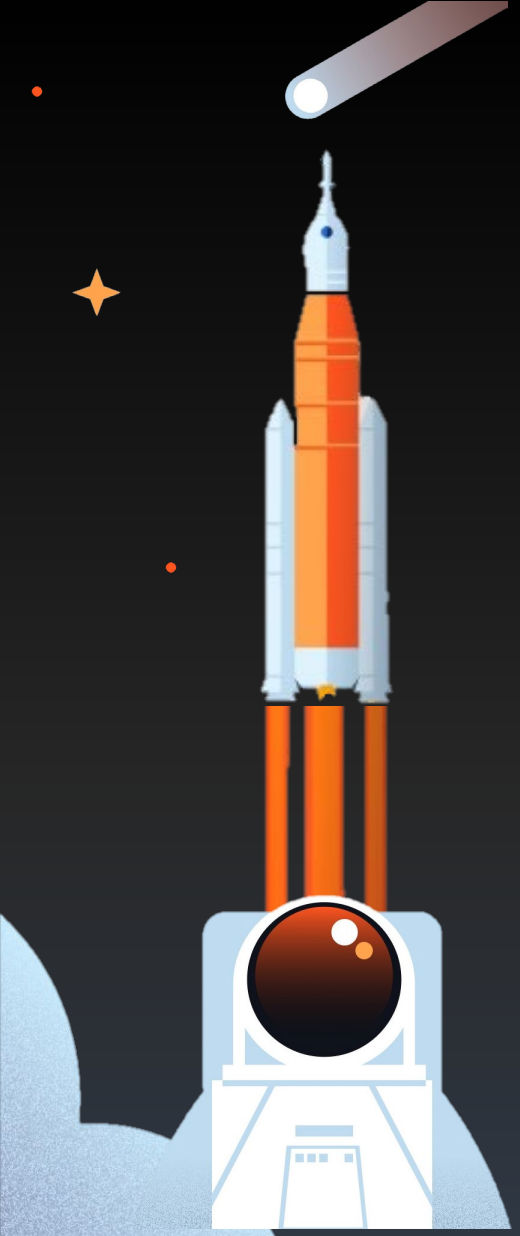

# MICROBIAL SURVIVAL IN BREWED TEA

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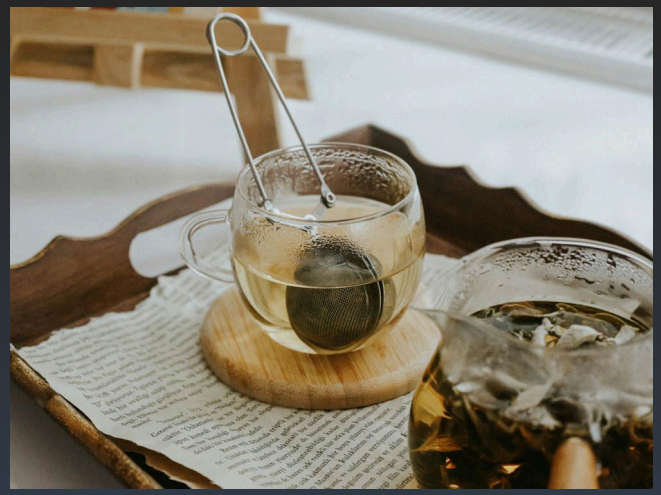
2024 Human Research Program

Investigators' Workshop

# Providing Loose-Leaf Tea in Spaceflight

- Loose-leaf bagged tea is a common crew request
  - Up to 7% of samples in the spaceflight food system
- Physical and mental wellbeing
- Tastes are varied and specific



