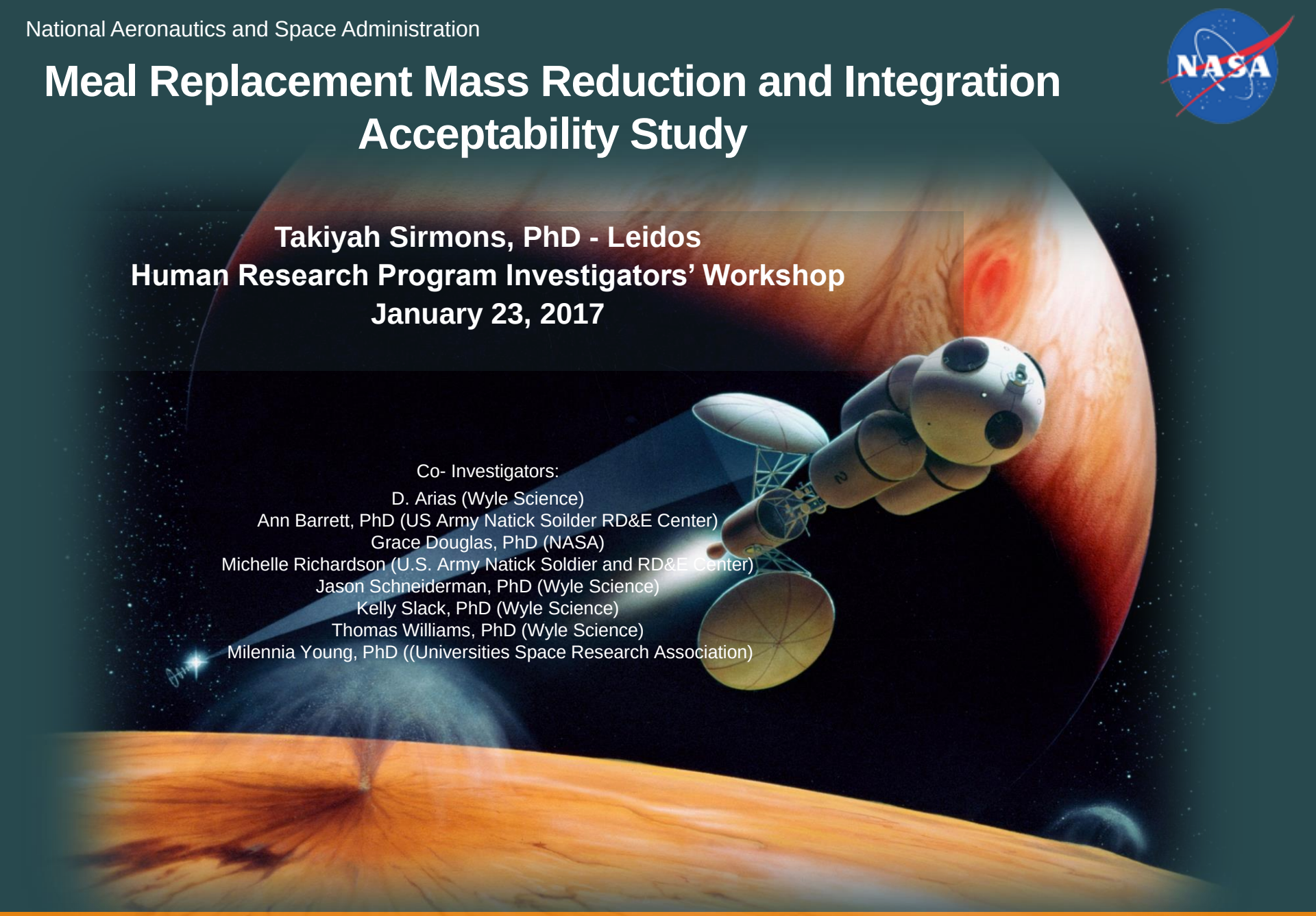
# Meal Replacement Mass Reduction and Integration Acceptability Study

**Takiyah Sirmons, PhD - Leidos**

**Human Research Program Investigators' Workshop**

**January 23, 2017**



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# Study Aims

- Develop 4 calorically dense meal replacement bars
- Determine the microbiological, nutritional, and sensory shelf-life over two years
- Determine an acceptable implementation schedule using the Human Exploration Research Analog (HERA)

# Background

- The Orion MPCV does not have up mass and volume to support the current food system
- NASA is challenged to provide a 10% food mass savings, while preserving nutrition, acceptability and safety
- Cannot be achieved via beverages or freeze-dried foods because both require water

# Bar Requirements

- Target caloric density of ~4.1kcal/g
- Target 35% fat
- Water activity of 0.6 or below
- Full nutritional replacement of the average spaceflight menu breakfast
- Maintain sensory acceptability with minimal bar hardening over time

# Bar Types

| | Savory | Sweet | Chocolate | Fruity | Cake Bar | Nut Bar |
|---|---|---|---|---|---|---|
| Banana Nut | | X | | | X | |
| Chocolate Peanut butter | | | X | | X | |
| Cinnamon Roll | | X | | | X | |
| Ginger Vanilla | | X | | | X | |
| Hickory Smoked BBQ | X | | | | | X |
| Jalapeno Nut | X | | | | | X |
| Maple Bacon | X | X | | | | X |
| Orange Cranberry | | | | X | X | |

