NSBRI Summer Apprenticeship Program

Advanced Food Technology
Space Food Systems Laboratory

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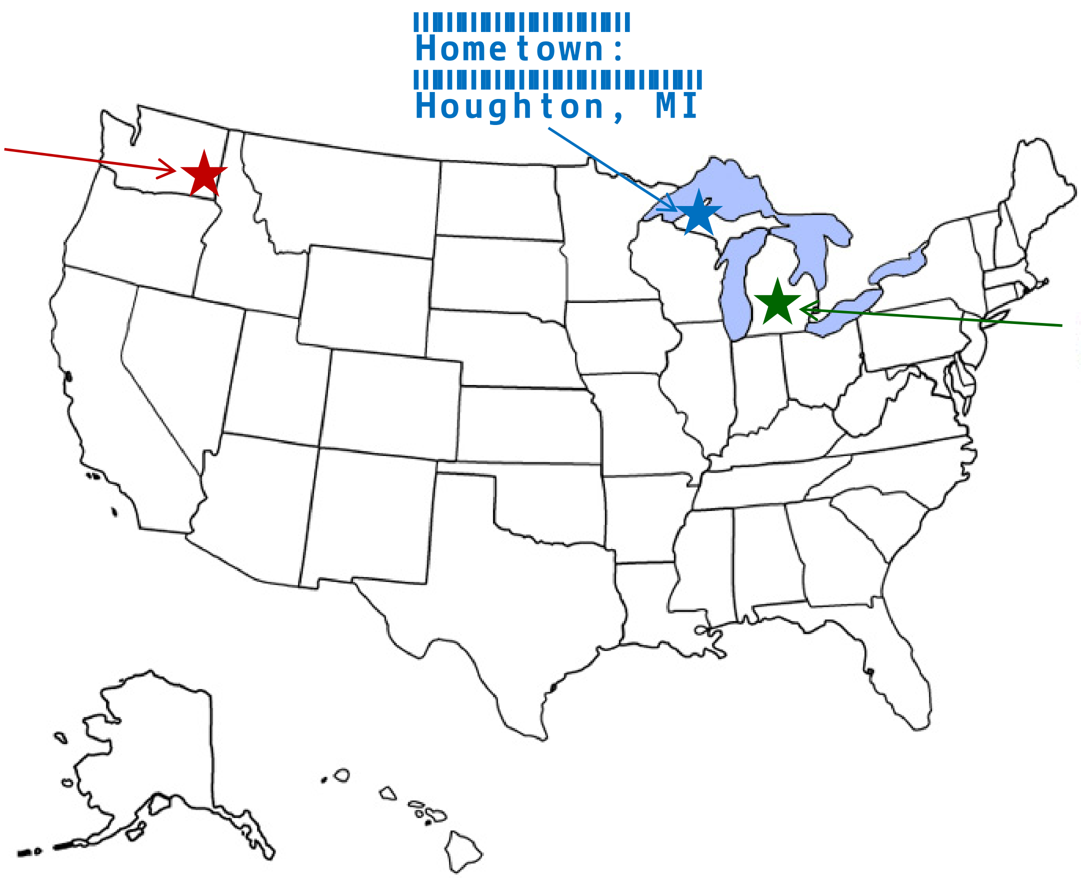
SPACE LIFE SCIENCES SUMMER INSTITUTE

About Me

Education

- Biological and Agricultural Engineering, Food Engineering concentration
  - B.S. from Michigan State University
  - M.S. and Ph.D. (in progress) from Washington State University



About Me

Work Experience

- Cornell University Food Science Summer Scholar
- Campbell Soup Company Co-op
- PepsiCo Intern

Goals

- Shadow scientists and engineers in food lab and across NASA

Project 1

- Mini trade study on food processing equipment for a Mars habitat galley

Project 2

- ISS production process for Italian Herb Flat Bread

Project 3

- Feasibility of omega-3 supplementation for space food

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Project 1: Background

Food Processing vs. Packaged Food System Trade Study (Cooper 2012)

Key Question: Is it better to take food to Mars or grow it on the surface?

