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Space Food

Many people ask NASA what and how the astronauts eat aboard the space shuttle and the International Space Station. The foods they eat are not provided in tubes and they are neither bland nor unsavory. Food systems and menu items have evolved tremendously since the days of Project Mercury. Here's a look at how food systems and menu items have evolved, what and how astronauts in space eat now and what future voyagers may eat.

History

The food that NASA's early astronauts had to eat in space is a testament to their fortitude. John Glenn, America's first man to eat anything in the near-weightless environment of Earth orbit, found the task of eating fairly easy, but found the menu to be limited. Other Mercury astronauts had to endure bite-sized cubes, freeze-dried powders and semi-liquids packaged in aluminum tubes. Most agreed the foods were unappetizing and disliked squeezing the tubes. Moreover, freeze-dried foods were hard to rehydrate and crumbs had to be prevented from fouling instruments.

Eating on the Gemini missions improved somewhat. Bite-sized cubes were coated with gelatin to reduce crumbling, and the freeze-dried foods were encased in a special plastic container to make reconstituting easier. With improved packaging came improved food quality and menus. Gemini astronauts had such food choices as shrimp cocktail, chicken and vegetables, butterscotch pudding, and applesauce. Astronauts were able to select meal combinations themselves.

By the time of the Apollo Program, the quality and variety of food increased even further. Apollo astronauts were the first to have hot water, which made rehydrating foods easier and improved the food's taste. These astronauts were also the first to use utensils via the "spoon bowl," a plastic container that could be opened and its contents eaten with a spoon. Thermostabilized pouches were also introduced on Apollo.

The task of eating in space got a big boost in Skylab. Unlike previous space vehicles for astronauts, Skylab featured a large interior area where space was available for a dining room and table. Eating for Skylab's three-member teams was a fairly normal operation: Footholds allowed them to situate themselves around the table and "sit" to eat. Added to the conventional knife, fork and spoon was a pair of scissors for cutting open plastic seals. Because Skylab was relatively large and had ample storage area, it could feature an extensive menu: 72 different food items. It also had a food freezer and refrigerator - a convenience offered by no other vehicle before or since.

Space Shuttle Food System

The kinds of foods crewmembers eat aboard the space shuttle are not mysterious concoctions, but foods prepared here on Earth. Many are commercially available on grocery store shelves. Astronauts select their menus from a large array of food items. Diets are designed to supply each astronaut with 100 percent of the daily value of vitamins and minerals necessary for the environment of space.

Foods flown on space missions are researched and developed at the Space Food Systems Laboratory at Johnson Space Center in Houston, which is staffed by food scientists, dietitians and engineers. Foods are

analyzed through nutritional analysis, sensory evaluation, storage studies, packaging evaluations and many other methods.

Food evaluations are conducted with shuttle flight crews about eight to nine months before the scheduled launch date. During the food evaluation sessions, the astronaut samples a variety of foods and beverages available for flight. Crewmembers choose their menus and can repeat days at their discretion. They plan a breakfast, lunch and dinner; snacks are listed with the meals. Types of food available include rehydratable, thermostabilized, irradiated and natural form items.

Rehydratable items include both foods and beverages. One way weight can be conserved during launch is to remove water from certain food items. During the flight, water generated by the shuttle fuel cells is added back to the food just before it is eaten.

Foods packaged in rehydratable containers include soups such as chicken consommé and cream of mushroom, casseroles such as macaroni and cheese and chicken and rice, appetizers such as shrimp cocktail, and breakfast foods such as scrambled eggs and cereals. Breakfast cereals are prepared by packaging the cereal in hydratable packages with nonfat dry milk and sugar, if needed. Water is added to the package just before the cereal is eaten.

The rehydratable food package is made from flexible material to aid in trash compression. It consists of a flexible bowl and lid with a septum adapter for adding water from the galley. Velcro on the bottom of the package holds it in the meal tray. After adding the required amount of water to the package, it is placed in the oven if the food is to be served hot or directly onto the serving tray if the food is to be served cold. The top of the package is cut off with a knife or scissors, and the contents are eaten with a fork or spoon.

Thermostabilized foods are heat processed to destroy harmful microorganisms and enzymes. Individual servings of thermostabilized foods are commercially available in aluminum or bimetallic cans, plastic cups or flexible retort pouches. Most of the fruits and fish, such as tuna and salmon, are thermostabilized in cans. The cans open with easy-open, full-panel pullout lids. Puddings are packaged in plastic cups. Most of the entrees are packaged in flexible retort pouches. This includes products such as beef tips with mushrooms, tomatoes and eggplant, chicken àla king, and ham. After the pouches are heated, they are cut open with scissors. The food is eaten directly from the containers with conventional eating utensils.

Some irradiated meat items are also available for space shuttle crews. These products are very similar to thermostabilized foods in that they are ready to eat and only require warming prior to consumption. These items are packaged in flexible pouches.

Foods such as nuts, granola bars and cookies are classified as natural form foods. They are ready to eat, packaged in clear, flexible pouches that are cut open with scissors, and require no further preparation for consumption in flight.

