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CHALLENGES AND SOLUTIONS FOR SPACE FOOD IN LONG-TERM EXPLORATION MISSIONS

Abstract

Historically, food and nutrition are key factors for the success – or failure – of exploration. Many expeditions failed because of flaws in the food and nutrition system, particularly in harsh environments such as the polar circles. A similarly extreme environment is space, where food becomes as crucial as the hardware of a spacecraft – if not more decisive - in keeping the astronauts healthy, i.e., in "a state of complete physical, mental and social well-being". Nowadays, with humanity committed to expand its presence to the Moon and on to Mars, it is time to rethink the way space food is produced, stored and consumed. Such a feat comes with extensive challenges that the next food system is required to overcome in a deep space scenario: the infeasibility of regular food resupply and the physiological and behavioral decrements experienced by astronauts.

This paper investigates a multi-faceted food system consisting of two key elements: production and storage facility and a software application. The latter interfaces the production and storage with the astronauts as the end user to optimize their dietary intake in long duration missions. The system is conceived in such a way to produce and manage food according to the fundamental requirements for space food systems: nutrition, safety, usability, stability, resource minimization, reliability, variety and palatability. For the production, soil based, aeroponic and hydroponic growing methods in a closed loop greenhouse were considered. Food waste, faeces and non edible parts of the plants are used as fertilizer while water is supplied by the recycled urine and wastewater. Green and vegetables grown in situ are the main source of fresh food, contributing to a more Earth-like experience for the crew, while optimizing mass and volume budgets in the long term. For food processing, 3D printing techniques have been evaluated, allowing astronauts to customize the nutritional content in each meal.

Finally, a software design is proposed that continuously adapts the diet and eating patterns of astronauts to measured physiological parameters and to the feedback coming from the astronauts themselves. The objective is to counteract the physiological and psychological decline resulting from prolonged time in deep space, by means of adaptive nutrition.

For mankind to take the next giant leap, the state of the art in space food and nutrition needs to be further developed. In situ food production and storage in a sustainable way is essential. Equally important is to guarantee a beneficial eating experience for the astronauts that contributes to high morale and level of performance.

With the present study, the team aims to share solutions that overcome the challenges coming with

space food in the long duration missions that humanity dares to venture into and hopes that it will be a source of inspiration for future research studies.