



REVIEW ARTICLE

The new era of space food system: a review

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Received: 29.05.2021

Accepted: 21.07.2021

ABSTRACT

Space food is a kind of food item made and prepared for utilization by space explorers during missions to space. Food ought to be solid and nutritious as space travelers face numerous medical conditions because of the absence of legitimate air. Space explorers initially conveyed food in space on Mercury's mission. After that, the food of various assortments was devoured on missions, for example, Gemini, Apollo, Skylab, Apollo Soyuz test project, and in the International space station. Different techniques like drying, irradiation, freeze-drying, and refrigeration are utilized for Physicochemical, Sensorial and Microbial security of room food. Freeze-drying methods in the space program comprise cutting, dicing, or condensing arranged food to decrease planning time. A space explorer can browse numerous kinds of food varieties like organic products, nuts, peanut butter, chicken, meat, fish, treats, brownies and so forth and beverages incorporate espresso, tea, squeezed orange, fruit juices and lemonade. As of late, space food has been utilized by different countries connecting with on space programs as an approach to share and flaunt their social personality and encourage intercultural correspondence.

Keywords: Nutrition, properties, different technology, different foods

Citation: Patil, S., Swami, U., Shetty, S., Phalke, P., and Sahoo, A. K. 2021. The new era of space food system: a review. *Journal of Postharvest Technology*, 9(3): 90-99.

INTRODUCTION

Nutrition has assumed a basic part since the commencement of investigation, and space investigation is no exemption. People have adjusted well to space flight, and in the course of recent years, we have considerably expanded our comprehension of the different physiologic changes that happen during and after space flight. Nourishment in space has numerous parts of effect, including arrangement of required supplements and upkeep of endocrine, invulnerable, and musculoskeletal frameworks. In any case, the fundamental instruments for a large number of these changes stay muddled. Sustenance and food science research cover with are essential to numerous different parts of room medication and physiology including mental wellbeing, rest and circadian rhythmicity, taste and scent sensitivities, radiation openness, body liquid moves, and wound mending and to changes in the musculoskeletal, neuro tactile, gastrointestinal, hematologic, and immunologic frameworks. Supplement admission assume a basic part from wellbeing upkeep to the psychosocial advantages of supper time, the job of nourishment in space is clear. Late advances in genomics and proteomics are simply starting to be applied in space biomedical examination, and almost certainly, discoveries from such investigations will be pertinent to applied human nourishing science (Enrico, 2016).

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Throughout the most recent many years, space food has developed essentially and has gone from toothpaste-like tubes to food like what we eat on earth. By virtue of that, regardless of how much supplements food contains, it should be burned-through to satisfy its motivation, and to be devoured, food needs to have an organoleptic request and furthermore be variable. Moreover, during longer missions, consider that food isn't just a wellspring of supplements, however it ought to likewise guarantee individual and passionate prosperity. All in all, food assumes a significant part as a countermeasure to the mental difficulties that people insight on profound space missions (Obrist et al. 2019).

Crossing into profound space, space explorers face a few physiological and actual difficulties because of expanded openness to radiation and the manner in which microgravity influences the body. Nourishment is basic for people to survive constantly the physiological and actual difficulties in space. On the other hand, the natural conditions in space seriously influence our metabolic cycles and the body's capacity to use supplements. Besides, microgravity influences pharmacokinetics and since the examination on drugs and possible results in space is scant, food is the essential wellspring of sustenance and the main countermeasure for these difficulties (Blue et al. 2019).

The handled and prepackaged spaceflight food framework is a basic human emotionally supportive network for monitored space flights. As missions broaden longer and farther from Earth throughout the following 20 years, methodologies to settle the wholesome and tangible nature of food should be distinguished. For a mission to Mars, the space food sources themselves should keep up quality for as long as 5 years to line up with freight repositioning situations. Advancing the food framework to accomplish a 5-year time span of usability mitigates the danger of a deficient food framework during expanded missions (Sirmons et al. 2020).

Long-length missions will require the perfect measure of supplement prerequisites for support of wellbeing and assurance against the impacts of microgravity. Psychosocial parts of nourishment will likewise be significant for more beneficial missions and team resolve. Acknowledgment of the full job of sustenance during spaceflight is basic for the achievement of broadened span missions. Examination led to decide the effect of spaceflight on human physiology and ensuing dietary necessities will likewise have immediate and circuitous applications in Earth-based sustenance research (Enrico, 2016).