Condiments include commercially packaged individual pouches of catsup, mustard, mayonnaise, taco sauce and hot pepper sauce. Polyethylene dropper bottles contain bulk supplies of liquid pepper and liquid salt. The pepper is suspended in oil and the salt is dissolved in water.

Flour tortillas are a favorite bread item of shuttle astronauts. Tortillas provide an easy and acceptable solution to the breadcrumb and microgravity-handling problem and have been used since 1985.

Beverages come in powdered form and include coffee, tea, apple cider, orange juice and lemonade. The beverage package is made from a foil laminate to provide maximum barrier properties for a longer product shelf life. A septum adapter is sealed in the package after the beverage powder has been added. The septum adapter holds a septum that interfaces with the galley water dispenser for the addition of water and with a straw for drinking the beverage.

Foods are individually packaged and stowed for easy handling in microgravity. All food is precooked or processed so it requires no refrigeration and is either ready to eat or can be prepared simply by adding water or by heating. The only exceptions are the fresh fruit and vegetables. Without refrigeration, the fresh foods must be eaten within the first few days of the flight or they will spoil.

Once astronauts select their menu about five months before flight, the menus are analyzed for nutritional content and recommendations are made to correct any nutrient deficiencies. The menus are then finalized and provided to the shuttle food contractor in Houston three months before launch. Food is packaged and stowed in the locker trays at JSC about a month before each launch. Stowed food lockers and shipping containers are kept under refrigeration.

About three weeks before launch, the food lockers are shipped to Kennedy Space Center in Florida. There they are refrigerated until they are installed in the shuttle two to three days before launch. Besides the meal and pantry food lockers, a fresh food locker is packed at KSC and installed on the shuttle 24 to 36 hours before launch. The fresh food locker contains items such as tortillas, bread, breakfast rolls, and fruits and vegetables such as apples, bananas, oranges, and carrot and celery sticks.

Meals are stowed aboard the orbiter in locker trays with food packages arranged in the order in which they will be used. A label on the front of the locker tray lists the locker contents. A five-section net restraint keeps food packages from floating out of the locker while keeping visible the items inside.

Astronauts are supplied with three balanced meals plus snacks. Each astronaut's food is stored aboard the space shuttle and is identified by a colored dot affixed to each package. A supplementary food supply pantry consisting of two extra days per person is stowed aboard the space shuttle for each flight. Additional pantry items are flown in case the flight is unexpectedly extended because of bad weather at the landing site or for some other unforeseen reason. During the flight, this food supply provides extra beverages and snacks.

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Dining Aboard the Space Shuttle

Meals in space consist of familiar, appetizing, well-accepted food items that can be prepared quickly and easily. A full meal for a crew of four can be set up in about five minutes.

Reconstituting and heating the food takes an additional 20 to 30 minutes – about the time it takes to fix a snack at home and far less than it takes to cook a complete meal.

On the space shuttle, food is prepared at a galley installed on the orbiter's middeck. The galley is a modular unit that contains a water dispenser and an oven. The water dispenser is used for rehydrating foods and beverages, and the galley oven is used for warming foods to the proper serving temperature.

During a typical meal in space, a meal tray is used to hold the food containers. The tray can be attached to an astronaut's lap by a strap or attached to a wall. The meal tray becomes the astronaut's dinner plate and enables the astronaut to choose from several foods at once, just like a meal at home. Without the tray, the contents of one container must be completely consumed before opening another. The tray also holds the food packages in place and keeps them from floating away.

Following the meal, food containers are discarded in the trash compartment below the middeck floor. Eating utensils and food trays are cleaned with premoistened sanitizing towelettes.

International Space Station Food System

For shuttle flights, the menu planning process starts eight to nine months before the scheduled launch. For space station expeditions, menu planning is not based on when the crew is scheduled to launch, but rather on when the food for that crew is scheduled to launch. Thus, when a crew arrives on board the station, a good portion of its food is already there.

Space station crewmembers have a menu cycle of eight days, meaning the menu repeats every eight days. This cycle may be increased to add further variety to the menus. Half of the food system is U.S. and half is Russian; plans are to include foods of other space station partner countries in the future, including Japan and Canada. The packaging system for the daily menu food is based on single-service, disposable containers. Single-service containers eliminate the need for a dishwasher.

Since the electrical power for the space station is generated from solar panels rather than from fuel cells (as on the shuttle), there is no extra water generated on board the station. Water is recycled from cabin air, but not enough for significant use in the food system. Hence, the percentage of rehydratable foods will decrease and the percentage of the thermostabilized foods will increase over time. However, in general, the space station food system is similar to the shuttle food system using the same types of food – thermostabilized, rehydratable, natural form and irradiated – and the same packaging methods and materials.

As on the shuttle, beverages on the space station are in powdered form. The water temperature is different on the station; unlike the shuttle, there is no chilled water. Station crewmembers have only ambient warm and hot water available to them.

All space station increment crewmembers taste or sample every U.S. food item and rate them based upon how well they like them. Then, while training in Russia, they repeat the procedure for the Russian food items. U.S. and Russian dietitians use those ratings to plan menus for each Expedition crew.