# Microbiology of Loose-Leaf Tea

- No existing FDA standard for microbial limit on dried teas in the US
- Some teas are dried in the sun—increased potential exposure to birds, bugs, etc.
- Non-homogenous mixture


http://en.people.cn/n/2015/0706/c90782-8916318-2.html

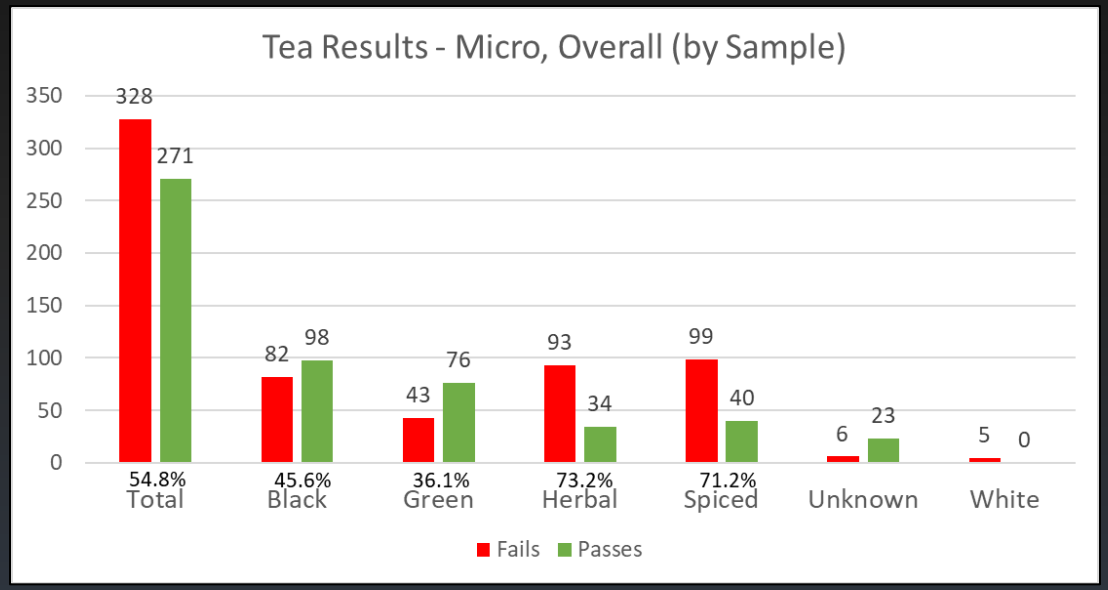
# Foodborne Illness and Tea

- Teas are considered to be generally safe because brewed tea is prepared with boiling water for 3-5 minutes (Virginia Department of Health*)
- Known Outbreaks:
  - 2003, Germany – *Salmonella* Agona (Koch et al, 2005, Emerg Infect Dis 11(7):1124-1127)
  - 2008, Serbia – *Salmonella* Senftenberg (Ilic et al, 2010, Emerg Infect Dis 16(5):893-895)
  - 2017, United States – Salmonella (CDC, 2018 https://www.cdc.gov/salmonella/kratom-02-18/)
- Many teas contain herbs and spices, which are associated with a number of outbreaks (28 between 1973 and 2012 – WHO)

*This is also frequently attributed to CDC, but the original document is not available

# Loose-Leaf Teas in the Spaceflight Food System

- ISS-Specific micro requirements
  - Total aerobic: more than one sample exceeds 10,000 CFU/g OR one sample exceeds 20,000 CFU/g
  - Enterobacteria: more than one sample exceeds 10 CFU/g, OR one sample exceeds 100 CFU/G, OR any pathogenic EB detected
  - Any Salmonella detected
  - Yeast/Mold: more than one sample exceeds 100 CFU/g, OR one sample exceeds 1000 CFU/g, OR more than 10 CFU/g *Aspergillus flavus* detected
- High rate of failure
- Herbal teas and teas containing spices are more likely to fail
- No trends associated with brand or specific ingredients




