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Short Overview on Space Nutrition

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ABSTRACT

Food and nutrition have always played a significant role in determining the success—or failure—of exploration expeditions. Food that satisfied the dietary requirements of astronauts and was wholesome, nourishing, and delicious was necessary. In recent decades, humans have carried out a large number of space flights, and the success of these operations depends on a variety of criteria, the primary one being astronaut health. Nutrition and well-being are: Food provides two essential elements for life: nutrition and energy. It keeps people alive, nourished, and energized—including astronauts on extended manned trips. The purpose of space exploration must be completed, but the explorers' lives must come first. Maintaining the astronauts' health, vitality, and happiness throughout extended manned missions has emerged as a significant field of study in recent years. It appears that a significant factor is the food they consume. Food could be carried from Earth by astronauts on short-term manned space missions, but for long-term space missions that are currently being researched to the Moon, Mars, and Venus, astronauts will need to find other ways to survive, like growing plants, to sustain themselves. Astronauts who eat healthily can maintain good physiology and psychology. Solutions for providing astronauts with food during extended missions to the Moon, Mars, and Venus—where the atmosphere, gravity, soil, radiation, and other factors differ and may not support plant germination, growth, and development—will be discussed in this paper.

Keywords: Food, Space Food, Nutrition, Types of Space food

INTRODUCTION

Food provides the body's constant supply of nutrients, which are necessary for maintaining life on Earth and in space, to every cell in the human body. It is an undeniable reality that all human explorations—space exploration included—have been significantly impacted by diet [1]. For many years, people have been fascinated with space exploration, and they have successfully conducted multiple space missions. Humans have spent decades immersed in space exploration, and they have accomplished several noteworthy spaceflight missions. There are still a lot of unfinished missions in the future; nevertheless, several considerations, like astronaut nutrition in space, must be taken into account to accomplish these missions [2]. The process of eating and using food that is necessary for development and growth is known as nutrition. Thus, the process of collecting food in space that is essential for the growth and development of the human body is known as "space nutrition" [3].

The desire to explore space is fueled by political, scientific, and cultural imperatives. The cultural imperative is reflected in humanity's inbuilt need to push limits and enter new areas to obtain a sense of advancement and shared accomplishment. This innate human will explore and progress appears to stem from a basic survival impulse. The need for science stems from humankind's need to comprehend its environment, whether to arouse natural curiosity, obtaining pecuniary gain, or allaying dread of the unknown.

Given the extensive historical documentation of scientific thought, observation, and experimentation, this could be yet another example of the same basic human nature trait. We now understand that researching the surroundings of our solar system and seeing phenomena in deep space are the only ways to find answers to some of the most important and fundamental questions about our origins and future [4].

A range of food items that have been properly prepared and processed for astronaut ingestion in space is known as "space food." Since the process of supplying or obtaining the food required for growth and health is known as nutrition, the process of providing or obtaining the food required for health and growth in space is known as space nutrition. Space exploration is not an exception to the rule that nutrition has been crucial to exploration throughout history. A challenge for space travellers has always been how to bring enough food for their trips because there hasn't been enough room for storage. The proper ratio of nutrients is needed for long-term spaceflight in order to maintain health and protect against the consequences of microgravity. Maintaining a sufficient nutrient intake during spaceflight is critical for two reasons: first, it helps offset the detrimental effects of space travel on the human body and prevents deficiency diseases. In other words, food must remain edible throughout the journey and must contain all the nutrients needed to prevent illness.

Astronaut Nutrition

Human physiology is impacted by spacecraft, the space environment, and weightlessness itself. To maintain a habitable environment, one needs access to clean water, clean air, and efficient waste-collecting systems. Getting enough energy is arguably the most crucial component of astronaut nutrition [5]. This is because, in general, if enough food is ingested to meet energy needs, then other nutrients will also be consumed in adequate proportions. Additionally, energy is more important than other nutritional components in and of itself.

Nearly every system in the body is impacted by weightlessness, including the heart, blood vessels, bones, muscles, and neurons. Maintaining a caloric intake during spaceflight involves numerous factors, such as energy needs, physiological changes in taste and satiety, scheduling challenges related to setting aside time for meal preparation, consumption, and clean up, food quality, and even food availability.

Space Food

A range of food items that have been carefully prepared and processed for astronauts to eat while they are in space is known as "space food." The food must meet certain criteria to meet the needs of astronauts operating in low-gravity, machinery-filled spaces: it must provide a complete diet while being simple and safe to make, store, and eat [6].