**Ginger Vanilla Bar**
701.6 kcal per serving
4.3 kcal/g

**Banana Nut Bar**
702.4 kcal per serving
4.08 kcal/g

**Orange Cranberry Bar**
704.4 kcal per serving
4.1 kcal/g

**Cinnamon Roll Bar**
701.1 kcal per serving
4.0 kcal/g

**Jalapeño Nut  Bar**
700.9 kcal per serving
3.8 kcal/g

**BBQ Nut Bar**
702.5 kcal per serving
3.9 kcal/g

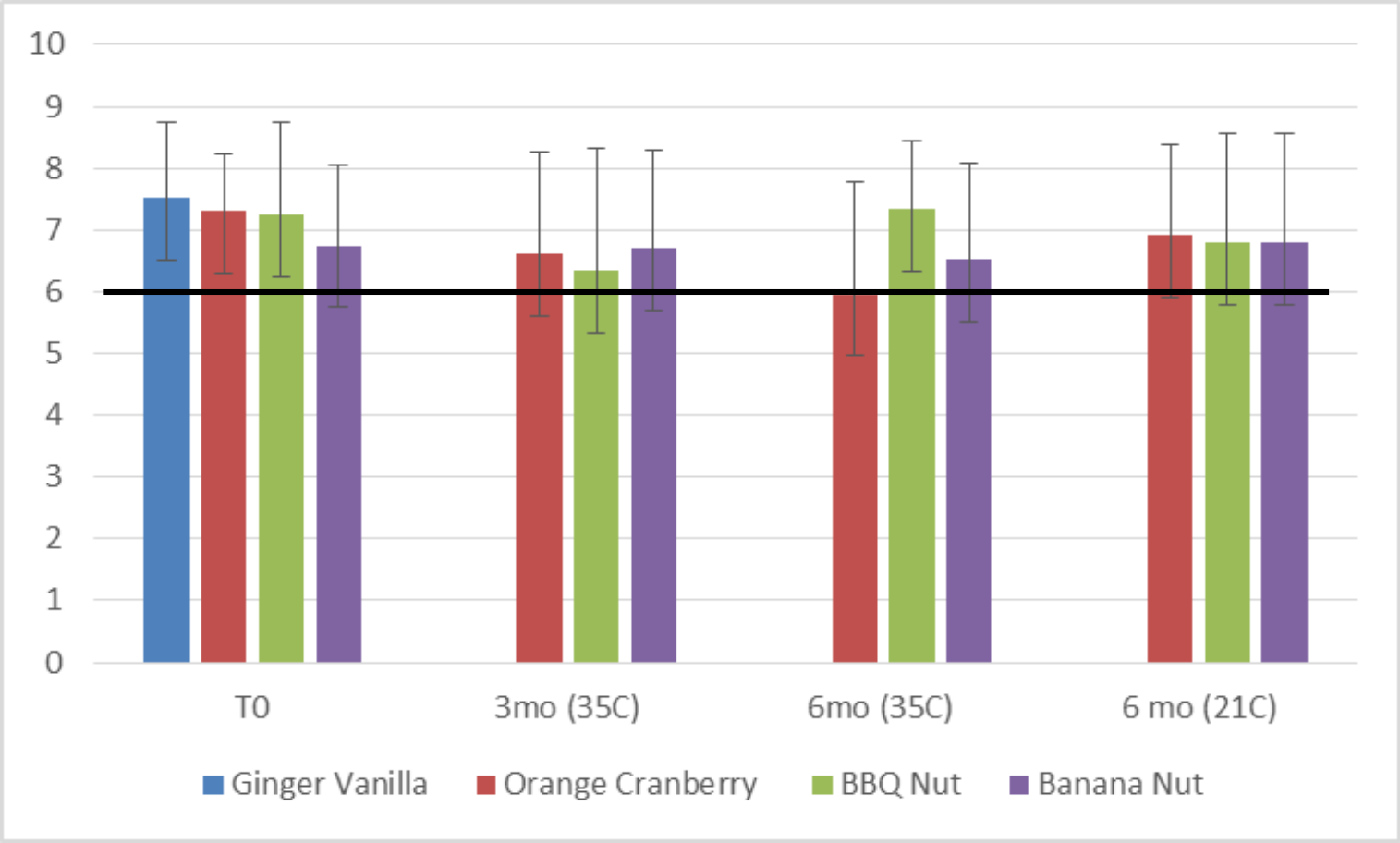
**Maple Bacon Nut Bar**
700.7 kcal per serving
3.8 kcal/g

