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Space Foods: Technological Developments and Challenges

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Space food is a range of food products, especially created and processed for the utilization of the space explorers. The food must necessarily provide balanced nutrition for astronauts working in space, but at the same time it is important that it must be very convenient to store and prepare in the zero-gravity environment. Since the space missions are of a very long duration, the food to be consumed needs to be processed and packaged in such a manner that it does not spoil in due course of time. Therefore, various methods of processing and packaging the food, in order to make it fit for consumption in the weightless environment have been developed and scientifically tested by the leading organizations of the world.

History & Various Space Projects

First Space Foods

Onboard on Friendship 7 mission in 1962, John Glenn was the first American astronaut to eat food on board. At that time, it was not yet known whether humans can consume and digest food in space. The scientists were not sure about how would the body enzymes and nutrients react to a zero-gravity atmosphere.

Glenn's first consumption was that of the applesauce and xylose sugar tablets with water, which thus was a historic meal in itself; it confirmed that humans could eat, swallow and digest food in space.

1. **Project Mercury (1959-63)**

In the early days of the space program, known as Project Mercury, space flights lasted from a few minutes to a full day. Because of the short duration, complete meals were not needed.
The major meal was consumed prior to the flight. These first astronauts found themselves eating bite-sized cubes, freeze-dried foods, and semi-liquids in aluminum toothpaste-type tubes.
The food was unappetizing, and there were problems when they tried to rehydrate the freeze-dried foods.

2. **Gemini Mission (1965 - 66)**

When the Gemini mission was launched by that time the food quality had become appetizing for the Space crew. The astronauts at that time were able to choose from a large variety of different food groups available to them be it sea food, turkey cubes, various vegetable and chicken soups or any dessert.

Packaging and Consumption: It is because of freeze drying that the food is able to sustain for a longer period of time without any changes in its flavour. In order to rehydrate that food astronauts simply used a water gun which is used to rehydrate the freeze-dried food when water as per instructions is injected into it. Water is added to the rehydratable food bowls and drink pouches through a small hole called a **septum adapter**.

3. Apollo Mission (1968 - 75)

When the Apollo program began (Moon Mission) it was for the first time that hot water was made available to the astronauts who made rehydrating the food products easier.

Packaging and Consumption: In this mission utensils were used for the first time and the explorers did not have to squeeze the food directly into their mouth now. This introduced a spoon and a bowl in space and a plastic container to carry dehydrated food.

After injecting water into the bowl, they open the seal and consumed it with spoons. It was because of the wet food that it got stuck to the spoons and did not float away.

4. **Skylab Mission (1973 -74)**

In 1973, a huge transition in space food led to the development of the **Skylab** that had many similar comforts of a domestic kitchen. A large dining room with a proper table and chair sitting was provided for the crew to sit down and eat. This even had a refrigeration facility (which the modern space shuttles don't have) and it allowed storing of almost 72 different varieties of food. It even had the facility to reheat the food using a food warmer tray.

In 1980, the modern space shuttle was launched in which there were all facilities just like those of a domestic and the food had almost become similar to what we eat on earth. The crew had a large variety of food to select from that included 74 different foods and 20 drinks. The food preparation was done in a galley with water dispenser and a forced air convection oven.

Production of Space Food

The space food is generally divided into following groups:

1. Freeze Dried or Rehydratable Foods

Foods that have been dehydrated by various technologies (such as drying with heat, osmotic drying, and freeze drying) and allowed to rehydrate in hot water prior to consumption. Reducing the water content reduces the ability of microorganisms to thrive.

Moisture is removed from the food during packaging food materials like Soups, casseroles, scrambled eggs and breakfast cereals are packaged in this manner. As the time passed technology grew more advanced and by the time Gemini mission (1965) was launched the food became tastier.

2. Intermediate Moisture Foods

These are those types of foods in which some moisture is removed and the rest is not. Foods like dried peaches, pears and apricots are examples of intermediate moisture foods.

(IMF) is regarded as one of the oldest foods preserving method tested by man. In this method the mixing of various ingredients to attain a given A_w that allows a safe storage for a long time but at the same time it maintains the eating quality of the food, but this work was only done on an empirical basis.

3. Thermo Stabilized Foods

These foods are processed by heat at high temperature to destroy bacteria and other microorganisms so they can be stored at ambient growth temperature.

Foods like fruits, pudding and tuna fish are preserved in this. Dehydrated foods are the most well-known space food groups thermo stabilized foods rank second in the preference, these are heated to destroy harmful bacteria and enzymes that cause food spoilage, the biggest advantage of these food is that they don't use any of the water available on the shuttle which is in a limited quantity. These foods are fast, easy and less time consuming to cook because they only need to be warmed (re heated) before eating.