HISTORY OF THE SPACE FOOD

From John Glenn's mission to circle Earth to the International Space Station program, space food research has met the test of giving food that preferences great and voyages well in space. To better under-stand this interaction, we can think back through history. Voyagers have consistently needed to deal with the issue of how to convey sufficient nourishment for their excursions. Regardless of whether those wayfarers are locally available a cruising transport or on the Space Shuttle, sufficient extra room has been an issue. Food needs to stay eatable all through the journey, and it likewise needs to give every one of the supplements needed to maintain a strategic distance from nutrient inadequacy infections like scurvy (Casaburriand Gardener, 1999).

Right off the bat ever, people found that food would stay palatable longer on the off chance that it were dried and put away in a cool dry spot until the time had come to be devoured. Early food drying out was accomplished by cutting meat, fish, and certain natural products into dainty strips and drying them in daylight. Scouring food with salt or absorbing it salt water, an early type of relieving food, likewise helped save it. Later methods were produced for cooking, preparing, pre-serving, and putting away food in fixed compartments. With the advancements of sanitization and canning, a lot bigger assortment of food sources could be put away and continued long excursions. All the more as of late, refrigeration and speedy freezing have been

utilized to help save food flavor and supplements and forestall deterioration. While these types of bundled food items are fine for movement on Earth, they are not generally appropriate for use on space flights. There are limits to weight and volume when voyaging and the microgravity conditions experienced in space additionally influence the food bundling. As of now, there is restricted extra room and no refrigeration. To address these difficulties, extraordinary strategies for the planning, bundling, and putting away of nourishment for space flight were created (Casaburri and Gardener, 1999).

Table 1: Space food for different space flights

Name of space flight	Year	Space food
MERCURY	1958-1963	Bite-sized cubes, freeze-dried powders, and semi-liquids in aluminum tubes that looked like toothpaste tubes.
GEMINI	1961-1966	Shrimp cocktail, chicken and vegetables, pudding, and apple sauce.
APOLLO	1961-1969	Hot water, package of turkey and gravy, bread slices with sandwich spreads and cheddar cheese spreads, frankfurters, Fruit juices
SKYLAB	1973	72 different food items, including steak and vanilla ice cream.
APOLLO SOYUZ TEST PROJECT	1975	Ham slices, corned beef, turkey slices, and a char-broiled beef steak.
INTERNATIONAL SPACE STATION	1998-2011	American foods and half are Russian foods. Japanese, European, and Canadian food items More than 300 items

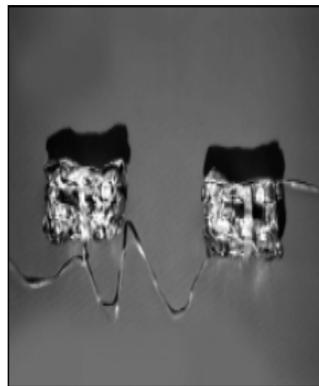
(Smith et al. 2012)

Mercury was the United States' first space program that sent people to space. Mercury space explorers were dispatched into space on either a Redstone or Atlas rocket, contingent upon how far they voyaged. Alan Shepard was the primary American in space. He went on his first outing to space under multi month after Yuri Gagarin's flight, and it kept going 15 minutes and 28 seconds. That first flight was a suborbital flight, implying that it didn't circle the Earth. The Mercury program finished with Astronaut Gordon Cooper finishing 22 circles around the Earth and remaining in space for an entire day (a little more than 34 h). The Gemini program, Project Gemini, was made to bring NASA one bit nearer to going to the moon. It incorporated the initial 2-man missions, and the principal space stroll by an American! Food sources utilized in Project Gemini were somewhat better compared to the first things created for Project Mercury. They included food varieties like shrimp mixed drink, chicken and vegetables, pudding, and fruit purée. In 1961, when the U.S. had around 15 minutes of room flight insight, President Kennedy provoked us to get to the moon before the decades over. With enormous cooperation and a remarkable exertion, in 1969 the Apollo 11 team arrived on the moon. At 4:18 p.m. EDT on July 20, 1969, Neil Armstrong radioed the primary words from the Moon: "Houston, Tranquility Base here. The Eagle has landed." Just under 7 hours after the fact, he removed the initial steps from the lunar module and announced "That is one little advance for man, one goliath jump for humanity." The Apollo space travelers were the first to have boiling water in space, so the assortment of room food sources expanded much more. On Christmas Day, 1968, the Apollo 8 team ate a bundle of turkey and sauce and ate with spoons. The Apollo groups appreciated bread cuts with sandwich spreads and cheddar spreads, and even sausages. Natural product juices were additionally added to the menu.