**Peanut Butter Chocolate Bar***
711.2 kcal per serving
4.4 kcal/g

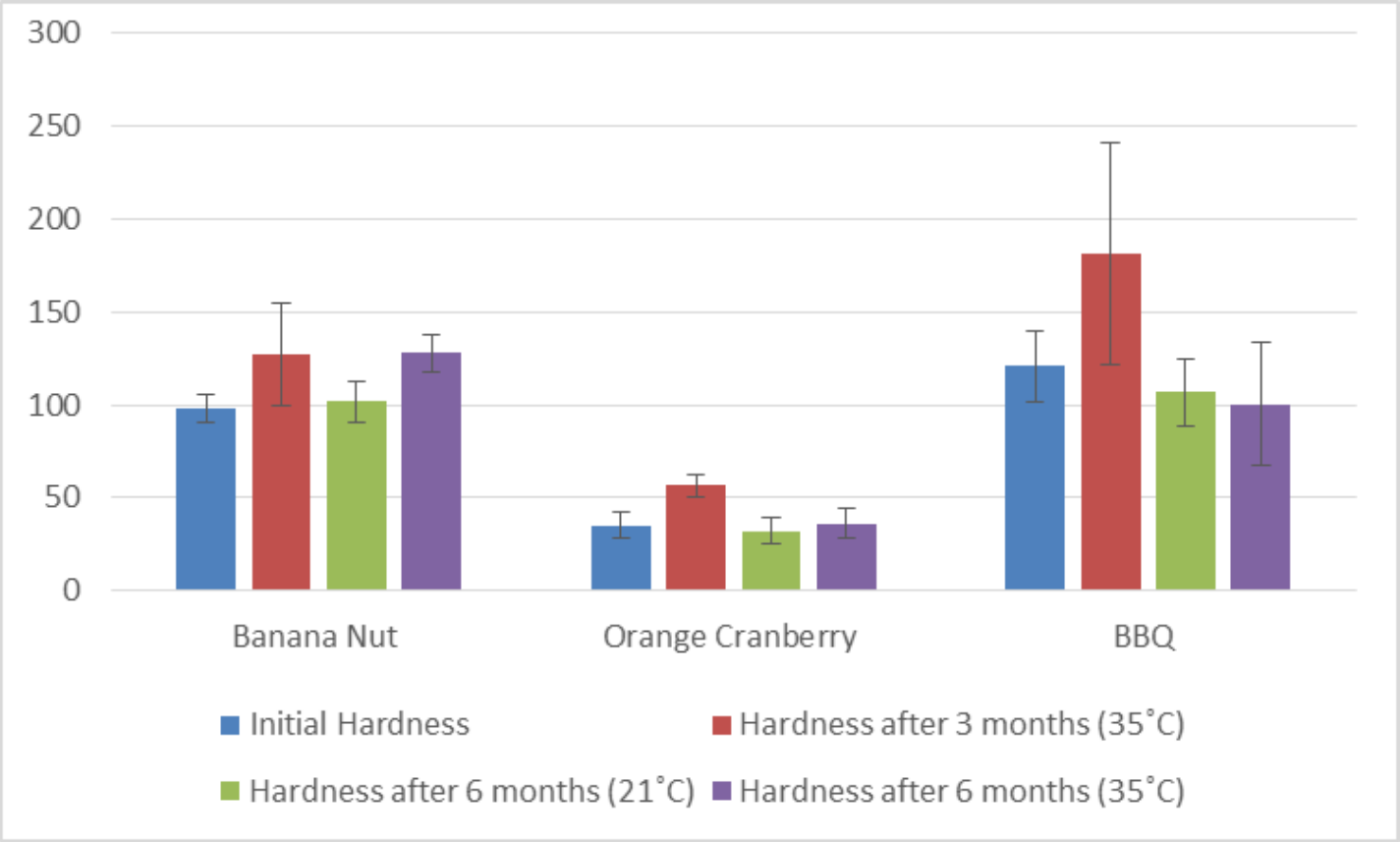

CARVER
HOBART


BRANSON

# Overall Acceptability Over time

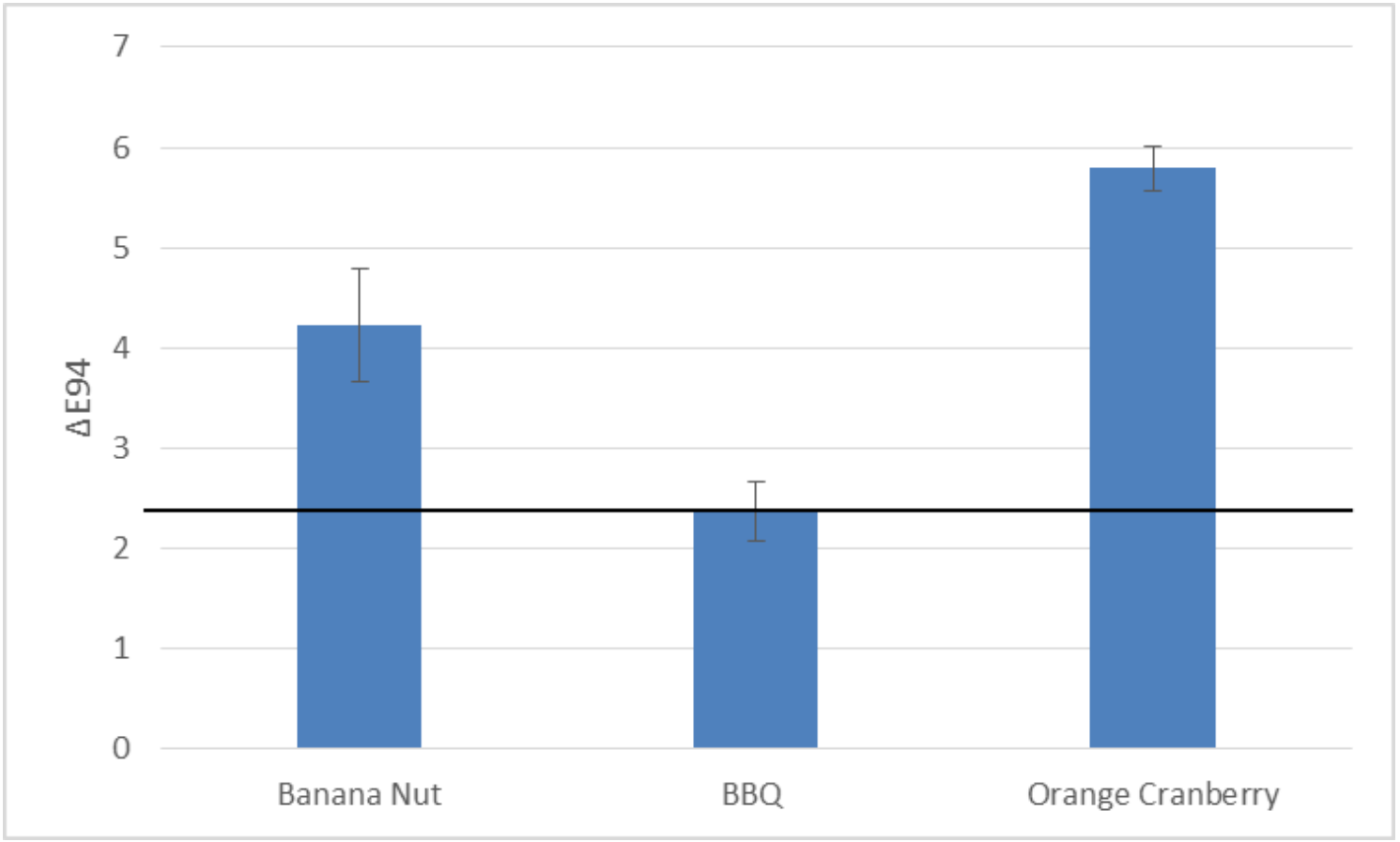


# Texture Change Over Time



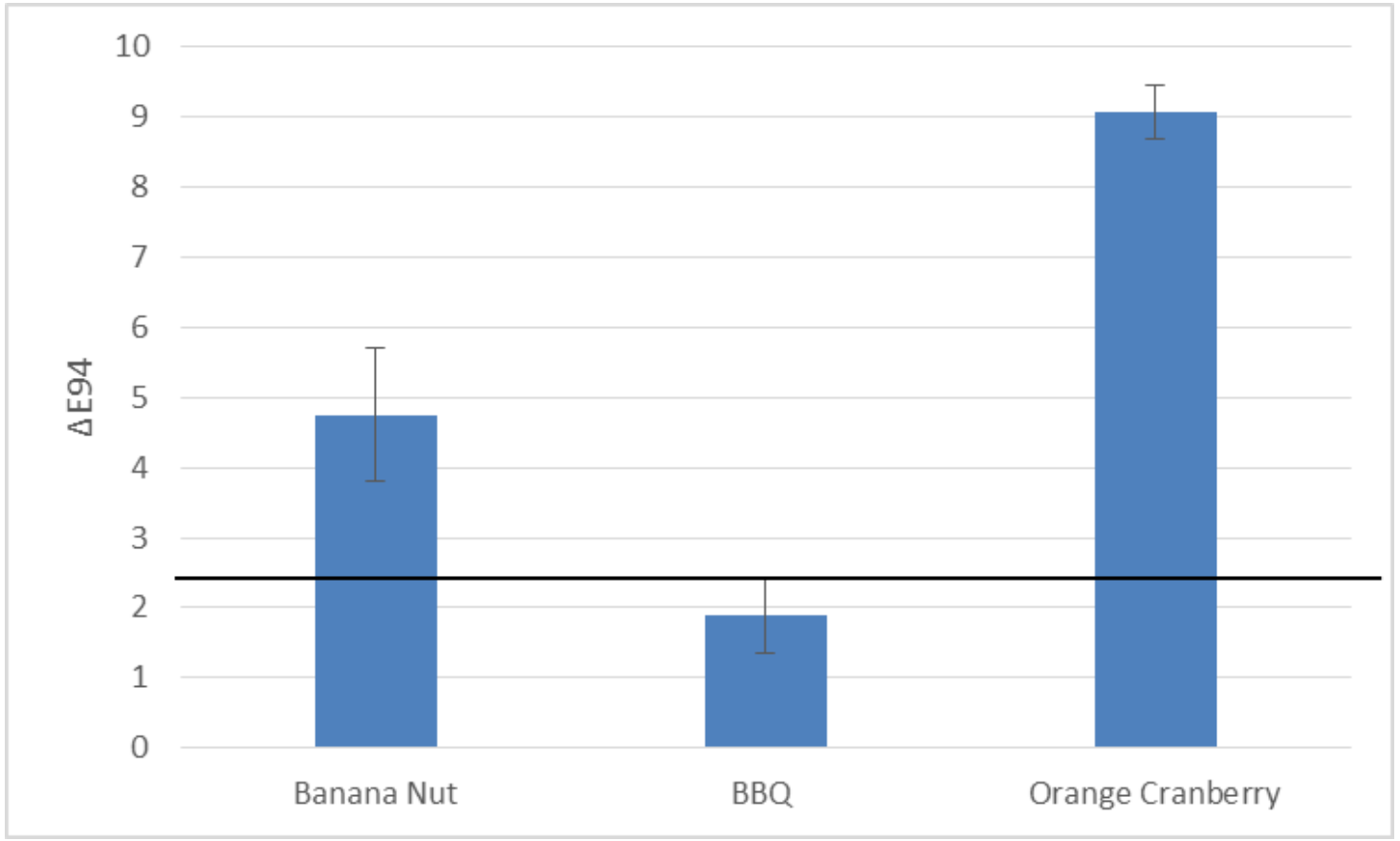