Answer: Ambiguous “yes”, a combination of both

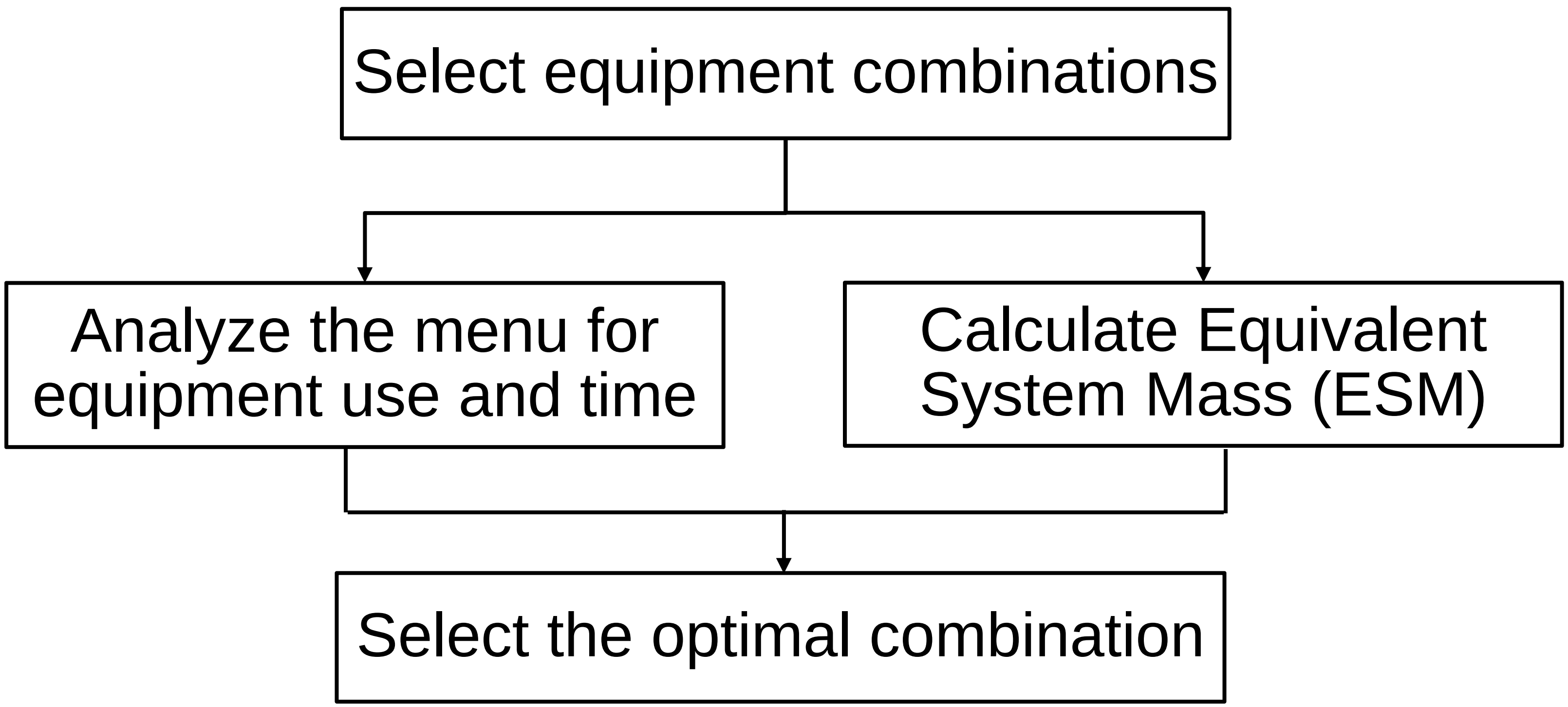
Project 1: Objective

Key Question: What is the optimal number of burners and ovens needed for a Mars habitat galley?

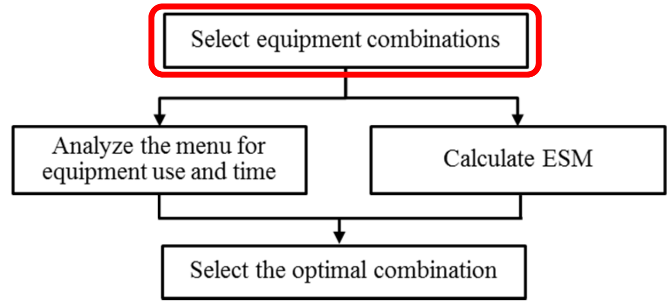
Objective: Complete a mini trade study to optimize the number of burners and ovens

