DEVELOPMENT AND PROVISION OF FUNCTIONAL FOODS TO PROMOTE HEALTH ON LONG-DURATION SPACE MISSIONS

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ABSTRACT

During long-duration NASA space missions, such as proposed missions to Mars, astronauts may experience negative physiological effects such as bone loss. Functional foods such as high-lycopene, high-flavonoids and high-omega-3 products and fruits and vegetables may mitigate the negative effects of spaceflight on physiological factors including the bone health of crewmembers. Previous studies showed that current ISS provisions provide high-lycopene and high-omega-3 food items but the variety is limited, which could promote menu fatigue. Bioactive compounds can degrade like other chemical compounds and lose functionality. The native concentrations and stability of bioactive compounds have never been determined in spaceflight foods, and adequate information is not available for commercial products for the storage durations required for space exploration (5 years). The purpose of this task is to develop new spaceflight foods that are high in omega-3 fatty acids, lycopene, or flavonoids, identify commercial products with these bioactive compounds that meet spaceflight requirements, and define the stability of these nutrients in storage to enable purposeful functional food incorporation into the space food system.

The impact of storage temperature on the stability of lutein, lycopene, β-carotene, omega-3 fatty acids, phenolics, anthocyanins and sterols is being studied in 12 ISS menu items stored at three different temperatures (4, 21, 35°C) over 2 years. Additionally, nutrient and quality stability are being assessed on a larger food set stored at 21°C over 2 years that contains twelve newly developed foods, 10 commercial products repackaged to spaceflight requirements, and another 5 current ISS menu items expected to be good sources of omega-3 fatty acids, lycopene, or flavonoids. All items were shipped overnight to the Linus Pauling Institute at Oregon State University (Corvalis, OR) after processing and 1-year of storage and analyzed for bioactive compound concentrations. . Sensory evaluation was conducted on the newly developed functional foods and commercial products with untrained panelists ($n \geq 25$) using a 9-point Hedonic scale to test sensory attributes and overall acceptability after processing and 1-year of storage (21°C). Repeat nutritional and sensory analyses will be conducted in the same foods after the 2-year storage period is completed.

The stability of bioactive compounds in the selected foods was dependent on storage temperature and food matrix. Omega-3 showed excellent stability in the analyzed products after 1-year of storage, regardless of the storage temperature; phenolic compounds also showed good stability. Lycopene was more stable in oil-based products rather than water-based products because of the protection that lipids offer to lycopene molecules. Also, lycopene was more stable in freeze-dried products than in high moisture foods. The 12 newly developed functional foods showed good overall acceptability in sensory attributes after processing (average score 7.2 out of 9.0) and maintained sensory quality through 1-year (21°C); the overall acceptability was on average 7.1 after storage. Similar behavior was observed for the 10 commercial products after 1 year. The developed products are good sources of omega-3 (both plant and marine), vegetables (7 vegetable-based products), and good sources of carotenoids, such as the Curry Pumpkin Soup and the Sweet and Savory Kale. Nine of the new products, such as Mango Salad, Pickled Beets, and Braised Red Cabbage, are rich in phenolic compounds.

Stability of most of the studied nutrients seems to be adequate after 1-year of storage in most of the tested foods. However, storage temperature of the food must be considered during long-duration space missions to achieve stability of all nutrients. Likewise, more information is needed regarding nutrient retention after 2-years of storage to identify nutritional gaps that may be expected over the 5-year shelf life required for a Mars mission. New developed products will be filling a gap in the current space food system to minimize menu fatigue, provide specific nutrients to reduce the negative effects of long-duration space missions and maintain crew members' health. Information about bioactive compounds in developed products after 1-year and 2-year of storage will provide the knowledge base for further product development.