The Space Food Challenge

The mission of the NASA Food Technology Commercial Space Center (NASA FTCSC) is to lead a national effort to develop foods and food-processing technologies that enhance space missions and advance commercial food products through cooperative efforts with NASA scientists and technologists, commercial companies, and academic researchers.

To accomplish this mission, NASA FTCSC is developing partnerships with commercial companies to meet the challenges of developing food systems for short- and long-term space exploration and habitation. Our commercial partners commit research staff, facilities, and materials to specific product development projects that address the unique requirements of space missions and have application on Earth as well. Commercial partners share the experience of working on a national/international project and maintain patent rights to potential developments.

Among the unique requirements for space are
- low weight, mass, and energy usage;
- minimum food product shelf life of nine months for the Shuttle food system, one year for the International Space Station, and up to five years for planetary outposts;
- a food supply that will be heavily dependent on regenerable crop production (crops to be grown in space are cabbage, carrots, chard, dry beans, lettuce, onions, peanuts, potatoes, radishes, rice, soybeans, spinach, sweet potatoes, tomatoes, and wheat); and
- food-processing systems that operate in microgravity (e.g., the International Space Station) and reduced gravity (e.g., planetary and moon outposts).

The Challenge: Developing New Food Products

To maintain the health of astronauts, foods must be nutritious, palatable, and flavorful. Product research and development are needed in the following areas.
- New food recipes for site-grown crops
- Probiotics
- Neutraceuticals
- Microencapsulated food flavors
- New meal menus and recipes
- Potential products
  - Meal replacement bars that provide one-third of daily calorie and nutritional requirements

  - Products that incorporate 25 grams of soybean per day into astronaut diets
  - Products from low-fat soybeans resulting in reduced flatulence
  - Products that incorporate okara from soymilk production

The Challenge: Developing New Food-Processing Equipment

Environmental constraints require that all equipment be compact, multifunctional, and lightweight. In addition, equipment must use minimal energy for operation, require minimal water for cleanup, be easy to operate and clean, and create minimal air pollution and odors. Research and development are needed for the following equipment.
- Refrigerators and freezers
- Ovens and microwaves
- Extruders, mixers, and grinders
- Equipment for processing whole grains
- Equipment for specific applications
  - Bread from grains
  - Tofu from soybeans
  - Sweeteners from starch crops
  - Oil recovery from grains
  - Meat analogs from grains

The Challenge: Extending Shelf Life

Food products must safely maintain a shelf life of nine months to five years under ambient storage conditions. Some refrigeration and frozen food storage will be available for long-term missions. Research and development are needed in the following areas.
- Packaging material improvements
- Novel compounds to reduce a_w, lipid oxidation, and microbial growth
- Products that prevent or minimize water migration
- Irradiation
- Novel processes such as high pressure, conductivity, and light intensity
- Modified atmosphere packaging and storage
- Accelerated shelf-life protocols for five-year food storage tests
- Potential products
  - Bakery products
  - Naturally dried fruit beverages
  - Meat and egg products
  - Dairy products

The Challenge: Improving and Monitoring Food Safety

Ensuring food safety and preventing the release of pathogenic microbes and undesirable odors are critical to the health and well-being of astronauts. Research and development are needed in the following areas.
- Nondestructive and rapid methods for evaluating food quality and safety inside packages to avoid food poisoning and the release of undesirable odors
- Sample nondestructive methods for rapid confirmation of food safety
- Sensors for rapid online continuous monitoring of food quality and safety
- Targets for food safety: color changes, a_w changes, and toxin detection

The Challenge: Packaging Foods

To ensure extended shelf life and food safety and to minimize weight and waste, new packaging methods and materials are needed. Research and development are needed in the following areas.
- Recyclable or degradable packaging
- Accelerated degradation
- Compatibility with composting
- Multifunctional packaging materials
- New edible food coatings
- Microwave compatible packaging

The Challenge: Developing a Food Waste Management System

In the closed environment of the International Space Station and inhabited outposts, water and air will be recirculated. Research and development are needed in the following areas.

- Accelerated food packaging degradation
- Bioconversion of biomass to useful products
- Equipment cleanup
- Gray water cleanup
- Biofilters for food-processing equipment, waste degradation, and air cleanup
- Unique deodorizing microbial consortia for air biofiltration
- Accelerated biomass hydrolysis via chemical treatment with nonresupplied components
- Bioreactor for wastewater cleanup and recycling
- Mushroom growth on residual biomass

The Challenge: Developing Disinfection Systems

Eliminating pathogenic microbes from the environment and preventing the release of undesirable odors are critical to astronaut health. Research and development are needed in the following areas.

- Disinfection of crops, foods, work areas, and food-processing and preparation equipment
- Odor control
- Disinfection generators from recyclable compounds such as water and air into H_2O_2 and ozone, respectively
- Development of disinfectants that are not harmful to solid and liquid biological waste management systems

The Challenge: Developing Other Food System Components

Numerous other opportunities exist for research and development of products and processes for space food systems. The following are examples of other areas for which research and development are needed.

Producing Cultured Food Products

- Starter culture production and preservation
- Bioreactors for microbial culturing in microgravity
- Potential food products
  - Miso, tempeh
  - Soy sauce, soy yogurt, soy cheese
  - Breads

Solvent-Free Extraction of Oil from Soybeans and Peanuts

- Development of low-fat soybeans
- Microbial oil recovery
- GRAS oil-binding compounds
- Development of unique oil recovery systems and protocols

Using Enzymes in Space Food Systems

- Amylases for production of sweeteners from sweet potatoes and potatoes
- Cellulase and xylanase for accelerated biomass degradation
- Microbial production of enzymes in microgravity and on planetary outposts
- Enzyme concentrates and extended preservation methods
- Development of a process-ready plant for enhanced biomass degradation

For More Information About How Your Company Can Participate in Meeting the Space Food Challenge, Contact:

Dr. Anthony L. Pometto, III
Director
NASA Food Tech. Commercial Space Center
Iowa State University
2901 South Loop Drive, Suite 3700
Ames, IA 50010-8632
E-mail: apometto@iastate.edu
Phone: (515) 296-5384
Fax: (515) 296-6272

or

Sharon Colletti
Administrative and Marketing Manager
NASA Food Tech. Commercial Space Center
Iowa State University
2901 South Loop Drive, Suite 3700
Ames, IA 50010-8632
E-mail: sharonc@iastate.edu
Phone: (515) 296-5385
Fax: (515) 296-6272

NASA FTCSC Internet Site:
http://www.ag.iastate.edu/centers/ftcsc/

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

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Building Partnerships Today, Developing Foods for Tomorrow.

NASA Food Technology Commercial Space Center Iowa State University