The primary space station worked by the U.S. was Skylab, portrayed in the figure beneath. The objectives of the Skylab program were to demonstrate that people could live in space for extensive stretches of time, and to perform logical tests. Space explorers on Skylab utilized uniquely made gear to watch out for, and better comprehend, what befalls the body when it is presented to weightlessness for quite a while. They likewise estimated radiation from the sun and noticed the Earth from space. Skylab had a standout amongst other space food frameworks. One territory on the station had space for a lounge area and table. A fridge and cooler were likewise accessible for putting away food, and subsequently the menu could be broader. The Skylab space explorers could look over 72 changed food things, including steak and vanilla frozen yogurt. American space travelers on the Apollo-Soyuz Test Project were given suppers like those devoured on Apollo and Skylab flights. Russian dinners were made out of food sources bundled in metal jars and aluminum tubes. Their rocket had a little warming unit installed, and singular menus were chosen for every cosmonaut. As a rule, a dinner comprised of meat or meat glue, bread, cheddar, soup, dried leafy foods, espresso, and cake.



Mercury flight food



Gemini meal wrap



Apollo meal wrap



Skylab food tray



Russian Space food



International space station food tray (frozen food)

Figure 1. Different Space food for different flights

The International Space Station (ISS) will become operational on a full-time basis with a crew of three. Later, the crew size will grow to a maximum of seven people. The food made arrangements for the ISS will be frozen, refrigerated, or thermo settled (heat prepared, canned, and put away at room temperature) and won't need the expansion of water before utilization. Albeit a large number of the refreshments will be in the got dried out structure, concentrated organic product juices will be added to the drinks offered and will be put away in the locally available fridge. ISS drink bundle is produced using a foil and plastic cover to

accommodate a more drawn out item timeframe of realistic usability. A connector situated on the pack-age will associate with the cook room, or kitchen zone, so that water might be administered into the bundle. This water will blend in with the beverage powder effectively in the Package. The connector used to add water additionally holds the drinking straw for the space explorers. The food Package is produced using a microwaveable material. The highest point of the Package is cut off with some scissors, and the substance are eaten with a fork or spoon. All different types of space flights food shown in figure 1. (Casaburri and Gardener 1999).

BASIC CRITERIA FOR SPACE FOOD

Safety and stability

It is principal that we comprehend and limit any food-related danger to space explorer wellbeing and to the vehicle. The ISS food framework goes through broad ground handling and testing to limit the danger of food contamination. Food sources filled in the space apparatus will have microbiological testing and cleaning necessities, just as bring waste streams into the territory air, water, and waste frameworks. Current microbiological and dietary examinations require significant assets and waste-handling limit that won't move as is to the asset confined shuttle. Current plans for Mars missions require food framework solidness (or potentially fixings and gear) through in any event 5 yr of capacity. While the utilization of fridges and coolers is conceivable, incorporation of this gear should be considered against mission volume, mass, and force imperatives. No food framework to date has been contrived or tried or has shown it can give sufficient agreeableness and sustenance to 5 y, not to mention one that additionally meets the limited mass, volume, and capacity in the antagonistic space flight climate (e.g., radiation openness, temperature limits) (Doughlas et al. 2020).