The gastronomic equivalent of space travel, space food represents an incredible combination of engineering, science, and cooking. It goes beyond the traditional boundaries of terrestrial cuisine, specifically designed to fulfill the particular demands of space travel. Every bite is painstakingly crafted to provide vital nutrients while overcoming the difficulties of protracted storage and microgravity. Space meals have a longer shelf life than typical perishables since they are sealed in special packaging. Whether in the form of ready-to-eat pouches or dried powders that need to be rehydrated, these celestial treats provide nourishment without sacrificing flavor or nutrients. Advancements in space food technology consistently expand the realm of possible cuisine, providing comfort and diversity in the vastness of space. Everything from crumb-free recipes to customized meal plans is painstakingly designed to promote astronauts' physical and mental health as they set out on missions to the farthest reaches of space. It's difficult to prepare meals to consume while in weightlessness. Crumbs are prohibited because they can float around the cabin and get stuck in air vents, instruments, or someone's eye or nose. Additionally, packaging and meals are made to minimize the issue of food floating away during astronaut consumption in space. Trash is another difficulty for those creating food systems. Compressible wrappers and empty packages are necessary to reduce the quantity of waste on board the spacecraft. There are extremely few opportunities to remove trash from the vehicle since the garbage truck doesn't stop by the International Space Station.

Actually, waste is only disposed of during spacecraft visits to and departure from the International Space Station (ISS), such as the Space Shuttle, Soyuz capsules, and other cargo vehicles. Trash must be as compact as possible because even these vehicles have a limited amount of space. This occurs around once a month. These are but a handful of the difficulties in creating space meals. The NASA Space Food Team performs an excellent job of creating meals that astronauts will enjoy while in space and of solving these obstacles.For space travelers, food storage is a major concern. Food on the ISS had to be "shelf stable" and not expected to decay for at least six to twelve months because, up until recently, there were no freezers or refrigerators for food. A Mars mission's food supply must be consistent for up to five years. Microgravity Experiment Research Locker/Incubator, or MERLIN, is a miniature refrigerator-freezer that was recently launched to the International Space Station. It is useful for storing a tiny quantity of fresh food and beverages. This is particularly useful for drinks, which have typically been served at room temperature.

The packaging and design of space food differ significantly from ordinary food. Food in space needs to be tightly controlled to prevent it from floating around in the microgravity, or low gravity, environment. In zero gravity, even seemingly harmless objects like a few crumbs might become lethal. Loose food fragments can lodge in shuttle vents or drift into an astronaut's mouth or nose, posing a choking or breathing hazard. Drinks including coffee, orange juice, apple cider, and tea are packaged as powders since liquids can float away as well. To rehydrate themselves, astronauts dilute the included beverages with water.

Food in space is packaged, just like it is on Earth, and needs to be thrown away. When the astronauts finish eating, they have to put their packages in a garbage crusher within the space shuttle. Some packaging stops food from flying off. When storing or discarding food containers, the flexible, user-friendly food packaging maximizes available space.

People on Earth consume 70% more food than astronauts do. The food that astronauts consume is the same as that of Earthlings, except it is preserved specifically to prevent bacterial infection. Food is properly confined, and liquids are packaged as dried powders to help with the microgravity issue. Before consuming, the astronauts add water to their drinks via a special tube. Food system deficiencies, such as nutrient toxicities, inadequate preservation, underconsumption of calories, and lack of one or more nutrients, have resulted in the highest number of deaths and mission failures in the history of human exploration on Earth [7, 8]. Up until now, advances in food science and modern nutrition have avoided these problems on space missions, but venturing beyond low-Earth orbit will reveal new mysteries. Furthermore, achieving the bare minimum of nutritional needs could merely prevent deficiency, but an

optimal system—which could include a range of fruits and vegetables as well as related bioactive compounds—could improve performance and overall health [9, 10].

Meals in the Perspective of Space Flight

It's not easy to design human-food interactions in space. It is true that astronauts must complete specialized training on Earth before they may dine in space, and there are a number of issues to take into account, including those related to manufacturing, transportation, nutrition, and conservation [11]. The requirement to boost mission efficiency and morale while simultaneously improving nutrient intake has influenced the design of space cuisine [12–15]. When astronauts are chosen for an ISS trip, for instance, their training takes several years, covering topics such as food packaging kinds, preparation techniques, and how to consume in microgravity for meals and the onboard culinary environment (such as the food gallery, trays, and utensils).

Eating is done according to a set menu or schedule that includes breakfast, lunch, and dinner. Everything is made with efficiency in mind. The astronauts choose the package or packages from the pre-made menu, cut it open, and eat it with a spoon after following the necessary preparation instructions (heat, rehydrate, etc.) on the box. Because the person and several packages and parts are floating around, mixing is a difficult task in microgravity.