Data from 04/04/2019-09/08/2022

# Brewing Tea in Spaceflight

- "Danger Zone" – Food temperature at which microbial growth is not inhibited; high-moisture food should not be stored in this temperature range for longer than 2 hours
  - 40 °F – 140 °F (4.44 °C – 60 °C) (CDC)
- Lowest acceptable temperature for hot water dispensed from ISS PWD is 155 °F/68 °C
  - Below the recommended temperature for safe tea brewing
- Astronauts are instructed to drink tea within a 2-hour period

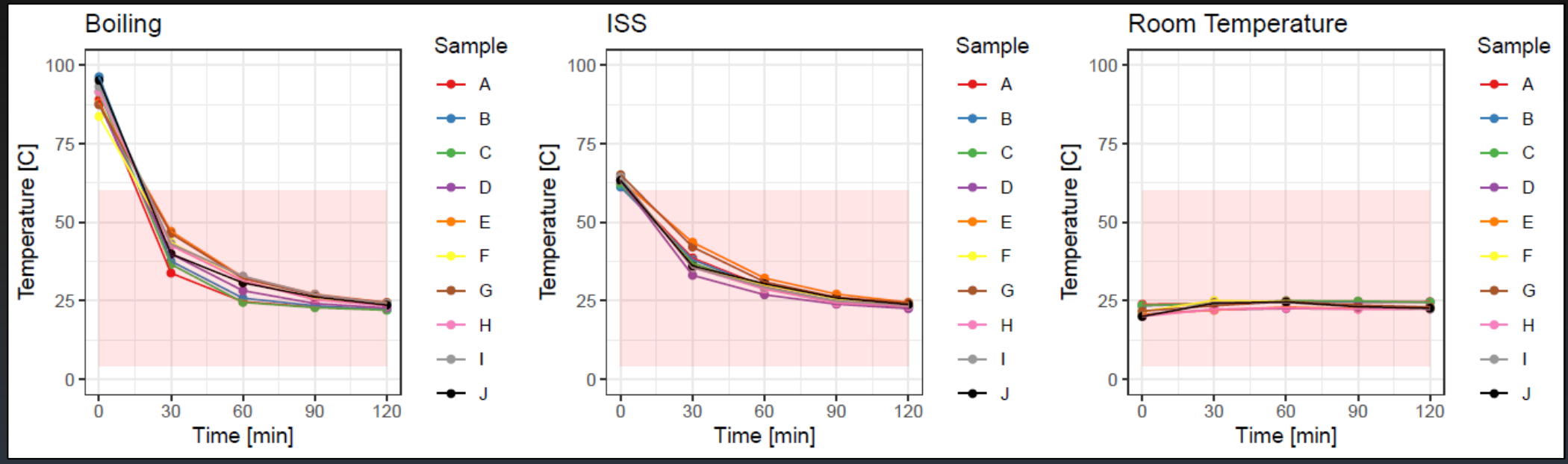
# Study Objective

- Loose-leaf bagged teas are tested for microbial concentrations as dry, unbrewed tea bags
- Tea is brewed on ISS in hot water before consuming
- We aimed to assess the effect of brewing temperature on the microbial concentration in teas to determine if there is a difference in risk between dry, unbrewed tea bags and brewed teas
- Potentially increase the micro limits for brewed teas to support more crew requests

# Method

- Chamomile tea bags from the same brand and lot were spiked with 3.47 ± 1.66 x $10^4$ CFU *Bacillus cereus*, a heat-resistant foodborne pathogen that has been found in dried teas (Messelhausser et al, 2014, BioMed Res Int 465603; El Saleeby et al 2004, Clin Infect Dis 31(10):1536-1539)
- Boiling (100 °C), ISS-like (68 °C), or room temperature (20-22 °C) water was added to each tea bag, which steeped at ambient temperature
  - 75 mL water added, so the total expected *B. cereus* concentration is 460 CFU/mL
- The tea was sampled immediately after adding water, and then every 30 minutes for 2 hours to simulate the allowed consumption time on ISS
  - The water temperature was recorded at each sampling
- Each sampling was assessed for total microbial and *B. cereus* concentrations

