

# It is Rocket Science – Food Science for the Rockets

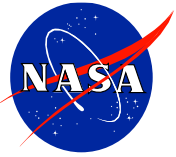
National Aeronautics and  
Space Administration



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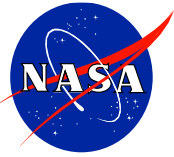


# Food is Essential



- Nutrition
  - Calories
  - Macronutrients
  - Micronutrients
  - Phytochemicals
- Performance
- Crew Morale





# Food Supporting Space Flight



- Pre-flight Health Stabilization Program (HSP) Food Service
- Post-flight Reconditioning Food Support



Avocado Toast, Egg Your Way, Choice of Meat



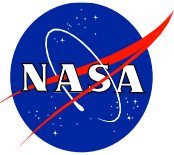
Steak Salad, Poppyseed Fruit Salad



Chicken w Kiwi Mango Salsa, Coconut Rice, Broccoli Carrots



Chocolate Cake with Crew-4 Logo



# Food Supporting Space Flight - History



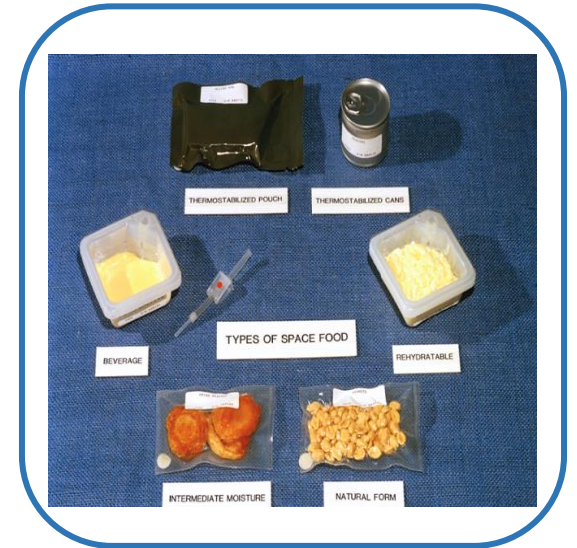
Mercury & Gemini



Apollo



Skylab



Shuttle



# NASA Food Supporting Space Flight - Current



Commercially Sterile Food



Rehydratable Food



Intermediate Moisture



Natural Forms & Condiments



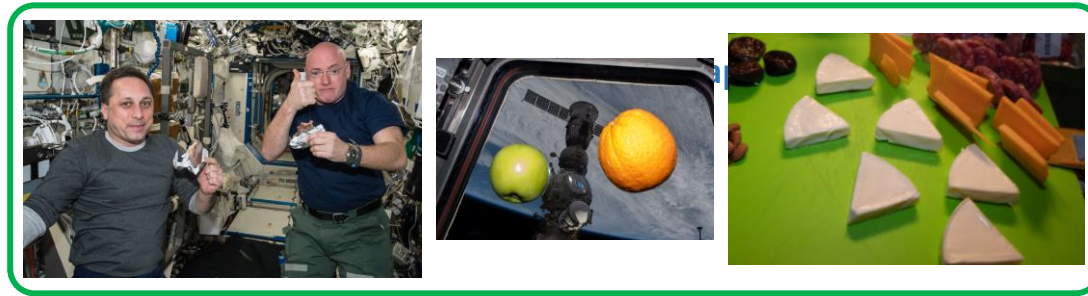
Bulk Overwrap Bag (BOB)



Beverages

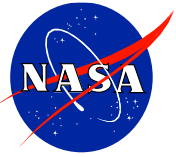


Crew Preference & Holiday



Specialty Kits

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# Dining on ISS



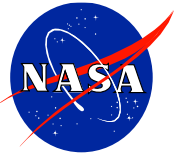
Galley (Water, PWD, Food Warmer)  
Crewed vehicle may be different