Types of Space Food

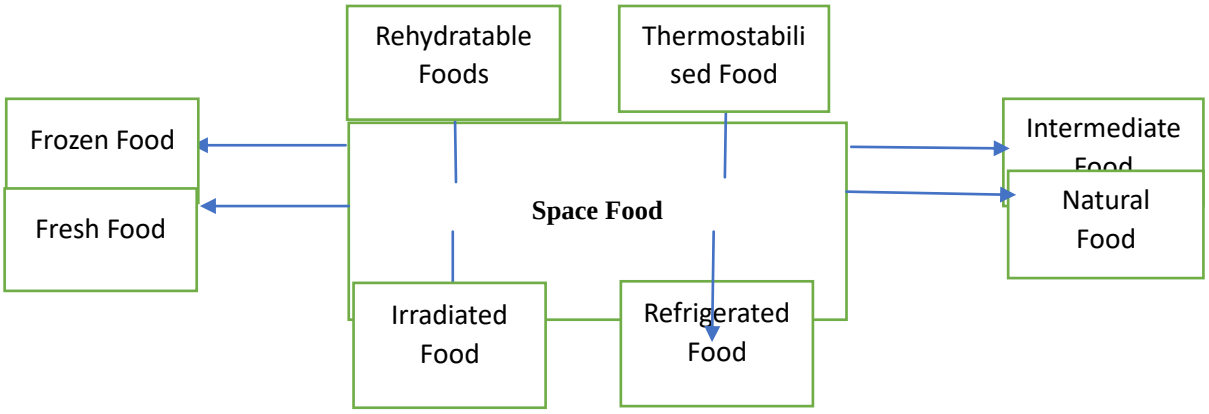

Fig. Types of Food for Astronauts [16]

Rehydratable Foods

Food items intended to be rehydrated with water before to eating are referred to as rehydratable space food. Meals that are dehydrated or freeze-dried are the most common kind of rehydratable space food [17]. The water content of these meals is extracted, resulting in food items that are lightweight and compact. Astronauts add a certain amount of water to the food in order to rehydrate it and restore its original flavour and texture before consuming it [18]. To avoid too much waste or too much moisture buildup in the spaceship environment, the water used for rehydration is carefully regulated and supplied in small amounts. Food that has been rehydrated uses fewer resources in storage and during transportation because it weighs and is consumed less. Rehydrating also aids in bringing back the food's original flavor and texture, improving palatability and giving astronauts a more fulfilling mealtime experience.

Thermostabilized Food

The term "thermo-stabilized space food" describes a particular kind of packed food that has undergone heat treatment and sterilization to increase its shelf life, assure safety, and endure the demanding environmental conditions of space travel. Thermo-stabilized meals don't require further preparation or rehydration, in contrast to rehydratable space food. Food that has been thermostabilized in space must undergo stringent thermal processing, such as high-temperature short-time (HTST) processing or retort sterilization [19].

Long shelf life makes it unnecessary to go on frequent resupply runs. When in space, the meal is resistant to temperature changes, harsh environments, and zero gravity. Additionally, it removes the need for refrigeration and unique storage requirements, which makes resource management and logistics easier.

Foods that are ready to consume, such as sandwiches, fruits, vegetables, meat, and desserts, are examples of thermo-stabilized space food. These meals are meticulously prepared to fulfill nutritional requirements, offer a balanced diet, and guarantee that the astronauts have the fuel they need for their space trips [20].

Intermediate Food
Space food with a moisture content in between that of dry food and wet food is referred to as semi-moist space food or intermediate moisture space food. In terms of water activity, which gauges the amount of water available for microbial development, it is in the middle of the range. Food with an intermediate moisture content is made to last longer on the shelf than food that is wet or perishable while yet having a soft, delicious texture.

Intermediate moisture space food has a moisture content that usually falls between 15% and 45%. This moisture level promotes microbiological control and prevents the growth of mold, bacteria, and yeast. This is accomplished using a variety of preservation approaches,including the addition of sugar or salt, adjusting the pH, and using packaging strategies that preserve a regulated environment. Food with an intermediate moisture content has several benefits over wet food, such as a longer shelf life, less weight and volume, and the capacity to maintain a desired texture and flavour. During space missions, it provides astronauts with a greater range of food options, such as snacks, candies, and other semi-moist food items that satisfy their senses and improve their general well-being [21].