# Tea Brewed with ISS-Temperature Water Immediately Enters the “Danger Zone”

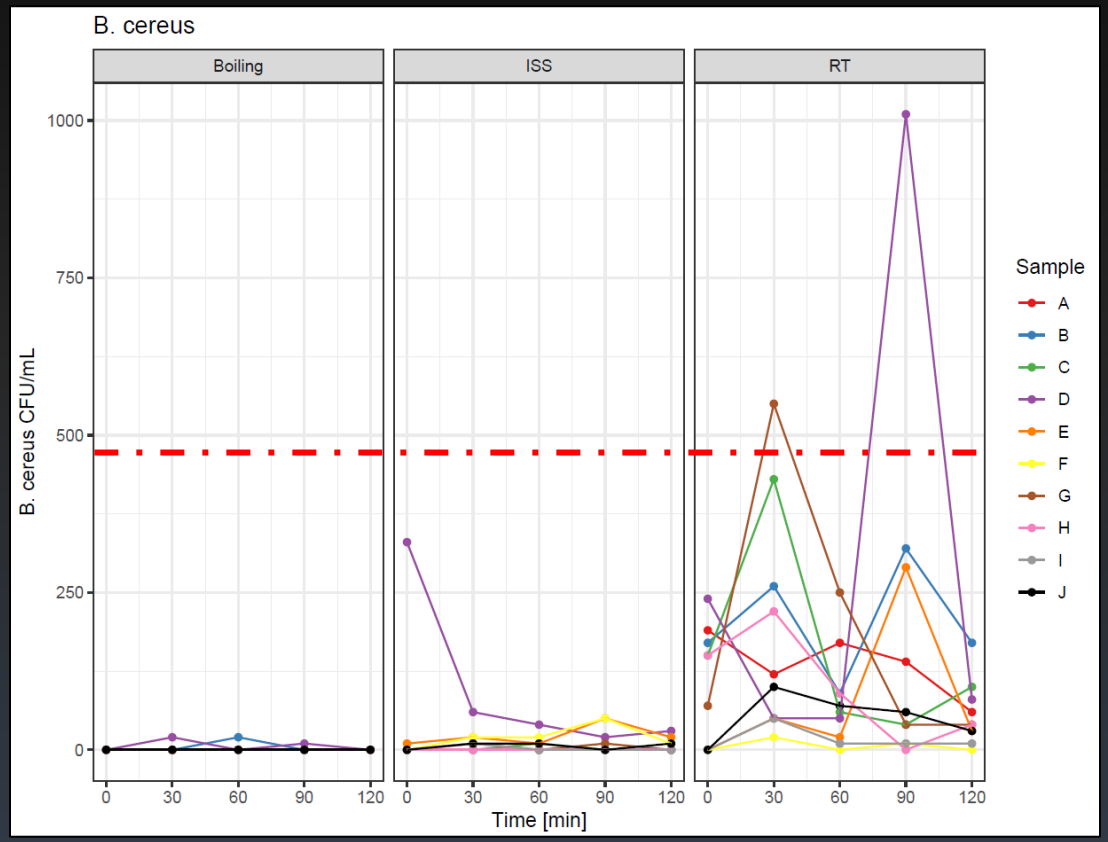



Red = “Danger Zone”