- Food system 3 (Cooper 2012) for a 6-member crew on a 600-day Mars habitat mission
- Factors: active crew time, total preparation time, crew flexibility, mass, volume, power

Project 1: Methods



Project 1: Results

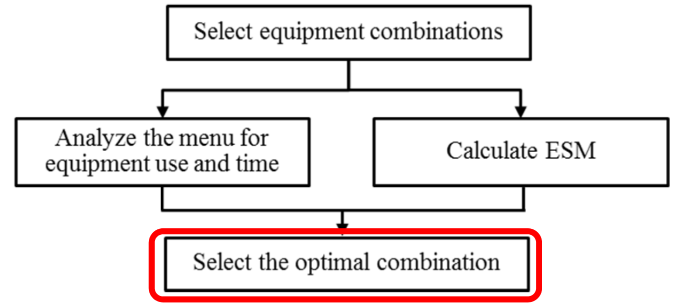


Equipment Combinations

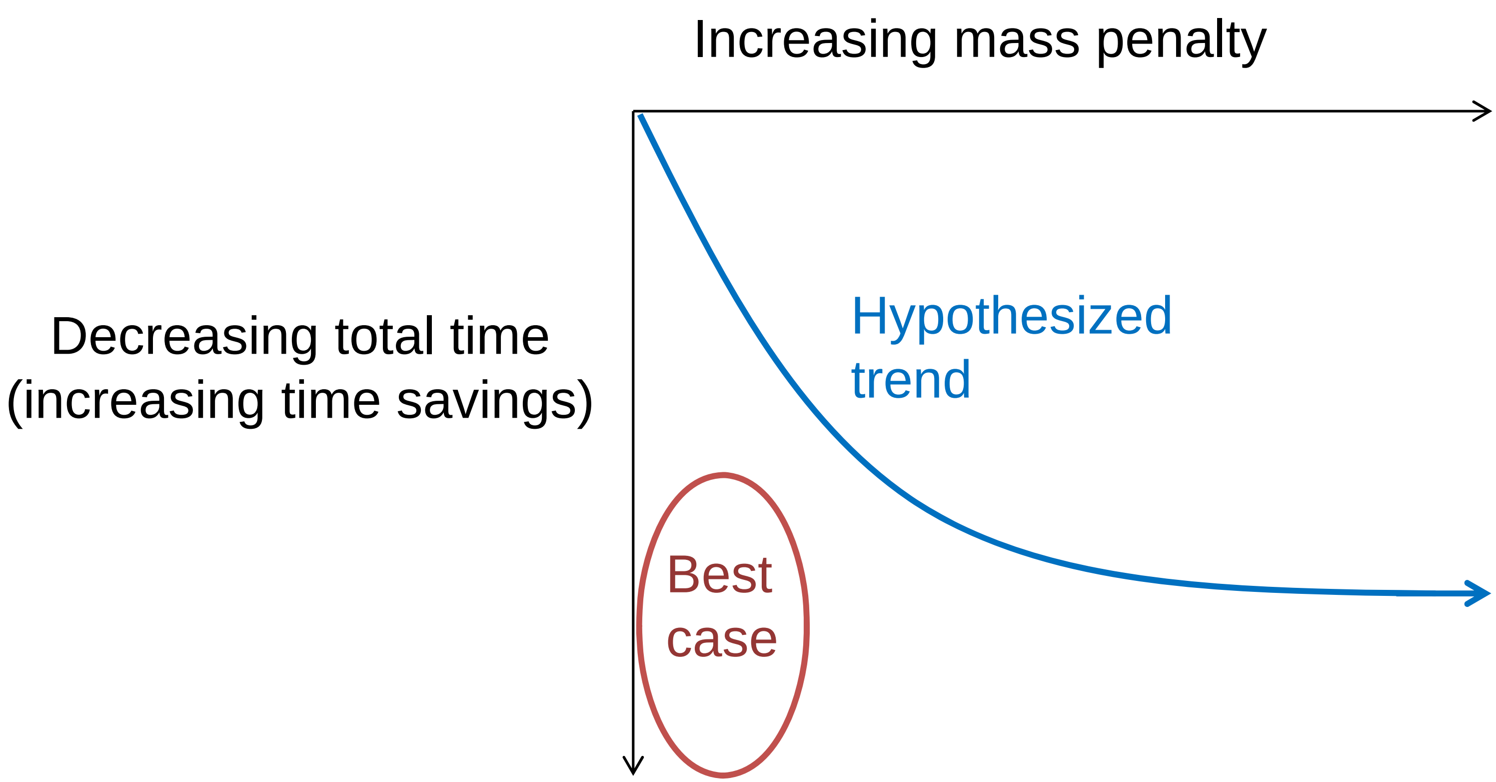
Based on an initial evaluation of the 10-day menu