Natural Food
Food that has undergone minimal processing while maintaining its original shape, texture, and nutritional makeup is referred to as natural form space food. It is intended to give astronauts on space missions a more authentic, fresh eating experience that is similar to what they would eat on Earth. The goal of natural form space food is to maintain the freshness, stability, and safety of food while making it suitable for ingestion in a microgravity environment. In order to preserve its nutritional value and sensory qualities, this kind of space food goes through very few processing stages [22]. To maintain their freshness and stop spoiling, these goods are usually cleaned, sterilized, and packaged. To increase the shelf life and maintain food quality, special packaging methods including modified environment packaging are frequently utilized. Natural form space food consists of carefully selected fresh fruits, vegetables, nuts, and seeds that are suitable for space travel and have a high nutritional value. These meals provide astronauts a range of vital elements required for their health and well-being since they are high in vitamins, minerals, fiber, and antioxidants.

Irradiated Food
Food that has been subjected to a process known as food irradiation—which includes subjecting food to ionizing radiation, such as gamma rays, X-rays, or electron beams—is referred to as "irradiated space food." This process helps control or eradicate potentially hazardous microorganisms, pests, and parasites that may be present in the food [23]. For space missions, radioactive food has various benefits. By lowering the possibility of foodborne pathogens, spoiling microorganisms, and pests that could result in disease or spoilage throughout prolonged periods of storage, it helps assure the safety and quality of the food. Additionally, it contributes to the food's longer shelf life, which lessens the need for frequent replenishment missions and increases the effectiveness of space missions [24].

Refrigerated Food
Food kept in a refrigerator can be kept at a slightly higher temperature range than that of frozen food, which is preserved at significantly lower temperatures. For astronauts, refrigerated space food has various benefits. Compared to shelf-stable or rehydratable alternatives, it offers a greater range of meal options while assisting in the preservation of the food's quality, taste, and nutritional value. Refrigeration aids in reducing the growth of bacteria and mold, two types of microorganisms that can contaminate food and cause health problems [25].

In order to keep the food refrigerated, these systems are made to maintain a steady temperature range, usually between 2 ◦ 8 C and 4 ◦ C (36 ◦ F and 39 ◦ F). In order to be lightweight, small, and manageable in the microgravity environment of space, chilled space food packaging is made.

Fresh Food
The term "fresh space food" describes meals and snacks that astronauts eat while in space that are made with fresh ingredients. The goal of fresh space cuisine is to give astronauts a more comfortable and natural dining experience in space, as opposed to other types of space food that are preserved by techniques like freezing or dehydration [26]. Certain packaging and storage techniques are used to guarantee the ingredients' purity and freshness.

Frozen Food
Meals and food products that are produced and kept at extremely low temperatures to keep them frozen during space missions are known as frozen space food. There are various benefits to frozen food when traveling through space. Firstly, freezing aids in preventing the growth of bacteria and mold, two types of microorganisms that can lead to food spoiling and foodborne illnesses. The growth and activity of these microbes are considerably inhibited or stopped by keeping the meal frozen [27].

Second, freezing aids in maintaining the food's flavour, texture, and nutritional value. It aids in preserving the natural texture and look of the ingredients along with their Flavors and fragrances. Additionally, freezing aids in maintaining the food's vital nutrients, guaranteeing that astronauts will eat enough to survive their journeys. When it comes time for the astronauts to eat the frozen food in space, they use sophisticated equipment on board the spaceship to reheat or

rehydrate the meals according to predetermined instructions. This enables them to eat a range of foods in the microgravity environment of space, such as appetizers, desserts, and side dishes.

Opportunities in Space Food

Wholesome meals that satisfy the particular dietary needs of astronauts. Improvements in nutritional science may result from this, which could benefit space travellers' health. Making meals in space presents special culinary difficulties. The chance to experiment with novel cooking methods, tastes, and food presentations opens up new avenues for the culinary arts and broadens the astronauts' gastronomic horizons [28]. The development of sustainable food production methods for space exploration may have wider effects on Earthly food production. Research on space food can aid in the development of effective cultivation techniques, waste reduction strategies, and resource optimization—all of which are essential for sustainable agriculture. By creating methods for cultivating food in harsh environments, such as dry regions or areas impacted by climate change, space food research can support efforts to ensure food security [29].

CONCLUSION

As space food provides astronauts with the nourishment, they need to maintain their health, well-being, and performance in the harsh conditions of space, space food is essential to the success of space missions. The metabolic alterations that take place in the human body while on space missions are one crucial factor to take into account. The nutritional value of space food must be balanced to offset these impacts and maintain astronauts' physiological needs. Various kinds of space cuisine have been created to satisfy astronauts' unique requirements. Options such as rehydratable, thermo-stabilized, natural form, irradiated, frozen, fresh, and refrigerated are among them. To meet the difficulties in delivering nutrient-balanced meals in the special environment of space, space food technology must constantly advance and innovate.

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