Nutrition and palatability

A food framework could meet every single essential rule, yet on the off chance that it isn't acceptable, it won't be devoured in sufficient adds up to help wellbeing, execution, and confidence. A typical misperception is that high-performing people, like space explorers, will devour whatever is needed to effectively finish a mission. The space explorers should be willing and ready to plan and devour the food varieties accessible for the length of any mission, and natural and worthy food turns out to be much more significant as span, distance, and separation increment. Like Earth-bound people, space travelers require pleasant food varieties that the normal individual would need to devour for quite a while and that rush to plan in the wake of expenditure extended periods of time at work. The best number of fatalities and mission disappointments throughout the entire existence of human investigation on Earth were because of food framework deficiencies, like lack of at least one supplements, deficient caloric stockpile and underutilization, insufficient conservation, or even supplement poison levels. Present day nourishment and food science has forestalled these issues on space missions to date, yet investigation past low-Earth circle will bring new questions. Also, meeting insignificant dietary prerequisites may just forestall lack, where as an improved framework, (for example, one including an assortment of products of the soil and related bioactive compounds) has the possibility to advance wellbeing and execution (Doughlas et al. 2020).

Resource minimization

All assets utilized (e.g., mass, volume, group time, water, force, gear) and all side-effects made (e.g., squander water, bundling, volatiles, natural waste) by a food framework are weighed against the sum and assortment of satisfactory, nutritious food accessible for space travelers. Mission organizers, with contribution from wellbeing and clinical subject matter experts,

will decide the wellbeing and execution emotionally supportive networks (e.g., food, work out, clinical) inside the bigger mission and vehicle asset limitations (Doughlas et al. 2020).

Variety and reliability

Type, surface, and kind of food all change it up. A mix of frameworks (e.g., prepackaged, developed) might be expected to evade menu weakness. Indeed, even a "great" food thing, fixing, or supplement source can't give a whole food framework (i.e., it can't be burned-through for each supper). Similar to the case for loss of different frameworks of a space vehicle, assuming part or the entirety of a food framework is lost, the outcome could be cataclysmic. This could occur if in situ food varieties don't develop sufficiently or if hardware breakdowns. All frameworks should likewise be approved in genuine or recreated limits of the spaceflight climate (e.g., pressure, gravity, temperature, radiation) (Doughlas et al. 2020).

Usability

What's more, food readiness could require assets and cycles for cooking and cleanup not the same as those utilized in Earth's gravity. Advancement and testing of such frameworks should represent the real factors and requirements of spaceflight while limiting asset use. Work and asset .The food framework should be simple and quick for the space travelers to plan or create food. Investigation missions will have totally different objectives from colonization missions. Groups of the underlying missions will zero in on investigation and science, and on these missions, space explorers will plan food as the normal individual would in their kitchen in the wake of a difficult day of work. In a perfect world, space travelers would cook utilizing mass fixings, however rocket specialized contemplations can make this troublesome, including contact temperature limits (to dispose of the danger of consumes), security concerns, and specialized difficulties with containing and handling fixings serious food frameworks perhaps more attainable during colonization missions than during investigation missions (Doughlas et al. 2020).

Space-ready appliances

Until this point in time, space food frameworks have just permitted space explorers to add water as well as warm food (i.e., not cooking). Food arrangement hardware must be exceptionally evolved to meet security (e.g., contact temperature cutoff points) and spaceflight prerequisites (e.g., microgravity, internal compression changes, and radiation), regularly adding mass. New gear should be produced for Mars class missions (Doughlas et al. 2020).

Table 2: New types of food in space flights

Type of space food	Examples
Rehydratable Food	Hot cereal such as oatmeal
Thermo stabilized Food	Fruits and fish (tuna fish) puddings
Intermediate Moisture Food	Dried peaches, pears, apricots, and beef jerky.
Natural Form Food	Nuts, granola bars, and cookies.
Irradiated Food	Beef steak and smoked turkey
Frozen Food	Quiches, casseroles, and chicken pot pie
Fresh Food	Apples and bananas
Refrigerated Food	Cream cheese and sour cream.
Extended shelf life bread products	scones,waffles, tortillas, and dinner rolls
Beverages	beverage mixes (such as coffee or tea) beverage mixes (such as coffee or tea)

(Cooper, 1982)

DIFFERENT TECHNOLOGIES FOR MANUFACTURING SPACE FOOD

The space food did not evolve in days or months, it took years for scientists and technologists to understand the practical problems of the food which is on board. There are many methods for the production of Fit to be Consumed Space Food. The space food is generally divided into following groups