S129E007955

Micro Gravity





# ISS Food System Composition



- Standard Menu Containers ~75%
- Specialty Containers ~25%
  - Crew Specific Menu (including International Partner foods)
  - Coffee Tea Preference
  - Shelf Stable Food Kit
  - Fresh Food Kit
  - Cold Stowage Kit
  - Holiday BOB
  - Science Containers
- Others (subject to SFSL approval) ~1%
  - Crew Care Package
  - Frozen Treats



BOB, 2~8kg  
(14.875"x12"x4.875")

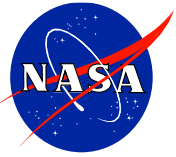


12"x12" Zippers



1/2 Cargo Transfer Bag

*Containers and its corresponding packaging types are color coded.*

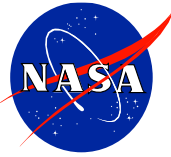


# ISS Standard Menu Containers



- “Pantry” shared by all USOS crewmembers
- Pre-packaged shelf stable foods with 3-year shelf life
- About 200 items on the Standard Menu
- 11 Categories
  - Beverage and Straws
  - Breakfast
  - Desserts & Snacks
  - Fruit & Nuts
  - Meat & Fish
  - Rehydratable Meats
  - Side Dishes
  - Vegetables & Soups
  - Nutrition Bars
  - Tortillas
  - Condiments
- Inventory and resupply rate are tracked at container level by each categories

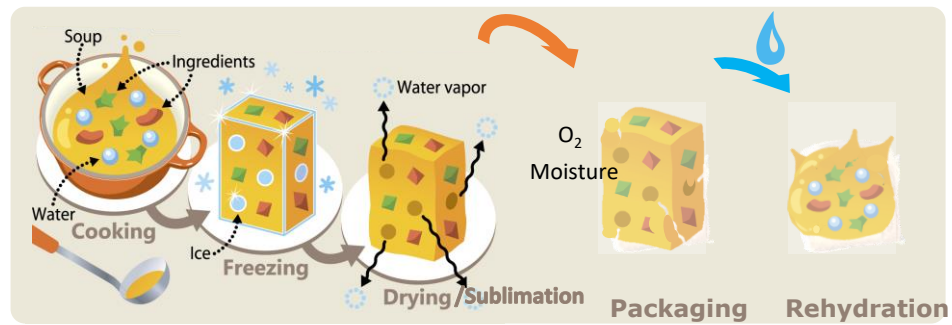




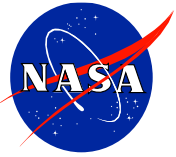
# Types of Space Food: Freeze-dried Food



- Produced in a commercial freeze dryer
- The food is first frozen, then freeze dryer pulls a vacuum
- Ice sublimates out of food into water vapor to reach low water activity which inhibits spoilage
- Preparation: foods are rehydrated on the ISS with the Potable Water Dispenser (PWD)



Pasta with Shrimp



# Types of Space Food: Thermostabilized Food

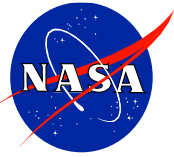


- Produced in a commercial retort at Space Food Research Facility
- It uses high temperatures to preserve and ensure the safety of food, based on the effect of microbial destruction
- Final products are commercially sterile for room temperature storage
- Preparation: None or heating