4. Irradiated Foods

Like thermo stabilized foods, these foods have been preserved by killing harmful bacteria and organisms. They come in come in flexible pouches having food that is ready to eat. The only difference is the process that is used to sterilize the food. Irradiated food is exposed to ionizing radiation from gamma rays or electron beams for a specific length of time determined by the type and content of food.

Irradiated food can include any food group from fruits and vegetables to meat. Despite the use of radiation, these foods do not raise the risk of cancer for those eating it. The World Health Organization and American Medical Association have labeled them as fit to be consumed.

5. Natural Form Foods

Nuts, Granola bars and cookies are examples of food with a naturally long shelf-life. They are simply packaged in ready-to-eat pouches.

6. Fresh Foods

These are the foods available for space flight for some initial days of the mission. Fruits and vegetables that are sanitized by chlorine are packaged in a simple plastic bag to preserve their freshness are loaded in the shuttle. But since there is no refrigeration onboard in the shuttle, these foods must be consumed within the first two to three days of the mission to prevent them from spoilage.

7. Condiments

All condiments are served in liquid form, like salt and pepper. In order to make it easy for astronauts to handle it while pouring, the salt is dissolved in water as brine and the oil suspension of pepper is used.

Procedure of Space Eating

During any meal, the food packets are taken out and some basic processing like heating, reconstitution etc. is done. The food packets are attached to food tray with the help of magnets or springs. The tray is attached to astronaut's lap by straps.

Contents of one container must be completely consumed before opening the another one. The cutlery (knife, spoon, fork and scissors) is attached to magnetic sheets so as to keep them in place. The food packets are discarded after the meal and the trays are cleaned in hygiene station.

Nutrition

Astronauts eat three meals a day: breakfast, lunch and dinner. Nutritionists ensure the food astronauts eat provides them with a balanced supply of vitamins and minerals. Calorie requirements differ for astronauts. For instance, a small woman would require only about 1,900 calories a day, while a large man would require about 3,200 calories.The foods having extremely high moisture content of ninety nine percent were reduced by moisture content to make them light weight thus the average content of proteins was 17 percent, 32 percent of fats and 51 percent of carbohydrates.

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Astronaut Menu Selection

Astronauts select their menu approximately five months before flight. The menus are analyzed for nutritional content by the Shuttle Dietician and recommendations are made to correct any nutrient deficiencies based on the Recommended Dietary Allowances.

The menus are then finalized and provided to the Flight Equipment Processing Contractor (FEPC) in Houston three months before launch. The FEPC processes, packages, and stows the food in the Shuttle lockers before being transferred to KSC(Kennedy Space Center, Florida). Included in the packet is a standard menu the astronaut has chosen, and the baseline shuttle food and beverage list.

Emergency Space Foods

These foods are consumed when the space flight time is delayed or in case of any on board failure. They are of two types- Safe haven foods and EVA (Extra Vehicular Activity) foods.

EVA food consists of food and drink for 8 hours (500 calories of food, and 38 oz. of water) which will be available for use by a crewmember during each EVA activity. EVA water and food containers are cleaned and refilled with galley subsystems.

The Safe Haven food system is provided to sustain crewmembers for 22 to 25 days under emergency operating conditions resulting from an on-board failure. A goal of the system is to utilize a minimal amount of volume and weight. The Safe Haven food system is independent of the daily menu food and will provide at least 2000 calories daily per person.

The Safe Haven food system will be stored at ambient temperatures which range from 60 to 85-degree F. Therefore, the food must be shelf-stable. Thermostabilized entrees and fruits, intermediate moisture foods, and dehydrated food and beverages are used to meet the shelf-stable requirement. The shelf life of each such food item will be a minimum of two years.

Water Requirements and Supply

Water is required in space for health and hygiene purposes.

The water as a part of food is carried to space from earth, while some of the water is also produced through fuel cells by combining hydrogen and oxygen- the main components of water. At the ISS, the water is also recycled from the cabin air, because there is very less water to spare and waste.

Recent Advances

In this modern era, various advances in technology such as edible cutlery is designed in such a way that their shape is of soup spoon, dinner spoon, fork etc. They can act as cutlery and be eaten after use. Other innovations are Self-cooling/ self-heating packages, Bite size compressed cubes, Plant growth in space and 3D printing.

Various Devices and Mechanical Developments

Some innovative gadgets and technologies also helpful for space programmes such as Food Warmer (Conduction and convection), Potable water dispenser or rehydration unit, Juice/ water/ beverage sipper and cups and Edible Cutleries etc.

Conclusion

Space foods are essential for astronauts for maintaining health, body maintenance and growth. The researchers have developed a lot of technologies in order to provide better eating alternatives to astronauts over a short time. In a long term space stay, space storage technology of food is important. Surplus food and the establishment of a safe save method of the food are important, for which the scientists are developing energy and nutrient dense foods which contain more nutritious values in comparison to their normal counterparts.

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