Ginger Vanilla not included in this analysis

# Color Change After 3 mo (35˚C)



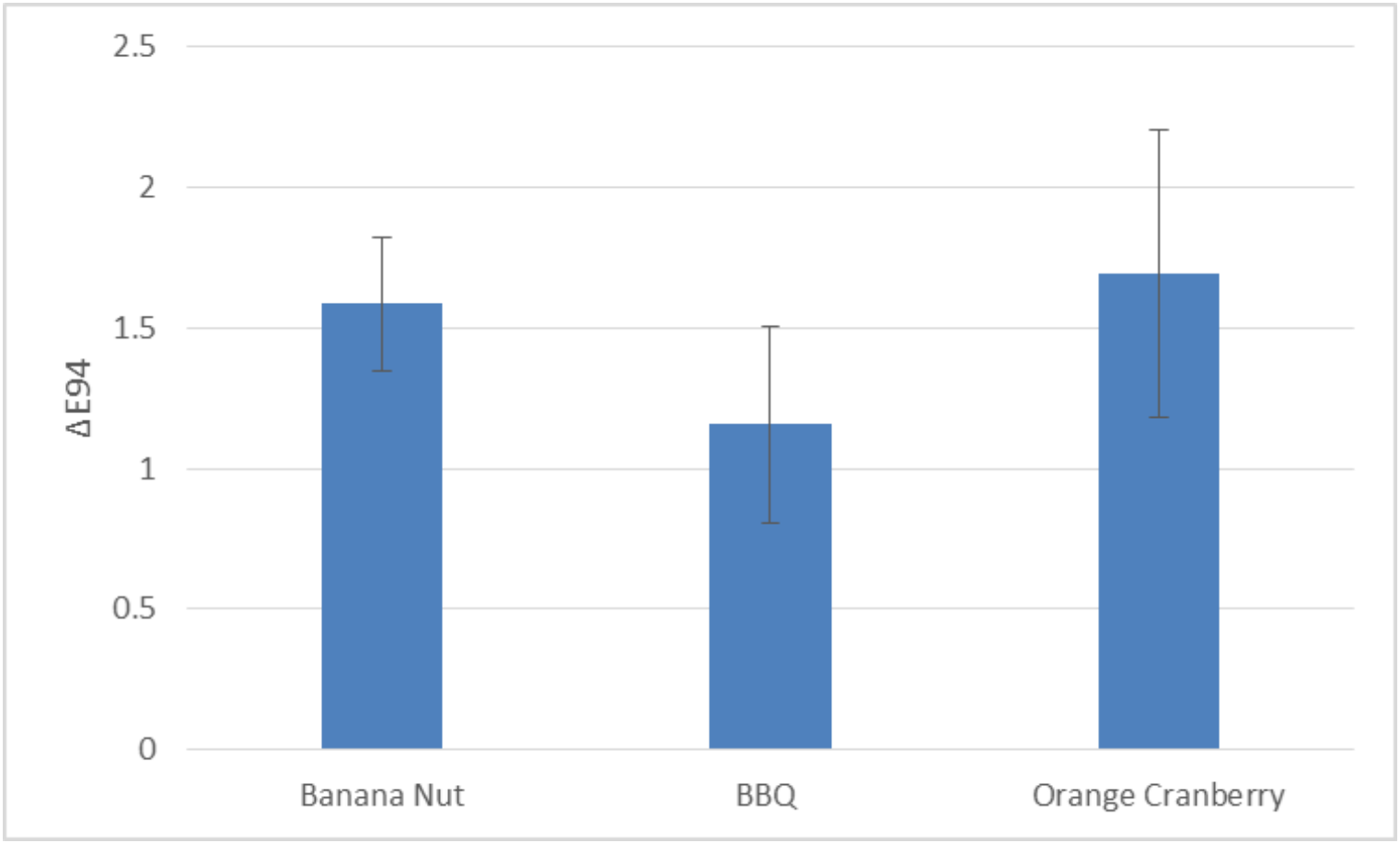

Ginger Vanilla not included in this analysis

# Color Change After 6 mo (35˚C)




Ginger Vanilla not included in this analysis

# Color Change After 6 mo (21˚C)

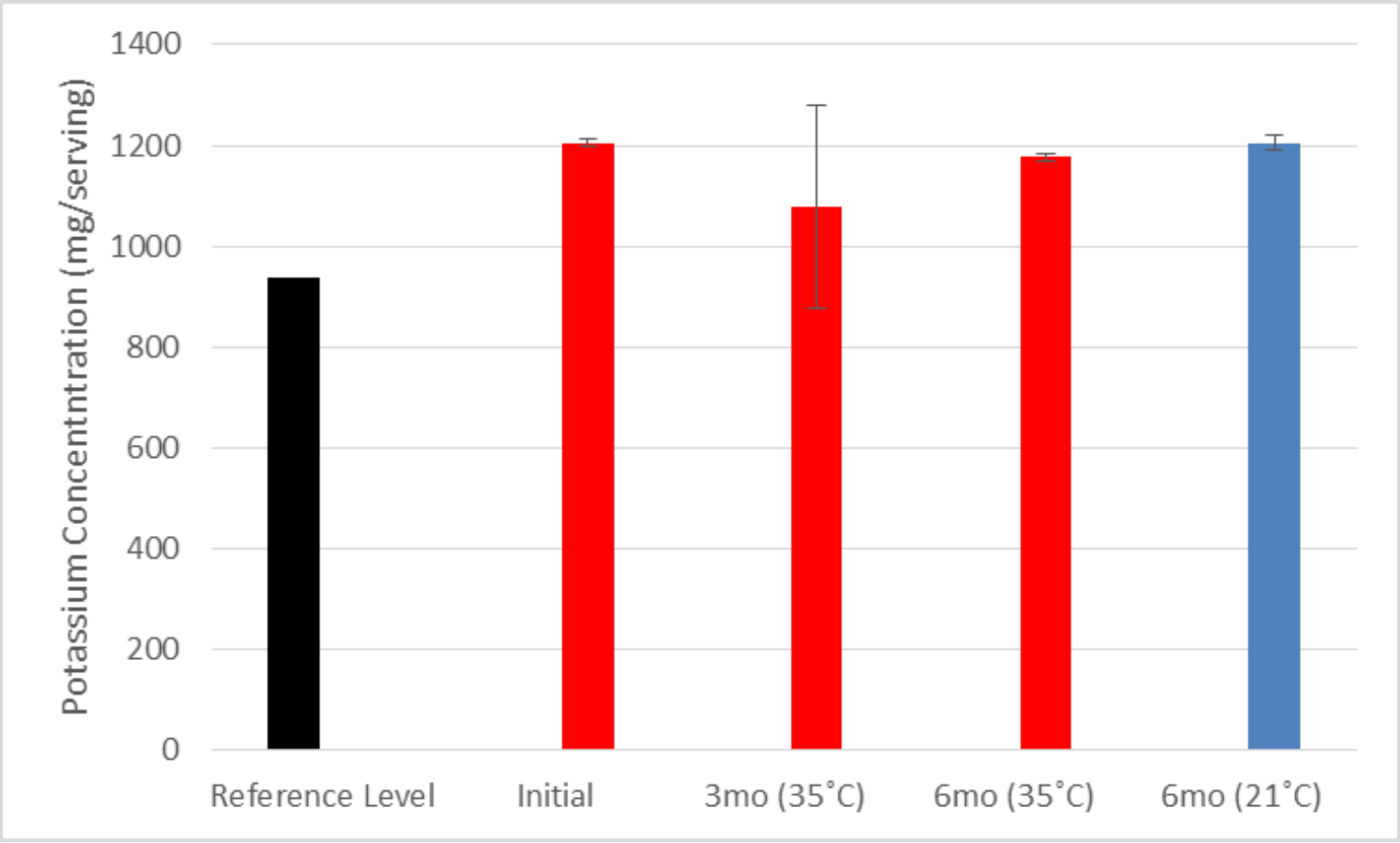