Chicken Fajitas

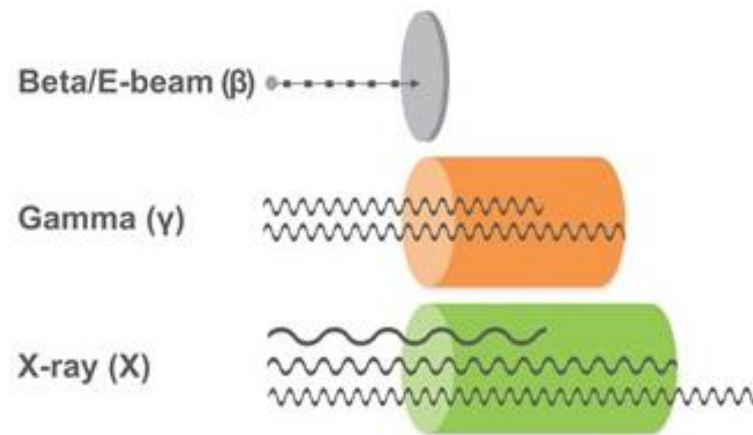




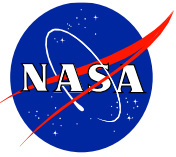
# Types of Space Food: Irradiated Food



- FDA approved 3 sources of irradiation for use on food
- Irradiated by a commercial irradiation facility using Gamma ray
- Resulting food is commercially sterile for room temperature storage
- Packaging: same as the thermostabilizing pouches
- Preparation: None or heating



BBQ Beef Brisket

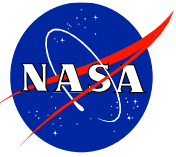


# Types of Space Food: Natural Form Foods



- Natural Form Foods rely on reduced water activity, preservatives (dried fruit), and oxygen scavengers to prevent microbial activity
- Preparation: None



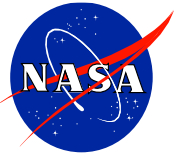


# Types of Space Food: Beverages



- All ISS Food System beverages are powdered COTS beverages packaged in beverage pouches by SFSL
- No beverages are flown to the ISS in hydrated form
- The low water activity prevents microbial activity and saves upmass
- Straws are required to drink from the self-sealing beverage pouch
- Preparation: beverages are rehydrated on the ISS with the Potable Water Dispenser (PWD)



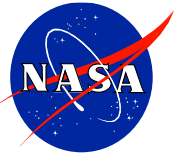


# Types of Space Food: COTS

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- COTS (Commercial Off The Shelf) food items are defined here as commercially available foods that are not repackaged by the Space Food Systems Laboratory.
- Examples: condiments, bars, etc.

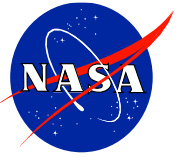


# Types of Space Food: Fresh Food



- Fresh Food Kits (FFKs) contain fresh fruits and vegetables that can be sent for late load onto vehicle
- All items flown are crew requested. Previously flown items include apples, citrus, garlic, and carrot sticks, etc.