Freeze dried or rehydratable foods

Moisture is eliminated from the food during packaging food materials like Soups, meals, fried eggs and breakfast cereals are bundled as such. As the time passed innovation developed further developed and when Gemini mission (1965) was dispatched the food got more delicious. The space travelers got this decision of chose from a wide assortment of food which included fish, turkey meat and cream of chicken soup with a sweet. The freeze drying zone should be endorsed by USDA. The pre necessities for this incorporate the capacity and accepting segment for crude materials, a food preparing zone lastly an enormous zone with bunches of huge freezing and drying chambers followed by a bundling segment. The office additionally incorporates an innovative work lab where in new improved strategies for freeze drying are found the food is then at last shipped off a test kitchen where in it is checked for the last quality boundaries of. The freeze drying measure differs many time temperature coefficients alongside numerous blends of pressing factor (Shefiee, 2017).

Freezing

The food pieces are then fanned out on an even metal plate that are marked over one another 20 to 30 all at once in a wheeled streetcar for the food that is as of now precooked and frozen the plate are pre chilled to forestall defrosting of the frozen material. For material like espresso, it is poured in a shallow container. These streetcars are then driven into an enormous, stroll in cool cooler where the temp is - 40oC. in this temp the food rapidly freezes, these streetcars are kept their till an opportunity to dry them into the drying chamber (Shefiee, 2017).

Drying

The streetcars are then driven into a vacuum drying chamber. For fluids like espresso, the frozen espresso is first pounded into little particles in a low-temperature processor machine. With semi-circular finishes, the drying chamber is an enormous, long, flat chamber one finish of which is shut and the other open. This strategy is called as Sublimation. In sublimation, a strong material is changed into vaporous state without changing into fluid state. If there should be an occurrence of freeze dried food, the ice precious stones present in the frozen food material are changed into water fume without changing into fluid water. In the chamber, drying is finished by eliminating the air with an assistance of a vacuum siphon to diminish the pressing factor till about 0.036 psi (0.0025 bar). The temperature of the food is expanded to about 100°F (38°C) by conduction warming going through the lower part of the plate, radiation is consumed from heat lights, or microwave warming. At the point when the chamber is made air free, the pressing factor is diminished beneath the limit at which water can coincide in a strong, fluid, and vaporous (fume) state. This point is known as the triple place of water. When the pressing factor falls not exactly this point, the warmth changes the air gems that are caught, straightforwardly to water fume. The fume is removed and by buildup inside the chamber food is abandoned. The dried food is currently made up for with minuscule shortfalls (like openings), like a wipe, where the precious stones of ice were once present. This not just makes it simpler for the food to be reconstituted when it is ready for utilization by the buyer, yet even the dried food holds its unique size and shape. The hour of this drying interaction contrasts. Freeze-dried fluids require just 4 hours planning while others may require 12 hours or more (Shefiee, 2017).

Irradiated foods

Like thermo settled food varieties, these food varieties have been safeguarded by slaughtering destructive microorganisms and living beings .they come in come in adaptable pockets having food that is prepared to eat. The lone distinction is the interaction that is utilized to sanitize the food. Lighted food is presented to ionizing radiation from gamma beams or electron radiates for a particular time span controlled by the kind and substance of food. Lighted food can incorporate any nutrition class from products of the soil to meat. In spite of the utilization of radiation, these food don't raise the danger of malignant growth for those eating it. The World Health Organization and American Medical Association have named them as fit to be devoured (Shefiee, 2017).

Natural 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 (Shefiee, 2017).

CONCLUSION AND FUTURE SCOPE

For Space investigation, we send people into a limited climate for longer timeframe, denied of sensorial incitement, it is fundamental for consider essential human requirements and which job food plays for mental and actual prosperity. For this reason, legitimate wholesome eating regimen is suggested for space traveler. To satisfy the reason, space and food innovation ought to be combinable valuable. Innovation, for example, 3D printing, bio regenerative framework, tank-farming and aeroponic framework ought to be utilized. We ought to create handling strategies that can keep supplement check, bioavailability and organoleptic acknowledgment of nourishment for longer timeframe. In bundling region, the material ought to must be regenerative, reusable and biodegradable. To have the option to accomplish appropriate food frameworks for future profound space missions, further examination should be led.

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