# *B. cereus* Concentration

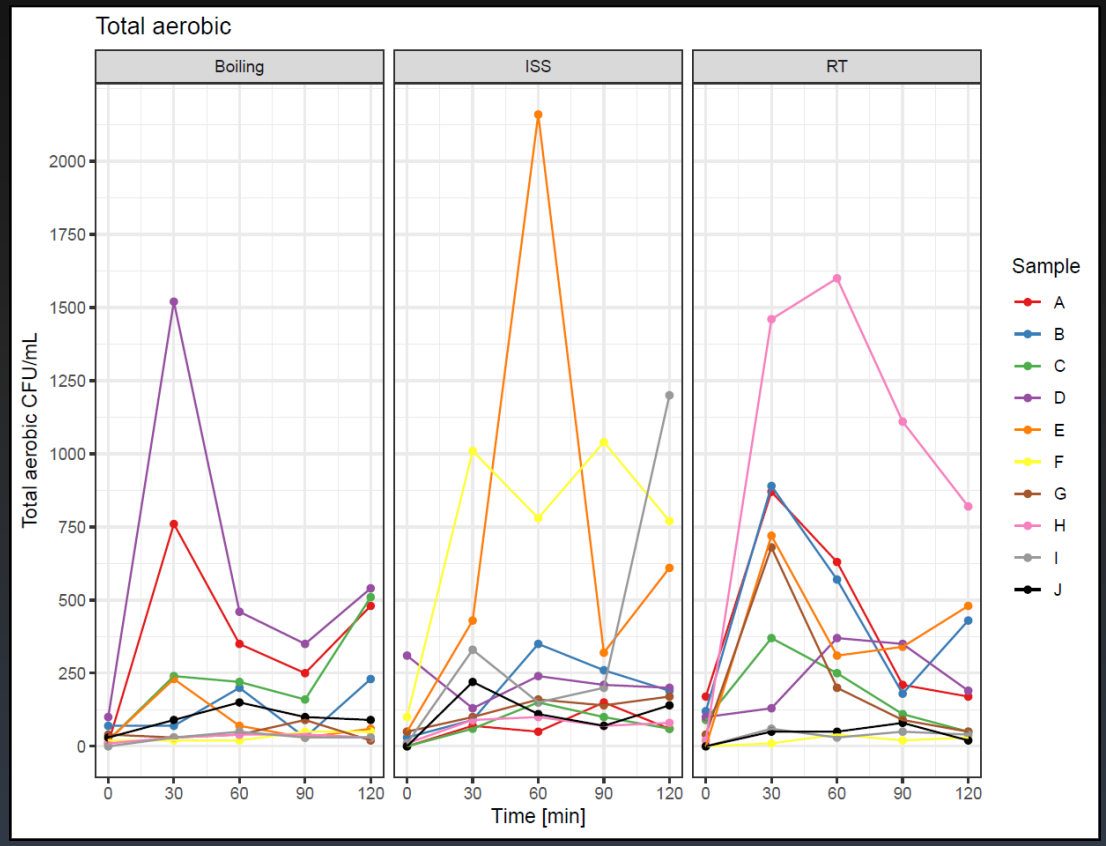
- Although boiling water was not sufficient to completely kill *B. cereus*, the microbial load was below a reported infectious dose
- *B. cereus* was detected in 70% of tea bags brewed with ISS-temperature water
  - Notably, in one case *B. cereus* was detected above a reported infectious dose of 200 CFU/mL

Red dash = *B. cereus* inoculation dose



# Total Microbial Concentration

- There is no significant difference of microbial tea load due to brewing temperature at any time point (p = 0.535, ANOVA)
- 60-90 minutes after addition of water, the microbial population declines
- The population begins to increase by 120 minutes
- Differences between tea bags are highly variable



# Conclusions

- Tea brewed with ISS PWD water dispensed at the lowest acceptable temperature immediately enters the “Danger Zone” for food safety, but consumption time is limited to 2 hours
- ISS PWD-temperature water reduces the load of *B. cereus*
- Water brewing temperature does not affect the total microbial load of brewed teas in the conditions we used, even in the case of boiling water
- Bag-to-bag variability in microbial concentration underscores the importance of using large sample sizes when evaluating teas provided for consumption in spaceflight

# Future Directions

- A follow-up study to investigate the effect of brewing temperature on other tea types that have high failure rates to determine the risk of increasing the microbiological limit for loose-leaf teas