Equipment combination	Burners	Ovens
1		
2		
3		
4		
5		
6		

Project 1: Results



Selection of Optimal Combination



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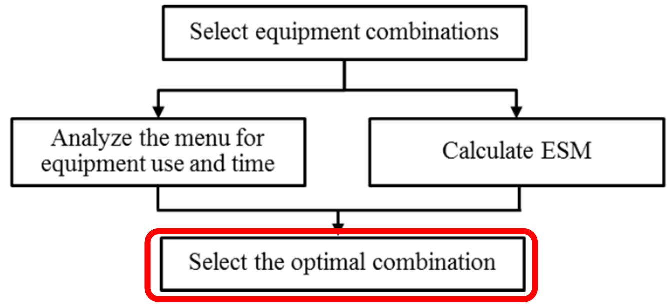

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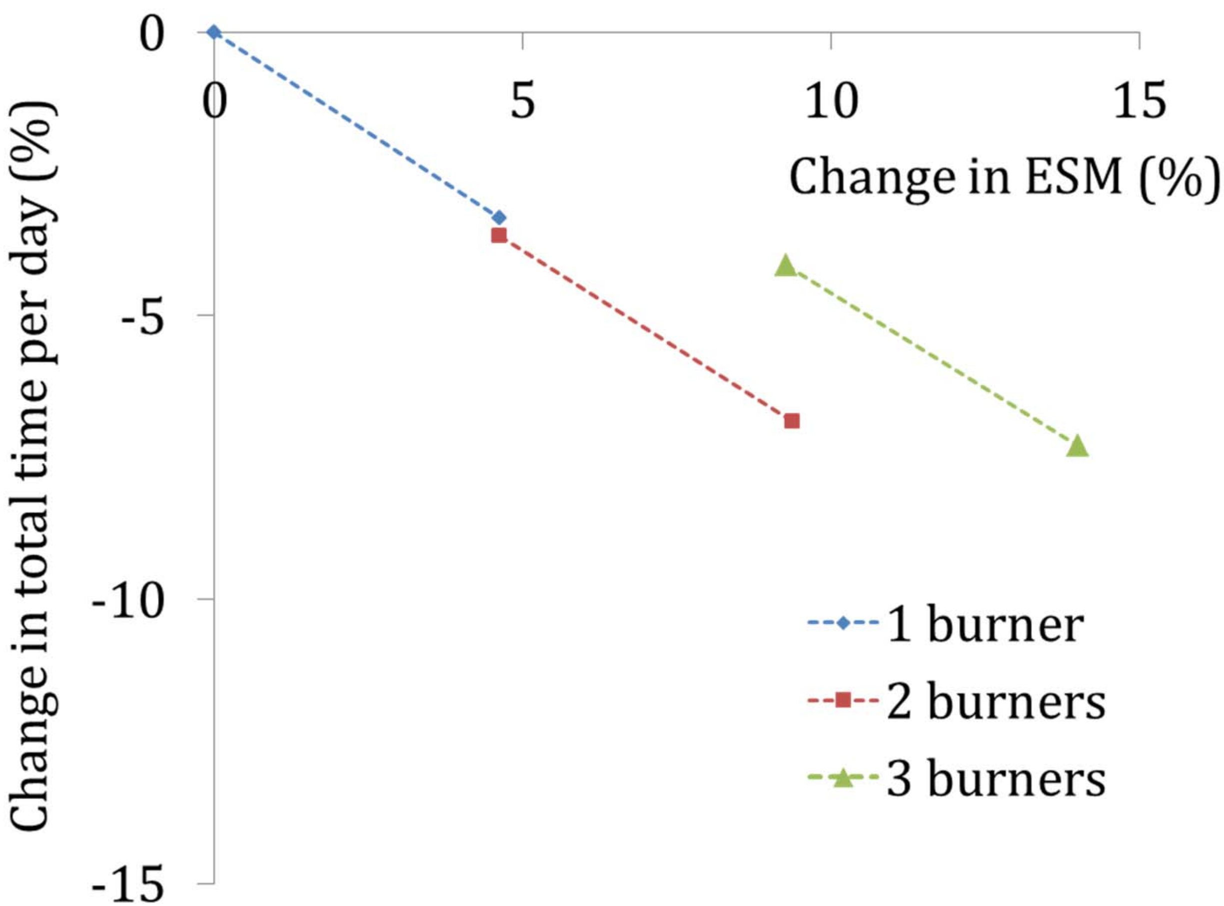

