OPINION

Galactic cosmic ray simulation's effects on food nutrition

Oliver Jonas

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ABSTRACT

Future deep-space exploration missions may have their food prepared in advance of the arrival of the astronauts, exposing it to Galactic Cosmic Rays (GCRs) and solar radiation at higher levels and with different spectra than those encountered in Low-Earth Orbit (LEO). In this work, we assessed the effects of two retort thermostabilized food products that are good providers of radiation-labile nutrients on a GCR simulation at the NASA Space Radiation Laboratory (NSRL) at doses of about 0.5 Gy and 5 Gy (thiamin, vitamin E, or unsaturated fats). The radiation-treated samples and the control samples showed no trends or nutritional changes either immediately following treatment or a year later. Several nutrients saw minor modifications after a year of storage, which were measured. Given that the items in this study were heterogeneous, additional research may be required to corroborate the findings since pouch-to-pouch fluctuations may have obscured significant differences.

Key Words: *Deep-space exploration; Thermostabilized food; Solar radiation; Astronauts; Radiation-treated samples*

INTRODUCTION

Food and the nourishment it provides are essential for maintaining human health, performance, and wellbeing. In order for the crew to continue consuming enough calories and other necessary macro- and micronutrients while still being safe and appetising, the meal must meet these requirements. The majority of food that is shelf stable on earth only needs to be kept fresh and edible for a maximum of two years. Food prepared for upcoming deep-space exploration missions may be prepositioned ahead of the crew, meaning that by the end of a trip, the food may be up to five years old .Inadequate food poses a serious risk to human spaceflight since foods that are stored for such long periods of time go through chemical changes that include vitamin degradation and unfavorable changes to texture and flavour. Additionally, the meals will be exposed to Galactic Cosmic Rays (GCRs) and solar radiation in low-Earth orbit (LEO) beyond Earth's shielding magnetosphere at higher doses and in different spectra than when in LEO (Simonsen et al., 2020 Despite the fact that a prior analysis of five spaceflight foods after 880 days of storage on the International Space Station (ISS) in low Earth orbit (LEO) did not discover any appreciable nutritional differences from ground controls, the food set was restricted in terms of nutritional measures and only contained one high moisture food that would allow for greater radical diffusion . As a result, the study and models developed using the limited data set cannot prove that radiation from sources other than LEO poses no damage to the global food system. The ISS has a conventional food system with more than 200 items, and there are hundreds more that would be suitable for use on exploration missions. The complexity and structure of the foods' compositions vary, and as a result, their stability may change unexpectedly in response to various environmental cues .Additionally, the effects of LEO storage of a high-moisture diet were not previously assessed for thiamin and vitamin E, two nutrients considered to be more radiation-sensitive (WHO 1999). The influence of the NASA Space Radiation Laboratory (NSRL) GCR simulation at two target doses (0.5 Gy and 5 Gy) on the stability of the full nutritional complement in two high-moisture diets was examined in this pilot study, notwithstanding the impossibility of evaluating all potential food combinations. Based on the importance of the mission, an accumulated dose of 0.5 Gy was chosen because a multi-year expedition outside the magnetosphere of Earth would receive this dose (Simonsen et al., 2020; Zeitlin et al., 2013In order to assess the upper limit of the food product's tolerance to radiation exposure, a dose of 5 Gy was used because it is anticipated that no consumables will be exposed to a dose higher than that .The foods were chosen because they include thiamin, vitamin E, or unsaturated fats, allowing for the inclusion of these

Editorial office, Journal of Food and Drug Research, South Hampton, United Kingdom.

Correspondence: Oliver Jonas, Editorial office, Journal of Food and Drug Research, South Hampton, United Kingdom

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radiation-sensitive nutrients in the assessment (WHO 1999). In order to take into account increased radical diffusion and any additional effects from the generation of reactive oxygen species due to the decomposition of water, high moisture spaceflight foods were chosen above freeze-dried and low moisture foods (WHO 1999; Spinks and Woods, 1990). For this study, two items were chosen from the baseline ISS food list maintained by the Space Food Systems Laboratory (SFSL). Thiamin was well-provided by split pea soup, and vitamin E and unsaturated fats were well-presented in seafood gumbo. At the Space Food System Research Facility, both foods were retort processed to commercial sterility in multilayer, high-barrier pouches in accordance with space food production criteria (College Station, TX). For each dose, only 10 packages of each item were treated due to volume restrictions in the beam. Two treatment sets and one control set were delivered overnight to the NSRL. Temperature trackers (Omega, Norwalk, CT) and thermoluminescence dosimeters TLD-100 (LiF:Mg,Ti) measuring 3.2 3.2 0.9 mm3 were transported with samples to prevent freezing .The NSRL GCR full spectrum mixed field beam, previously described, was used for radiation treatments .The exposure for the first treatment set was roughly 0.5 Gy over two hours, and for the second, it was roughly 5 Gy over five hours. To depict the orientation of food storage, stacks of five package were placed in front of the beam. With a target entrance radiation dosage of 0.5 Gy, TLD-100 (LiF:Mg,Ti) dosimeters were placed in front of and behind each package for one set of Seafood Gumbo and one set of Split Pea Soup .In the NSRL facility, the control (unexposed) set was kept at ambient temperature. A temperature data tracker was used to keep an eye on each set. Samples were returned to the Johnson Space Center (JSC) using the same packaging, and measurements of the interaction impact of the categorical variables Dose and Time (Nutritional Value Dose*Time) were each individually examined using ANOVA models. Pairwise comparisons were made using t-tests on the anticipated marginal means where overall statistical significance was determined with the F-test for at least one Dose and Time combination being different from the others. To ensure that the normality assumptions were not broken, residual plots were visually examined. In this pilot investigation on the effects of radiation, numerous nutrients were measured and examined. Due to the small sample size, no attempts were made to remedy the multiple testing issue. All potential impacts were assessed to see if they would provide a nutritionally significant change and if the projected effect was plausible based on dose response. The GLIMMIX method from SAS v9.4 was used for all studies. The LSMEANS statement. Method was used to get pairwise comparisons and estimations.