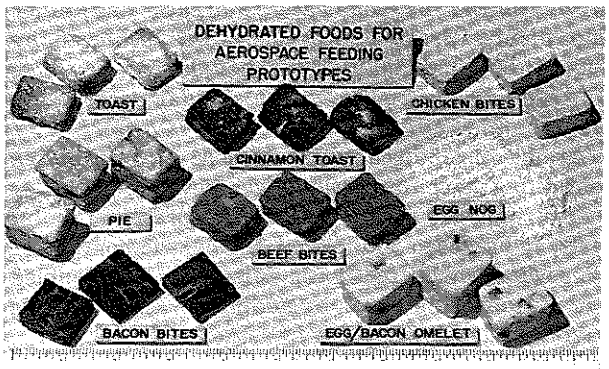

FIG. 3. *New products developed for Project Gemini.*

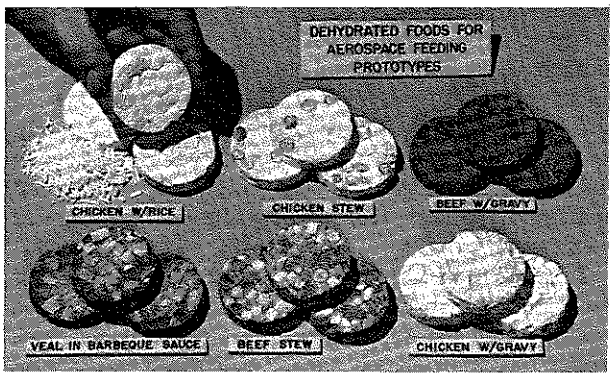

FIG. 4. *Six of the meat items selected for Gemini menus.*

Project Gemini

Initial planning of foods for Project Gemini began in early 1962 with food product development starting in December. The preliminary requirements were similar to those for Project Mercury, i.e., temperature of 110°F.; relative humidity 100 per cent; 15 G's shock without formation of crumbs, dust, or fragmentation. The types of foods under development are an extension of those described for the last Mercury flight. Increased emphasis has been placed on instant and precooked dehydrated foods to conserve food weight. Bite-size foods are used to increase menu variety and acceptability.

To minimize package requirements, maximum use is made of edible coatings which will protect against staling, moisture-vapor pick-up, and oxidation. These coatings also prevent fracturing, crumbling, or dusting of the product.

Because of the variety of bite-size products being developed, no one coating has been found suitable for all products. In many cases, it has been necessary to use a combination of coatings during various stages of processing. For example, with freeze-dehydrated sandwiches, soaking in gelatin before freeze-drying prevents crumbling. Figure 2 shows gelatin-soaked sandwiches being cut into bite-size units. However, the dried product is coated on the edges with a high-melting point, acetylated monoglyceride for additional "shock" protection.

There are four types of sandwiches: cheese, peanut butter, beef, and chicken. All but the peanut butter are made with rye bread, which studies have indicated is more stable than white bread. However, the opposite is true for the peanut butter sandwiches.

The higher-moisture cake products require a coating that will not only protect against crumbling and stickiness, but will also preserve freshness. Special product formulation, aseptic handling techniques, and vacuum packaging are also utilized to prevent product deterioration.

The fruit cake pieces were enrobed in gelatin, and edible starch wafers were applied to the top and bottom of the pieces to provide protection against stickiness.

Figure 3 shows a number of the newer products developed for testing for Project Gemini. All except the bacon squares are freeze-dehydrated. Only the egg nog requires reconstitution. The egg nog and pie are not in the current Gemini menu.

The fat content of the toast was raised to approximately 25 per cent by weight by using a double gelatin coating, the first containing a considerable amount of shortening. Since butter would not meet the temperature stability requirement, it is hoped to add a stable butter flavor to shortening in later products. Gelatin is used as a binder for the beef, chicken, and omelet.

The apparent simplicity of the products as they appear in the illustration is deceptive. There were problems peculiar to each product during development.

Another group of bite-size foods were formed by compression: three cereal-fruit combinations, Melba toast, and potato chip block.