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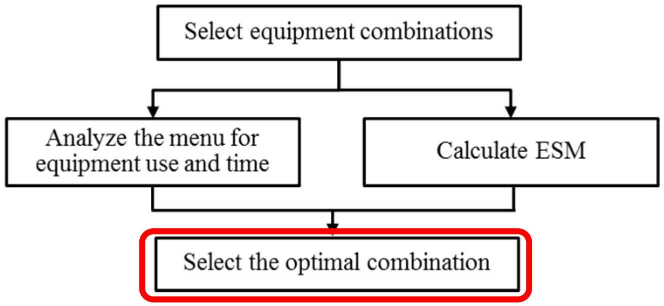

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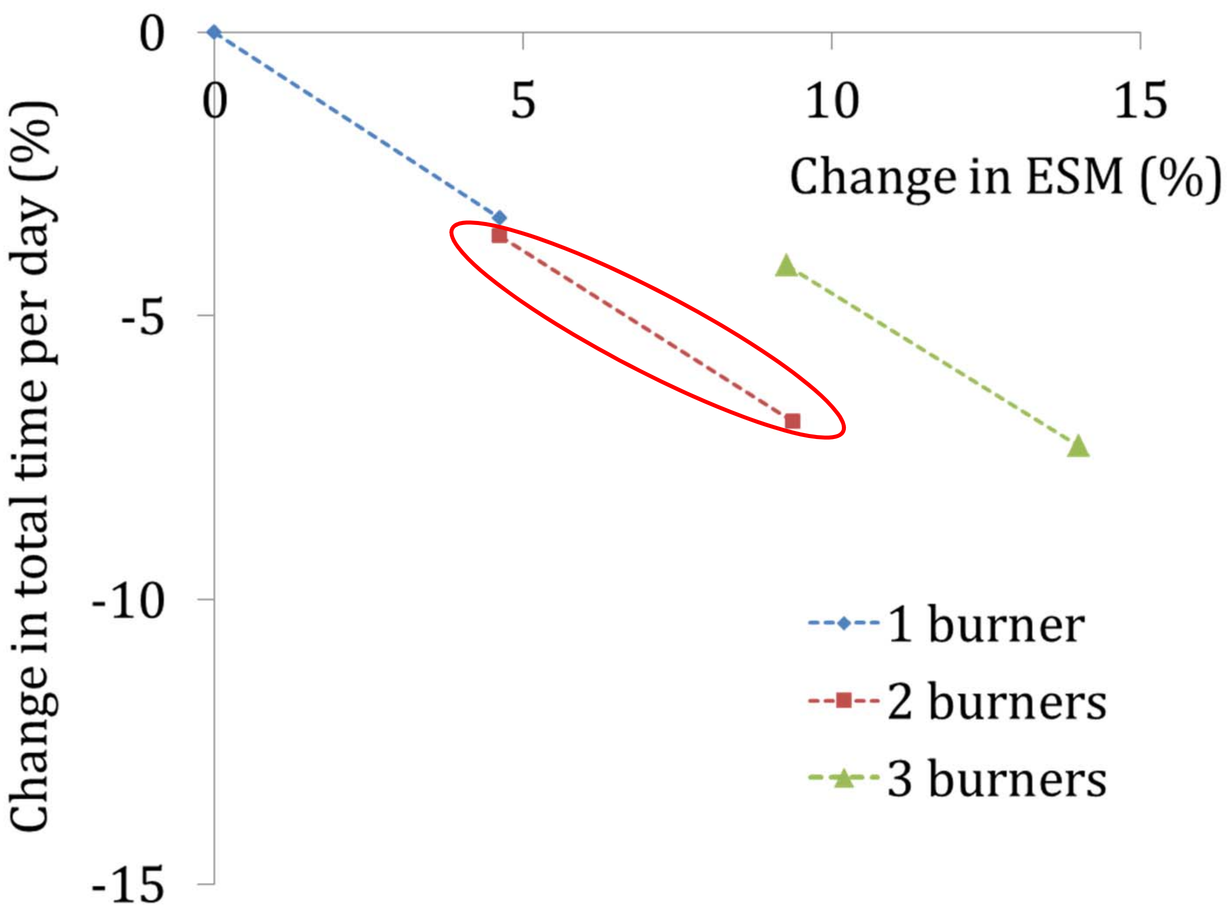