Once the menu is compiled, the crews attend a training session in Russia to try the actual menu. The crew makes its final changes, and the menu is finalized before it is packaged.

The U.S. half of the menu is prepared in Houston and shipped to Florida or Russia, depending upon where it is going to be launched. The Russians prepare their half of the menu and launch it on the Progress vehicle. Most of the food is stored in the Zarya and Node 2 modules in Russian food boxes. Fresh items are delivered to station crews when either a shuttle or a Progress docks.

Space station crewmembers usually eat breakfast and dinner together. The food preparation area in the Russian Zvezda service module is used to prepare meals.

It has a fold-down table designed to accommodate three crewmembers. Built into that table are food warmers to heat Russian cans and packages. Since the U.S. foods will not fit into the slots in the table, a suitcase-like food warmer is used. Adapters were made to fit into the Russian rehydration station to allow crewmembers to rehydrate U.S. foods. Used packaging is bagged and placed in a Progress vehicle, which is eventually jettisoned and burns up upon entry into the Earth's atmosphere.

Nutrition and Human Spaceflight

Food provides the nutrients that human beings need to maintain their health. Getting enough calories, vitamins and minerals is as important for astronauts as it is for people living on Earth. The space food systems supply a more limited variety of items than one would find in the grocery store here on Earth, so menu planning is very important to make sure the astronauts can get the nutrients they need from their food.

The nutrients astronauts need in space are the same ones all people need, but the amounts of some differ. Astronauts need the same number of calories for energy during spaceflight as they need on the ground. Most of the vitamins and minerals they need are the same as on the ground.

The amount of iron in an astronaut's diet should be less than 10 milligrams per day for both men and women. Astronauts have fewer red blood cells while they are in space. Most of the iron absorbed from food goes into new red blood cells. If astronauts were to eat foods high in iron, the iron would be stored in their bodies and could cause health problems.

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Sodium and vitamin D affect bone density. The amount of sodium in the astronauts' diet is limited because too much can lead to bone loss as well as other health problems. The body usually makes vitamin D when the skin is exposed to sunlight, but spacecraft are shielded to protect the astronauts from harmful radiation. On Earth and in microgravity, people need vitamin D for healthy bones. Vitamin D supplements are recommended for space travelers on the space station since the current space foods do not provide enough of this vitamin.

As the body adapts to weightlessness, many physiological changes occur. Many of these can affect nutrition or be affected by it. The changes include loss of bone and muscle, changes in heart and blood vessel function, and changes in blood and the amount of fluid in different areas of the body. While consuming enough nutrients may not stop these changes, consuming too few nutrients may make the situation worse. Astronauts usually lose weight during spaceflight. Being sure they eat enough calories is important because if they eat enough calories, they will also eat enough of most other nutrients, including vitamins and minerals.

For space station crewmembers, it is important that they begin their mission in excellent health, maintain that state of health as much as possible, then get back to it as quickly as possible after the mission. Space station crewmembers have their nutritional status checked before, during and after flight to help reach this goal. Before and after flight, blood and urine samples from crewmembers are analyzed for chemicals that indicate nutritional status (bone health, vitamins, minerals, etc.). During the mission, crewmembers fill out a computerized food frequency questionnaire to report what foods they have eaten during the previous week. The computer results are sent electronically to the ground, and nutrition specialists analyze the data right away so they can recommend ways to improve the astronauts' dietary intake.

Throughout history, nutrition has played a critical role in exploration, and space exploration is no exception. As mission lengths increase from weeks on the shuttle to several months on the space station, and perhaps to years on a mission to another planet, nutrition becomes even more important.

Advanced Food for Potential Future Use

Two different food systems will be used for future long-duration missions to other planets, one for traveling to and from the distant body and one for use on the surface of the moon or Mars.

The transit food system will be similar to the space station food system with the exception that products with three-to five-year shelf lives will be needed, especially for a mission to Mars. Thus, this part of the trip will be similar to what occurs aboard space missions now – eating out of food packages and heating food items in a similar fashion.

The surface food system, be it lunar or planetary, will be quite different. It will be similar to a vegetarian diet that someone could cook on Earth – minus the dairy products. Once crewmembers arrive on the surface and establish living quarters, they can start growing crops. Possible crops that could be grown and harvested include potatoes (sweet and white), soybeans, wheat, peanuts, dried beans, lettuce, spinach, tomatoes, herbs, carrots, radishes, cabbage and rice. Once the crops are processed into edible ingredients, cooking will be done in the spacecraft's galley to make the food items.

Disposal of used food packaging will be an issue since there will be no Progress vehicles to send off and incinerate into the Earth's atmosphere. Packaging materials will be used that have less mass but sufficient barrier properties for oxygen and water to maintain shelf life as those now in use.

Web Sites

For more information on space food and nutrition, visit:

http://www.spaceflight.nasa.gov/living/spacefood/index.html
http://advlifesupport.jsc.nasa.gov
http://jsc-web-pub.jsc.nasa.gov/hefo/hhfo/aft
http://haco.jsc.nasa.gov/biomedical/nutrition

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