

PROBIOTICS IN SPACE

Probiotic drink-maker Yakult and the Japan Aerospace Exploration Agency (JAXA) have joined forces to examine the effects of consuming **PROBIOTICS DURING SPACEFLIGHT**

Extended space travel exacts a toll on the body. Astronauts have been found to suffer from weakened immune systems as well as bone and muscle loss. It is thus critical to discover how to maintain health in space in order to enable long-term space missions of the future such as those to Mars and beyond.

“Longer space missions will require improved health management,” notes Satoshi Furukawa, leader of space biomedical research at JAXA, who himself has spent almost six months in space.

Yakult, best known for its probiotic drinks, is collaborating with JAXA to explore the effects of probiotics on human health in space. It is undertaking an unprecedented study that involves the participation of astronauts on the International Space Station (ISS).

“We are examining the effects of continuous consumption of probiotics in space,” explains Osamu Chonan of the Yakult Central Institute. “For the first time, we’ll discover what effects Yakult’s live probiotic bacteria have on the human immune system and gut microbiota during space missions.”

“Changes in the human gut microbiota in space were first studied using classical methods in the 1980s, but few studies have taken advantage of the advanced methods available today to test the effects of probiotics in space,” says Furukawa.

MILK DELIVERIES IN SPACE
The seeds of the project were sown in February 2012, when Yakult participated in JAXA’s Kibo Utilization Forum, a meeting designed to promote the use of the Japanese experimental module called Kibo on the ISS. Yakult then set up the Intestinal Environment Improvement Research Group and the collaboration was officially established in 2014. It is designated to run until March 2020.

Storing probiotic bacteria at room temperature (about 22 degrees Celsius) in the limited space aboard the ISS posed a number of issues. To overcome these problems, the project team developed a freeze-dried version of Yakult’s proprietary strain of lactic acid bacteria, called *Lactobacillus casei* strain Shirota. In capsule format, the live, but dormant, bacteria could be packaged as space food in light aluminium pouches suitable for delivery to the ISS.

“Importantly, we demonstrated that we can deliver *L. casei* strain Shirota even without a cold chain, which is usually needed for transporting probiotics in liquid form,” says Chonan.

Following a nine-month storage test on the ground, other sample capsules were delivered to the ISS in April 2016, where they were stored for a month. When the samples were returned to Earth for analysis, researchers found that the samples contained a similar

number of live bacteria as the control samples that had been stored on Earth.

The space experiment got underway in 2017. “Our experiment involves astronauts consuming five capsules per day for four weeks before returning to Earth,” says Chonan.

THIS RESEARCH IS AN EXEMPLAR OF THE POSSIBILITIES THAT SPACE MEDICINE OPENS UP.

One set of five capsules contains at least 40 billion live bacteria. Saliva, blood and stool samples taken before, during and after a flight will be compared to examine changes in immune function and gut microbiota. “The experiment is now in progress,” says Chonan. “We’re regularly sending our probiotics packages to the ISS.”

A WELL-GROUNDED APPROACH
Extensive research published in peer-reviewed journals points to the beneficial effects of probiotics. In terms of the human gut, *L. casei* strain Shirota has been demonstrated to reduce constipation, increase the amount of beneficial bacteria and reduce the number of harmful bacteria.

“As for the immune system, studies have shown that taking *L. casei* strain Shirota over three weeks boosts natural killer

cell activity,” says Chonan. He highlights a study in the UK that showed that continuous intake of *L. casei* strain Shirota reduced the incidence of infection in athletes (Gleeson, M. *et al. International Journal of Sport Nutrition and Exercise Metabolism* **21**, 55–64; 2011), a study in India that linked the probiotic with reduced incidence of acute diarrhoea in children (Sur, D. *et al. Epidemiology & Infection* **139**, 919–926; 2011) and clinical research in Japan that showed *L. casei* strain Shirota helped alleviate fever caused by norovirus gastroenteritis in the elderly (Nagata, S. *et al. British Journal of Nutrition* **106**, 549–556; 2011).