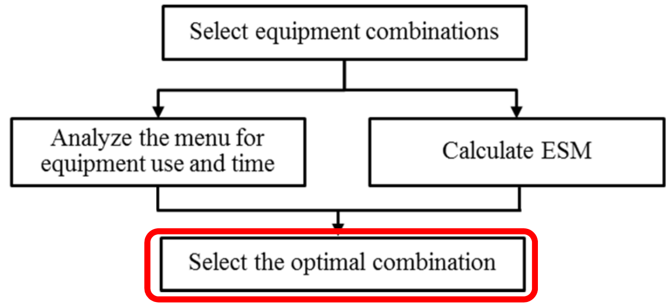
Best 2 combinations:

2 burners, 1 oven
2 burners, 2 ovens

Highest ratio:

$$\left|\frac{\textbf{\% Change in total time}}{\textbf{\% Change in ESM}}\right|$$

Project 1: Results

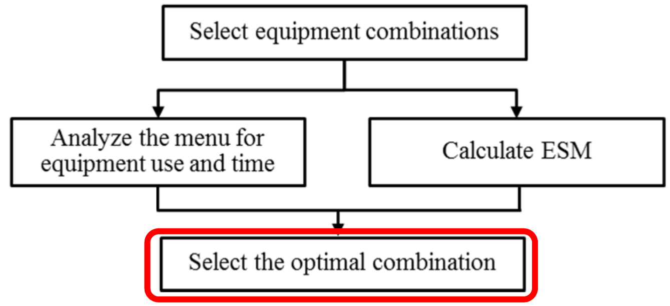


Selection of Optimal Combination

- Combine total time/ESM data with crew flexibility index
- Crew flexibility index: return on investment (potential value obtained from additional resources)

Best equipment combinations	$\frac{\text{\% Change in total time}}{\text{\% Change in ESM}}$	Crew flexibility index
2 (2 burners, 1 oven)	0.78	2.75
4 (2 burners, 2 ovens)	0.73	3.5

Project 1: Results



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Optimal combination: 2 burners, 2 ovens

Project 1: Conclusions

Optimal Equipment Combination

2 burners **2 ovens**




- 2nd highest ratio of total time:ESM
- 2nd highest crew flexibility index
- Compared to 1 burner, 1 oven
  - Total time saved: 59 min per day (7%)
  - ESM increased: 866 kg (9%)

- Results can be used in planning and optimizing food systems for long duration missions
- Future work: equipment design, recipe simplification, food system logistics and feasibility

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Project 2: Background

Mass Reduction Technology Development task
(Monica Leong, in progress)

Key Question: Is it possible to develop recipes that are high calorie, nutritious, good tasting, safe to eat, and have a reduced mass?






Answer: Yes! One example: Italian Herb Flat Bread

Project 2: Objective

Key Question: What production process could be used to make Italian Herb Flat Bread on a larger-scale for the ISS?

Objective: Propose a lab-scale, ISS production process for Italian Herb Flat Bread

- Ability to produce 200 servings in one 8-hour period
- Consistent weight: <5% variation from target
- Consistent quality: equivalent sensory overall acceptability, texture, and water activity as prototype
- Use Space Food Systems Laboratory personnel and equipment (minimize capital investment)

Project 2: Methods

- Determine main unit operations and scale-up options

1. Ingredient preparation

2. Mixing

3. Rolling, cutting into single-serving

4. Baking

- Test the scale-up options to select the most feasible ones
- Develop a production process