Ginger Vanilla not included in this analysis

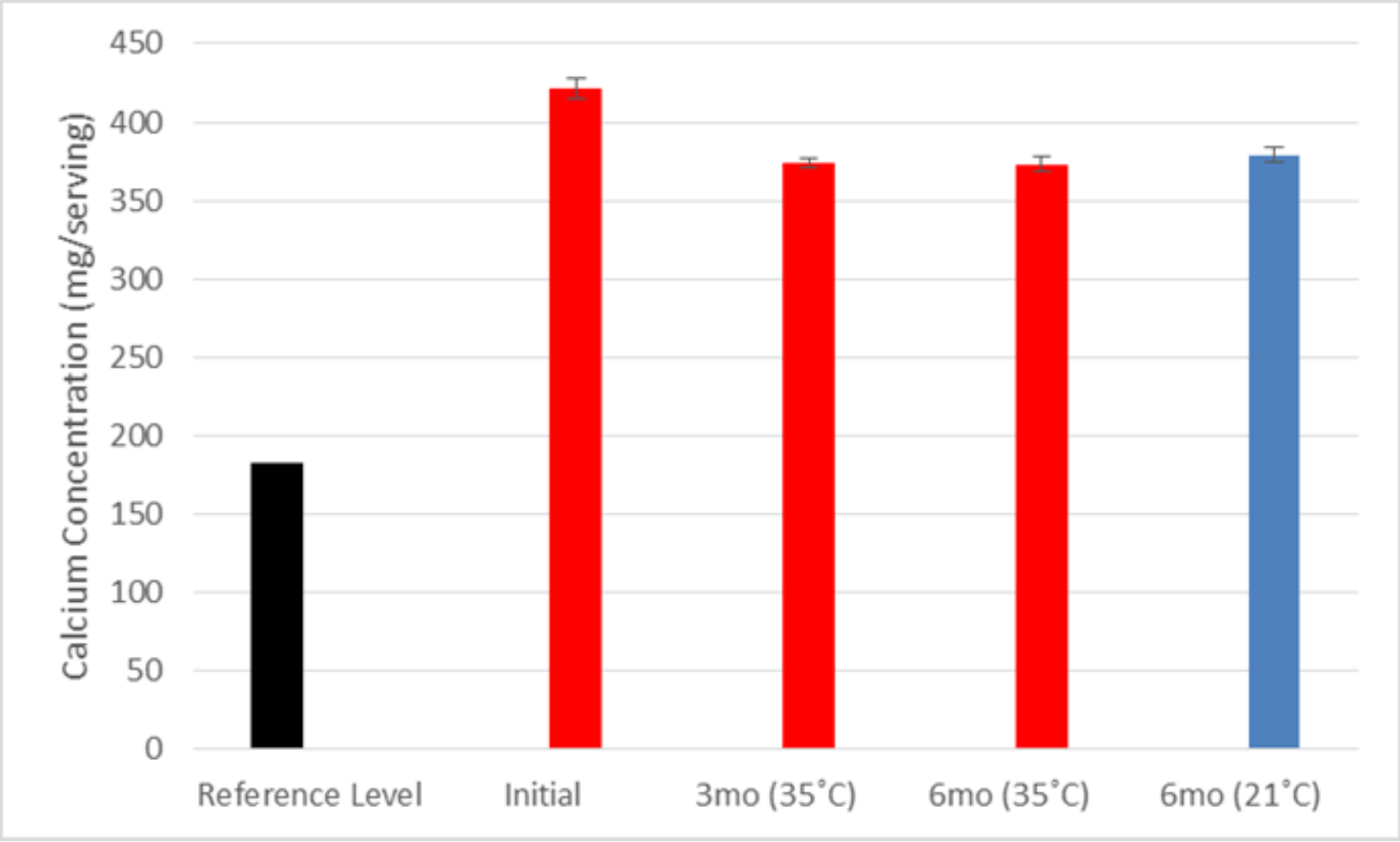
# Nutritional Analysis

- Banana Nut Bar was fortified with a premix containing:
  - Folic Acid (25%)
  - Thiamin (31%)
  - Vitamin B12 (62%)
  - Vitamin C (17%)
  - Vitamin K (20%)
  - Calcium (16%)
  - Potassium (5%)