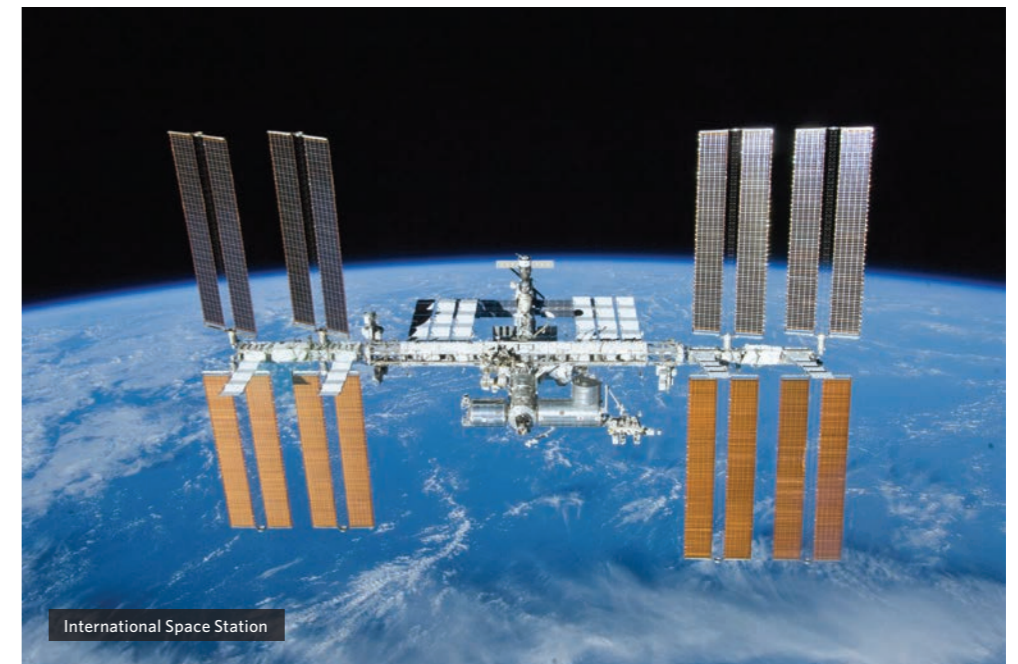
“These are just a few examples that form the basis of our hypothesis that taking *L. casei* strain Shirota can help maintain or improve human health in space,” he says.

EXPLORING NEW FRONTIERS IN SPACE FOOD

Looking ahead, Chonan highlights the importance of developing functional foods and technologies that will enable space food to be delivered in different forms. It will also be vital to contribute to international standardization on the use of live bacteria in space foods and investigate synergistic effects in conjunction with other research on the immune system. Given the growing international interest in studying probiotics in space, the project team anticipates further collaborations.

Outcomes from the space experiment are potentially also useful for applications on Earth. For example, learning more about the effects of microgravity, space radiation and a confined environment could provide insights into how human health can be supported in extreme environments on Earth such as the deep sea, high altitudes and disaster zones.

“Moreover, this research is an exemplar of the possibilities that space medicine opens up,” says Furukawa. “I’d be delighted if younger scientists become more interested in space medicine as a result of this project, and become inspired to enter this emerging area of research.” ■



International Space Station



Lactobacillus casei strain Shirota



Capsules containing freeze-dried Lactobacillus casei strain Shirota

A MESSAGE FROM THE PRESIDENT OF JAXA

Space development is a truly global affair, and JAXA intends to be an important player in it. The development of space will be advanced through space exploration promoted by international cooperation as well as through

the commercial development of space based on global competition. JAXA intends to lead innovation in Japan by maximizing research and development outcomes through collaborating with companies and

related organizations. This supplement provides a glimpse into some of the space projects that are currently being conducted in Japan as well as the role that JAXA is playing in initiating and supporting such development.



Naoki Okumura, President of JAXA