Project 2: Production Process

1. Ingredient preparation

- Yeast, sugar, warm water (105–110°F)
- Rest for 5 min

- Dry ingredients: bread flour, salt, dough conditioners, gum, preservative, herbs
- Mix for 0.75 min, speed setting 1

- Wet ingredients: shortening, preservative, glycerine

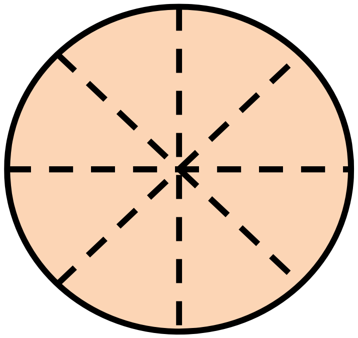
Project 2: Production Process

2. Mixing to form dough

- Combine dry, wet ingredients
- Mix for 3.75 min at speed setting 1

3. Rolling and preparing single servings

- Weigh out one serving (200 calories, ~64 g) and roll into circle (1/16” thick)
- Poke holes in a star pattern using a fork



Project 2: Production Process

4. Baking

- Temperature: 325°F
- Time:15 min
- Rotate tray in the middle of baking time

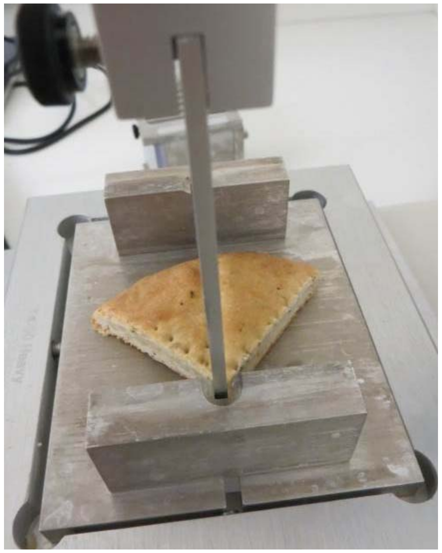
5. Quality Control

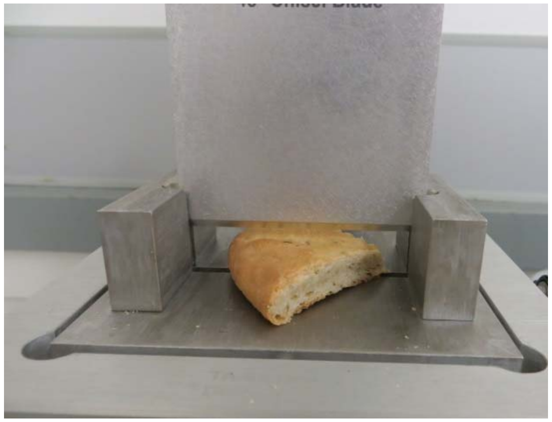
- Water activity, moisture content
- Texture
- Color
- Sensory

Project 2: Production Process

5. Quality Control

- **Texture analysis**: blade/cut compression test
- Measure maximum force, work due to shear
- 6 replicates





Project 2: Time Management

- 4 people on 2 teams, will rotate jobs to reduce fatigue
- Batch size 50 servings (~7.7 lbs), each team rolls 25 servings/batch
- Perform process 4 times to reach 200 servings (total ~6 hours)

Team 1		Team 2		Total time (min)
Person 1	**Person 2**	**Person 3**	**Person 4**	
Weigh ingredients (50 serv.)				**30**
Mixing to form dough (50 serv.)				**5**
Weigh out pieces (25 serv)	Roll out pieces (25 serv)	Weigh out pieces (25 serv)	Roll out pieces (25 serv)	**30**
Poke holes with fork (25 serv)		Poke holes with fork (25 serv)		
		Bake bread (50 serv)		**25**

Project 2: Conclusions

- Key process steps:
  1. Weigh, prepare ingredients
  2. Mix ingredients to form dough
  3. Weigh and roll single serving pieces
  4. Bake the bread pieces
  5. Quality control tests

- 200 servings can be produced in 8 hours with 4 people
  - Process steps 1–4: ~6 hours
  - Key quality control tests for each batch (water activity, texture): ~1 hour
  - Breaks for workers: ~1 hour (30 min lunch and two 15 min breaks)

- Results can be used in creating a refined ISS production process for the bread in the future

- Future work: production process test, packaging study to optimize vacuum level, sensory (in progress)

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Thank You!