Seven dehydrated meat combinations developed earlier for the Air Force program were selected for the Gemini menus. These products were originally designed for reconstitution in 5 to 15 min. with 165°F. water without agitation. For Gemini, they were reformulated for reconstitution in 80°F. water. These meat products were described by Jokay of our staff at the 1963 meeting of the Institute of Food Technologists (2). The meat items selected for Gemini include the chicken stew, beef with gravy, beef stew, and chicken with gravy shown in Figure 4, plus bacon with sauce, noodles with meat sauce, and beef pot roast. Other foods which have been developed, but not yet put on space project menus include: scrambled eggs, meat balls with gravy, fish creole, diced potatoes in gravy, cream-style corn, orange juice, and fruit cocktail.

Because meat and gravy, stews, and spaghetti mixtures have limited palatability served at room temperature, efforts were made to develop a variety of menu entrées normally consumed cold. Interestingly, we found that the use of mayonnaise in fish, meat, and vegetable salads did not alter reconstitution properties, but in fact actually improved the

consistency, flavor, and texture of the reconstituted product. Five salad-type items were developed: salmon, tuna, chicken, and potato salads, and shrimp cocktail. Freeze-dehydrated, these products all reconstitute almost instantly with the addition of tap water. To assure products which could not cause flatulence, ingredients such as onions were used sparingly. All five items were selected for Gemini menus.

In accord with the requirement for minimizing fecal residue, fruit and vegetable components have been limited to: applesauce, fruit cocktail, peaches, green beans in cream sauce, and diced carrots in cream sauce. All except the applesauce are freeze-dried; that product is air dehydrated. Calcium cyclamate is substituted for some of the sugar in the fruit products to assure the desired level of sweetness without sacrificing cube density in the dehydrated product. The sauce used with the vegetables serves as a binder and ameliorates rehydration.

For Gemini, the freeze-dried foods requiring reconstitution, with the exception of the pork sausage patty, were made in rectangles of 3¾ by 2 by 9/16 in. One and a half of these blocks are packaged to make one serving. Most servings require 3 oz. water for reconstitution. Two pork sausage patties make one serving.

SOUPS, PUDDINGS, AND BEVERAGES

To meet volume and weight limitations, product density in cube and calories is extremely important. Problems in this respect arose in developing soups, puddings, and beverages. None of the large number of commercial products available met the requirements. Except for low-calorie broths, the dehydrated soups available required cooking or water temperatures in excess of 80°F. to provide optimal flavor development, consistency, and reconstitution. Freeze-dehydration did not provide the answer. While the process improved flavor and rehydration, it did not improve the caloric density and also resulted in decreasing the product bulk density.

As an expediency, six commercially available soups and six puddings were modified by adding pregelatinized or cold-water starches and other ingredients. Great improvement was achieved by adding a commercial high-fat, non-dairy-type coffee whitener. It also improved the standard cocoa beverage powder.

At the specific request of NASA, an instant tea containing lemon and sugar was developed.

Although not resorted to in the present Gemini diets, it has been found that the caloric content of all seven dehydrated fruit juices can be doubled without affecting flavor by adding corn sirup solids having a very low level of sweetness.

MENU DEVELOPMENT

In the early planning stages, it was decided to develop a four-day menu cycle of four meals a day, with every effort made to include maximum variety of foods. These menus will be used for test purposes, including the initial flight qualification test. They will be modified, based on the test results, to assure optimal suitability for actual flights and to meet the individual astronaut's preferences.

Every effort has been made to include as many familiar foods as possible consistent with stability and other requirements. Twenty-three bite-size foods and thirty-seven dehydrated foods are included in the present menus. The bite-size components furnish 36 per cent of the food weight and 38 per cent of the calories. The average menu will provide 2500 calories per man per day. Of these, 16 per cent are derived from protein, 32 per cent from fat, and 52 per cent from carbohydrate. An average of 45 oz. (1330 ml.) water is required to reconstitute each day's menu. Products requiring reconstitution are limited to three per meal.

References

(1) TAYLOR, A. A., FINKELSTEIN, B., AND HAYES, R. E.: Food for Space Travel. ARDA Tech. Rept. No. 60-8, July 1960.

(2) JOKAY, L., AND HOLLENDER, H. A.: Development of dehydrated foods for aerospace feeding. Presented at the annual meeting of Inst. of Food Technologists, Detroit, May 1963.