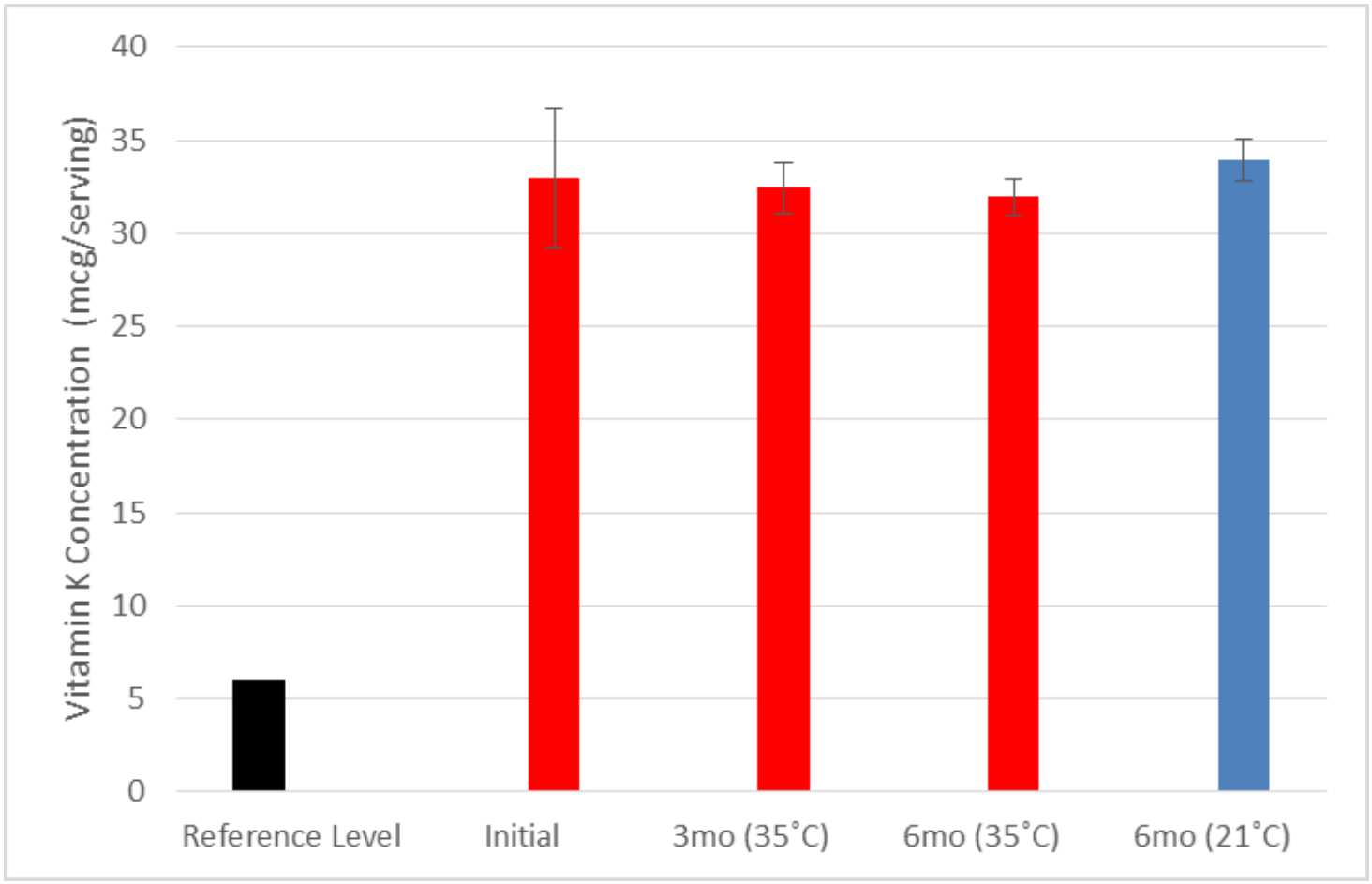
# Potassium Content



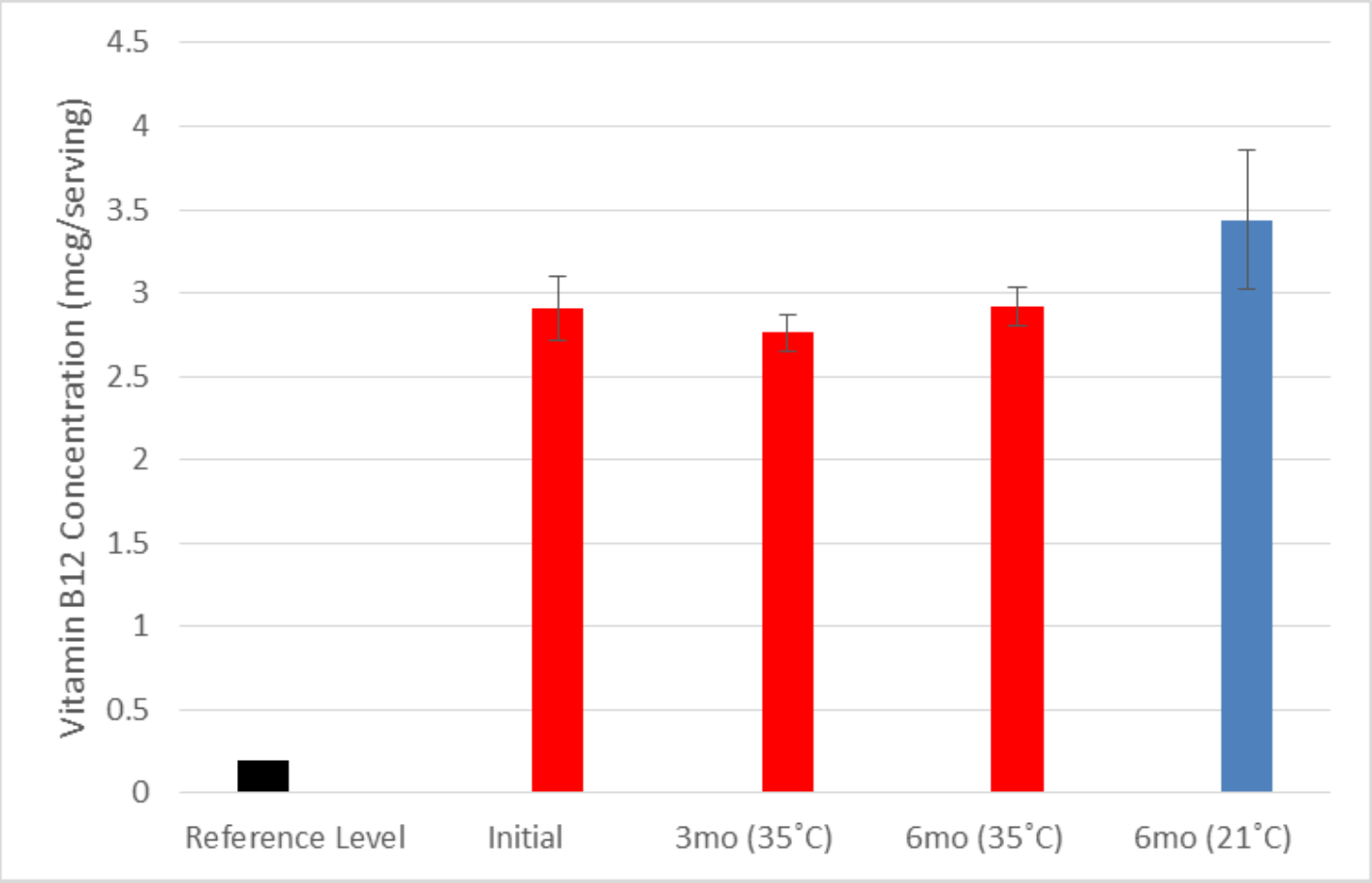
# Calcium Content



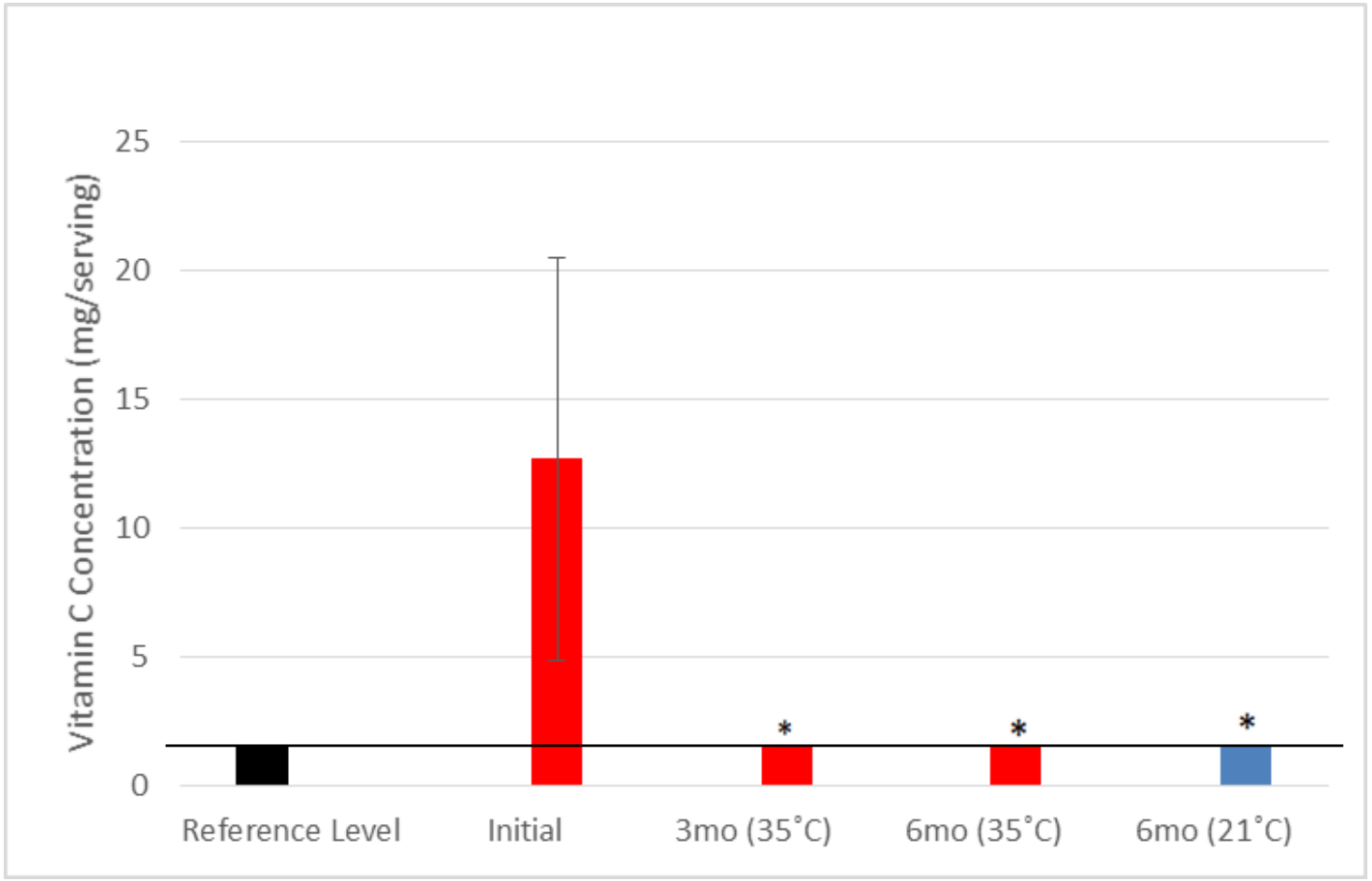
# Vitamin K Content



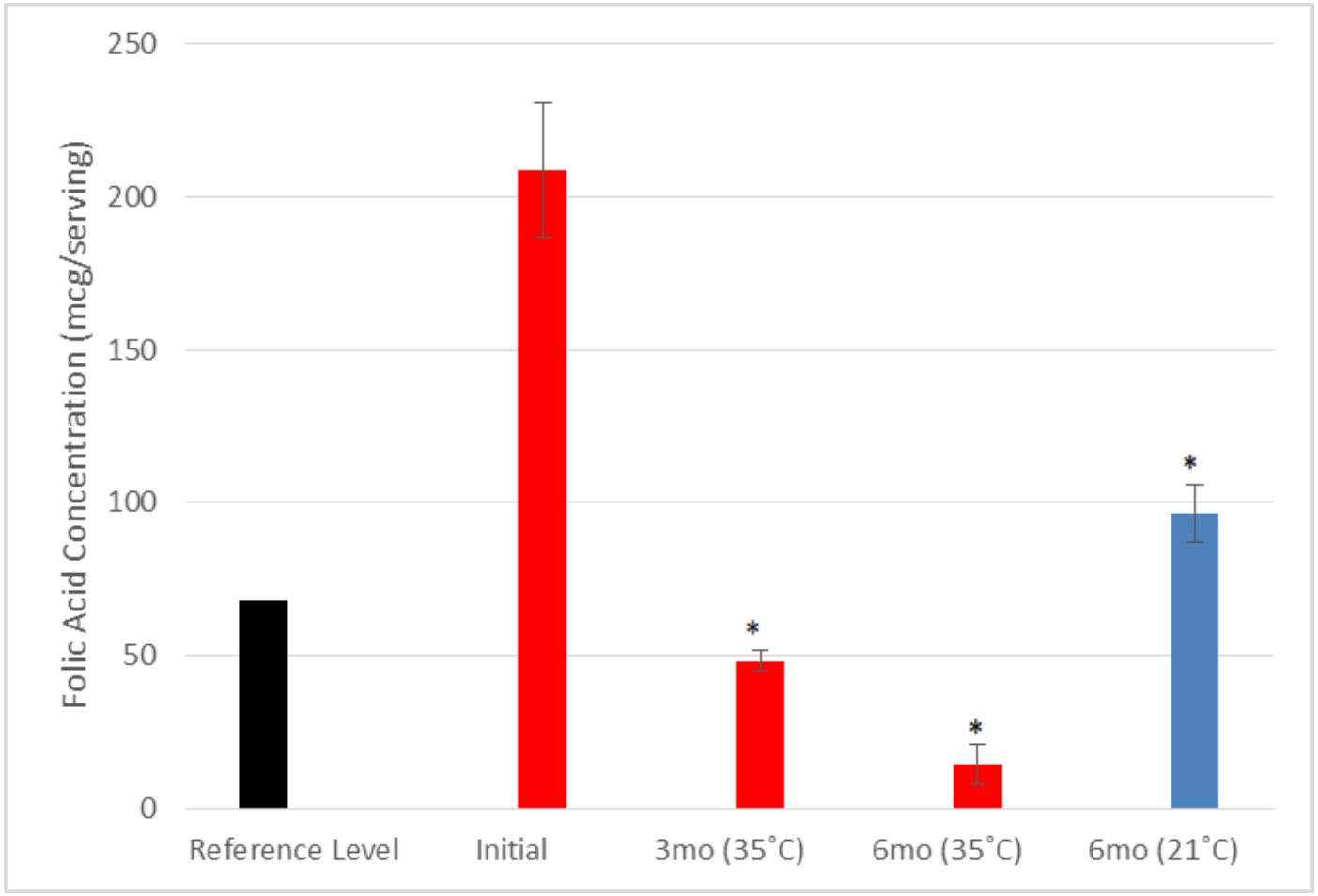
# Vitamin B12 Content



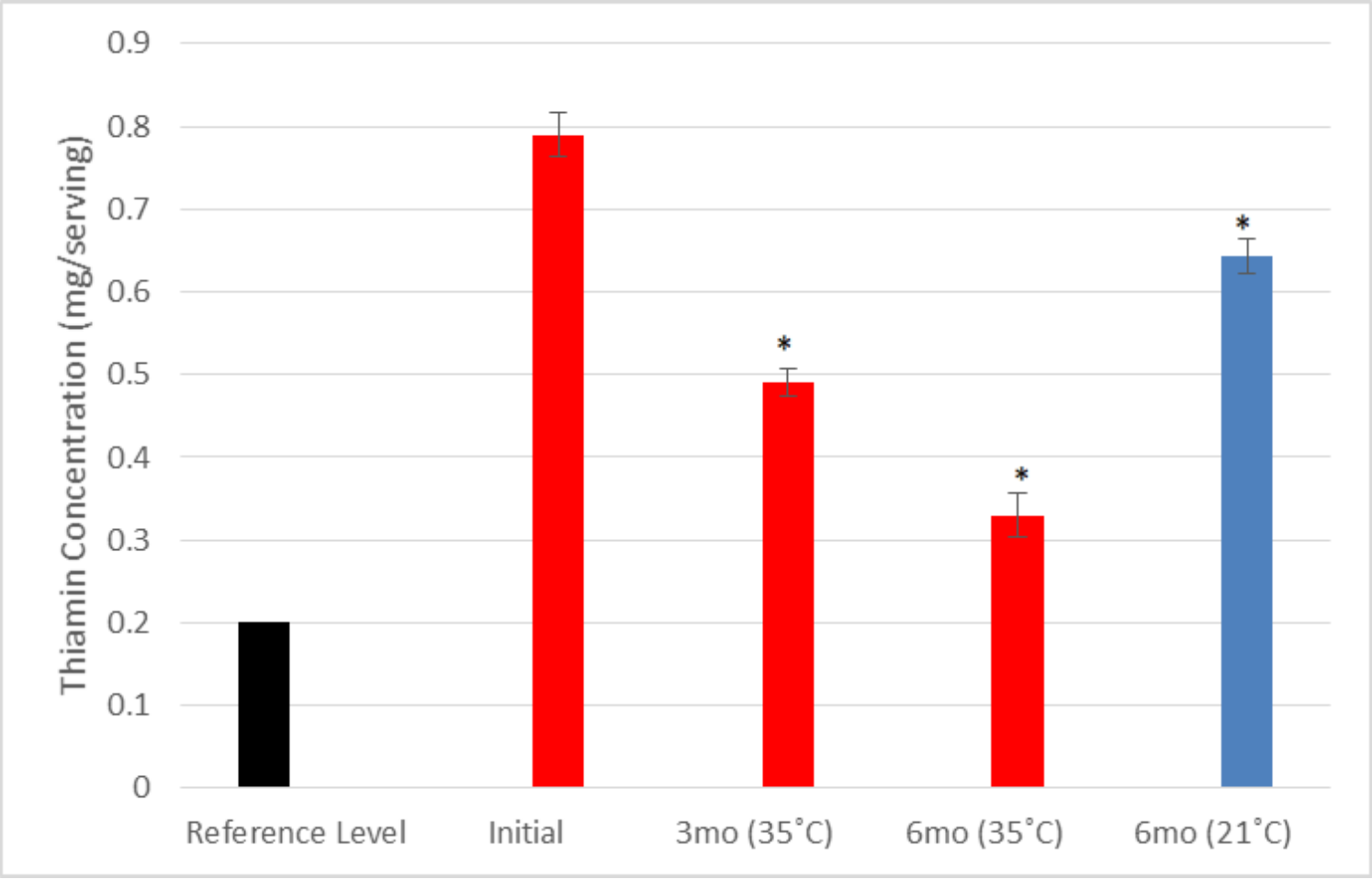
# Vitamin C content



# Folic Acid Content



# Thiamin Content



# HERA Feedback- Acceptability

| | Jalapeño Nut | BBQ Nut | Banana Nut | Orange Cranberry |
|---|---|---|---|---|
| Overall Acceptability | **4.81 ± 2.61** | **5.25 ± 2.41** | **6.31 ±2.09** | **7.31 ± 1.85** |
| Appearance | 6.69 ± 1.62 | 6.13 ± 2.13 | 6.44 ± 1.09 | 7.06 ± 1.48 |
| Color | 6.31 ± 1.49 | 6.19 ± 1.64 | 6.31 ± 1.20 | 7.00 ± 1.37 |
| Aroma | 5.56 ± 2.37 | 5.88 ± 2.22 | 6.69 ± 1.66 | 7.44 ± 1.55 |
| Flavor | 4.75 ± 2.77 | 5.50 ± 2.5 | 6.50 ± 1.97 | 7.25 ± 1.69 |
| Texture | 4.81 ± 2.86 | 5.00 ± 2.63 | 6.50 ± 1.60 | 7.19 ± 1.52 |