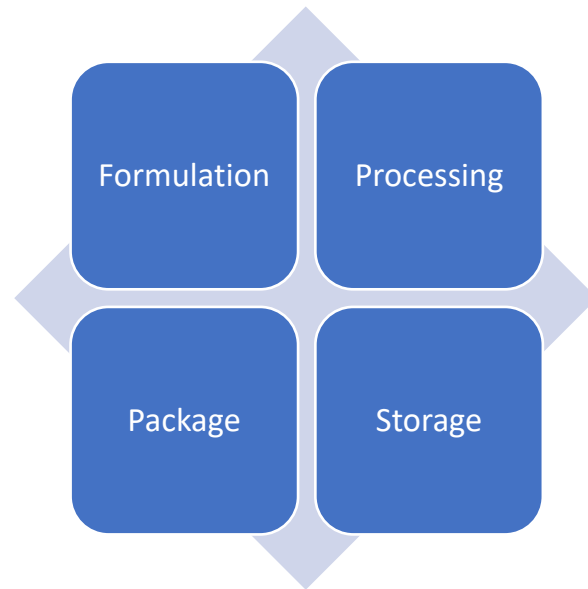
# Space Food System Requirements



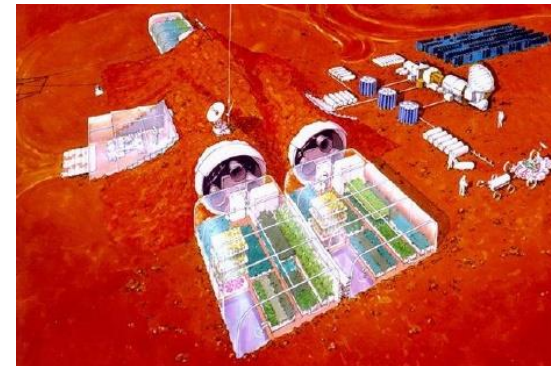
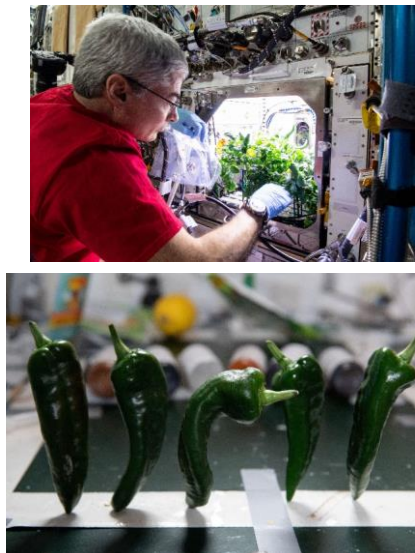
- Providing safe, nutritious, palatable, and sufficient food throughout shelf life.
  - **Safety**
    - ✓ Safe to **consume** throughout 3-year shelf life for ISS (micro, aw/moisture, packaging integrity, etc.)
    - ✓ Safe for space **flight** (FOD, ethanol, packaging material test, etc.)
  - **Nutrition**
    - ✓ Nutrient retention while meeting **safety** requirement
    - ✓ A food system with **balanced** nutrition
    - ✓ Nutrient degradation throughout **shelf life**
  - **Palatability**
    - ✓ Relatively small but diverse target consumer group with personal **preference**
    - ✓ Maintaining acceptability while meeting safety and nutrition requirement throughout the **shelf life**
  - **Sufficiency**
    - ✓ **Variety** needed to overcome menu fatigue – opposite of food industry (less variety, bulk quantity)
    - ✓ Sufficient reserve **inventory** in the event of cargo vehicle slip
    - ✓ Weight and volume constraint on cargo vehicles limiting food quantity

- A **COMBINATION** of pre-packaged shelf stable food, bioregenerative fresh produce, and potentially other technologies to address nutrient degradation and variety scarcity.

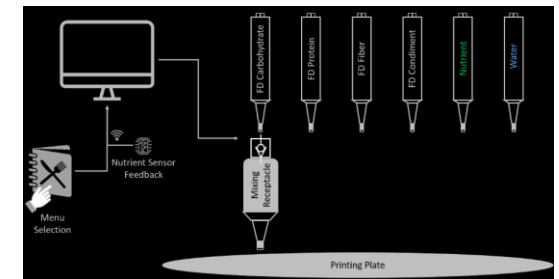
Pre-packaged shelf stable food

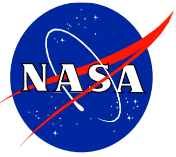


Bioregenerative food



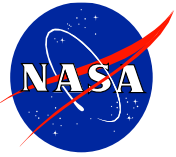
3D Printing of Freeze-Dried Ingredients





Thomas Marshburn: It's nothing short of miraculous y'all can put this all together and send it all around the world not knowing where it's going to launch from and still be good even after a year after sitting up on orbit. So really appreciate all the amount of expertise and work that goes into that.





# Space Food Trivia



**NASA invented Tang?**



**Astronauts eat freeze-dried ice cream?**



**Today's urine is tomorrow's coffee?**



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Courtesy Reference: <https://www.mondelezinternational.com/Our-Brands/Tang>

[https://www.amazon.com/Space-Ice-Cream-Count-Neapolitan/dp/B07CGXDNNW/ref=sr\\_1\\_13?keywords=Space+Ice+Cream&qid=1580003410&sr=8-13](https://www.amazon.com/Space-Ice-Cream-Count-Neapolitan/dp/B07CGXDNNW/ref=sr_1_13?keywords=Space+Ice+Cream&qid=1580003410&sr=8-13)

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