Carver Press

Ultrasonic Press

# HERA Feedback – Variety

- Selection is inadequate for mission length
- Pre-mission evaluation was not helpful for selecting bars
- Bar fatigue was evident by crew's tendency to trade or avoid bars
- Increased variety can improve meal replacement bar acceptability

# HERA - Caloric Requirements

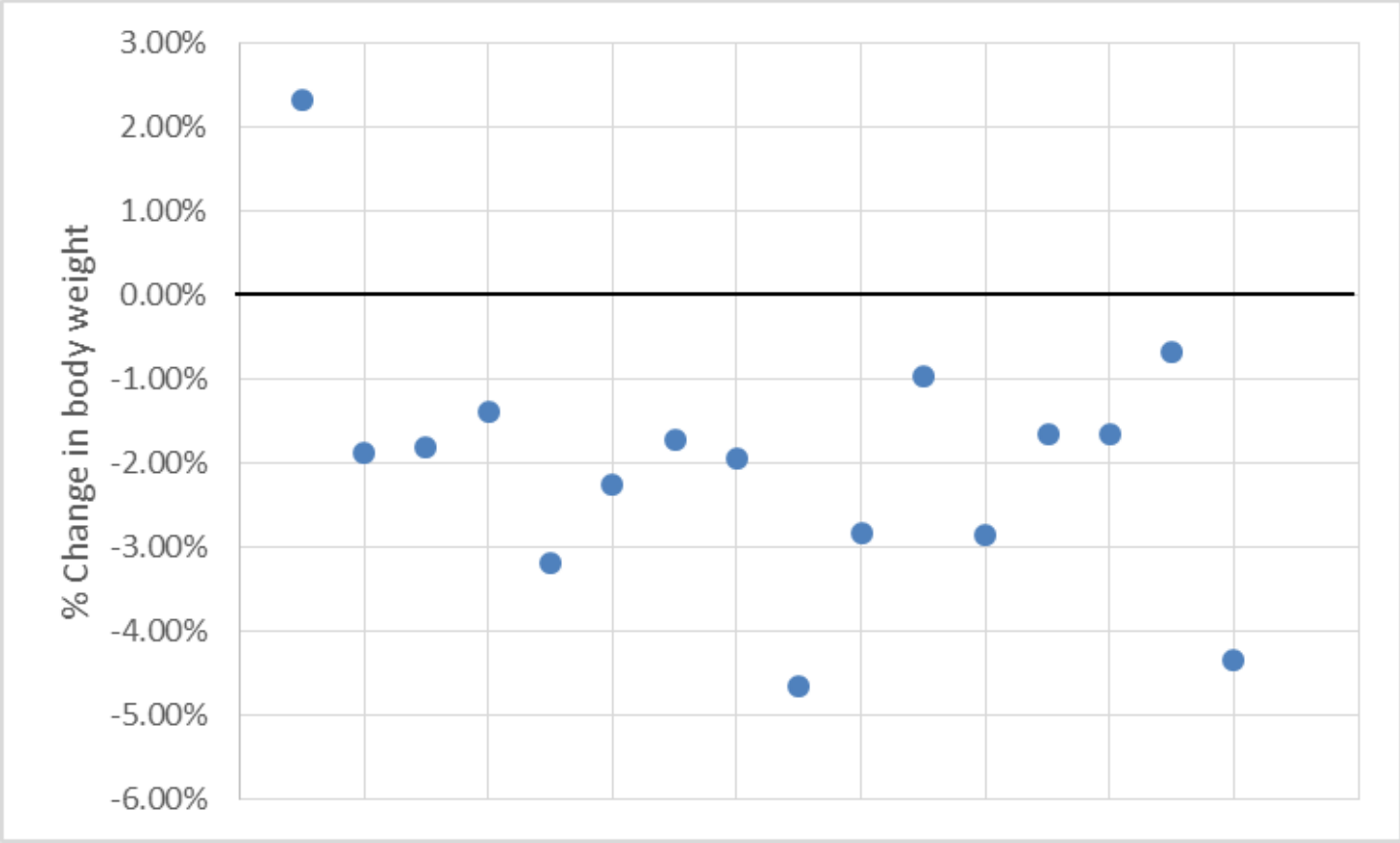
**EER for men 19 years old and older**

EER (kcal/day) = 622 – 9.53 x Age [y] + 1.25 x (15.9 x Mass [kg] + 539.6 x Height [m])

**EER for women 19 years old and older**

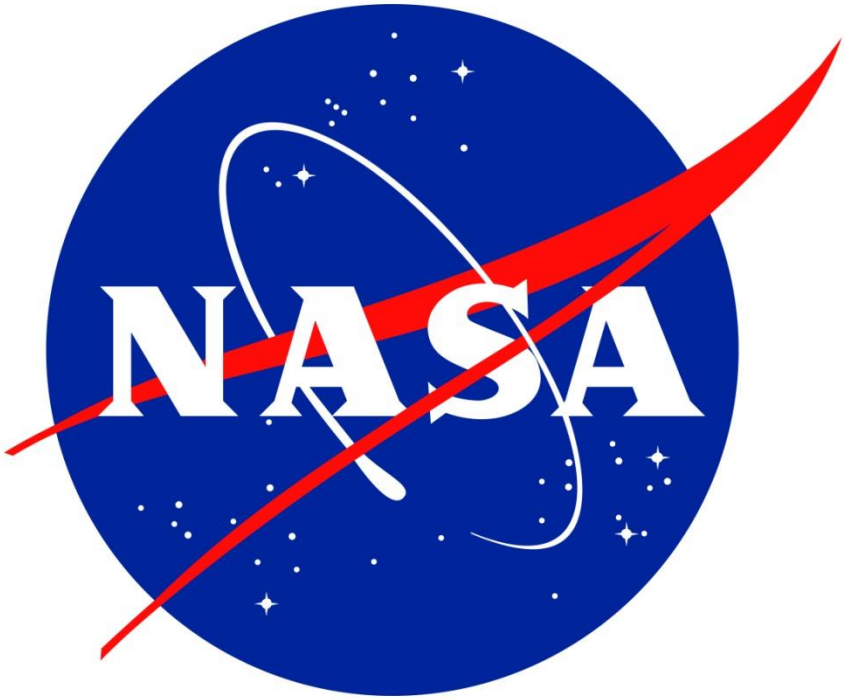
EER = 354 – 6.91 x Age [y] + 1.25 x (9.36 x Mass [kg] + 726 x Height [m])

# Crew Body Weight



# Conclusions

- Bars maintained overall acceptability over time
- Color and texture changes exacerbated by high temperature storage
- Vitamin degradation a concern for several key nutrients
- Preliminary HERA feedback suggests that variety needs to be increased


NASA