National Aeronautics and Space Administration

Packaged Food Mass Reduction Technology Development

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Breakfast Augmentation Rationing System

Work Continued From Mass Reduction Study

NASA Advanced Food Technology

Leong. 2013. Mass Reduction Develop.

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Introduction

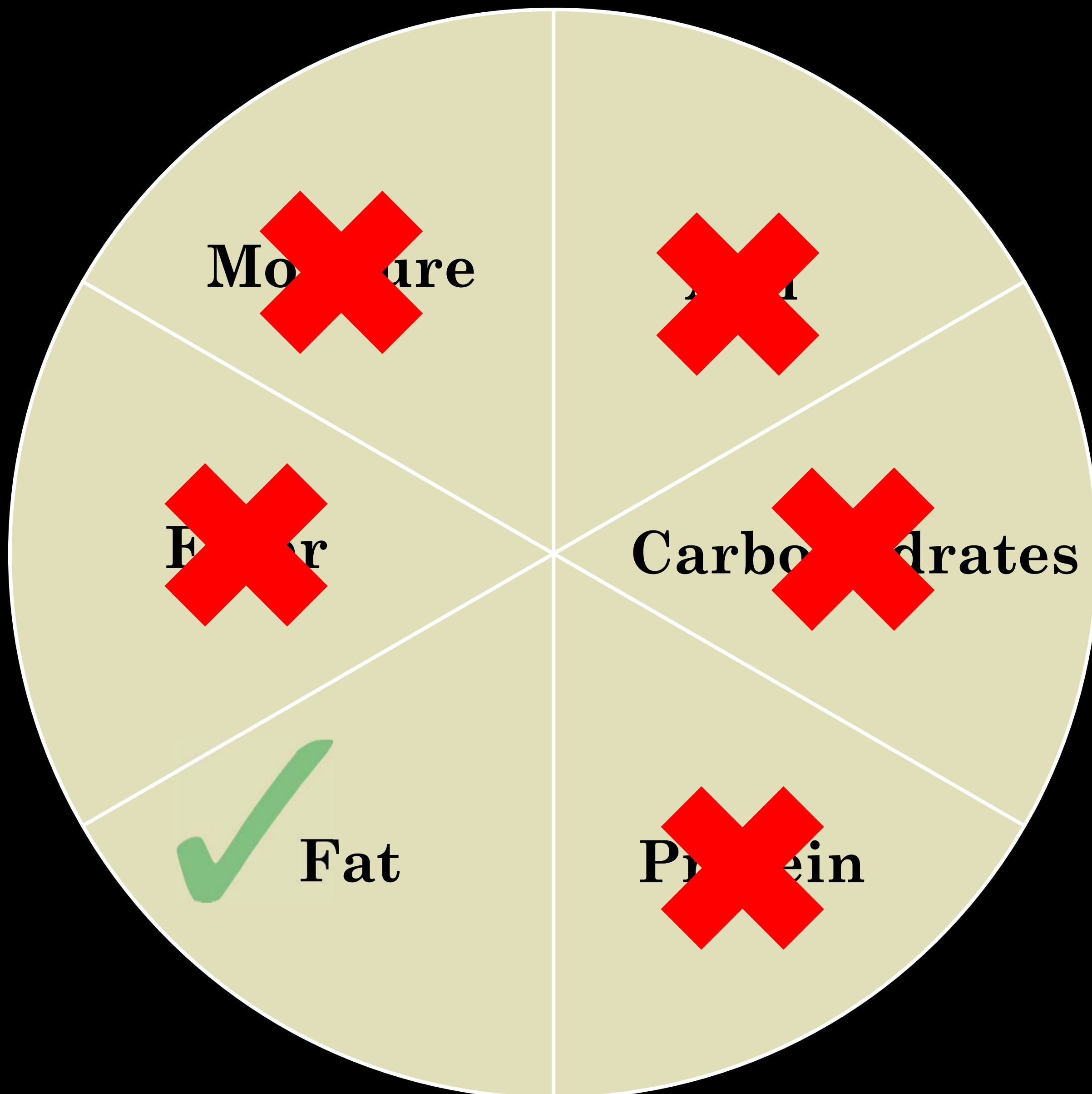
- Grew up in Auburn, Alabama
- Studied Food Science at North Carolina State University
- Starting Ph.D. at University of California, Davis
- Long Term Goal: Help NASA develop a Mars-ready Food System
- Short Term Goal: Return as Co-Op and Reformulate Other Bars

Houston, We Have A Problem

- Problem: Food is Heavy!
- Solution: 1. Increase Caloric Density & 2. Improve Protein Texture
- Approach: Optimize Recipe by Maximizing Caloric Density (kcal/g)
- Constraints:

Daily Nutritional Targets (NASA-STD-3001, Vol. 2)	
% kcal from Protein	$\leq$35%
% kcal from Carbs	50-55%
% kcal from Fat	25-35%
% kcal from Sat. Fat	<7%
Fiber (g/1000kcal)	10 to 14

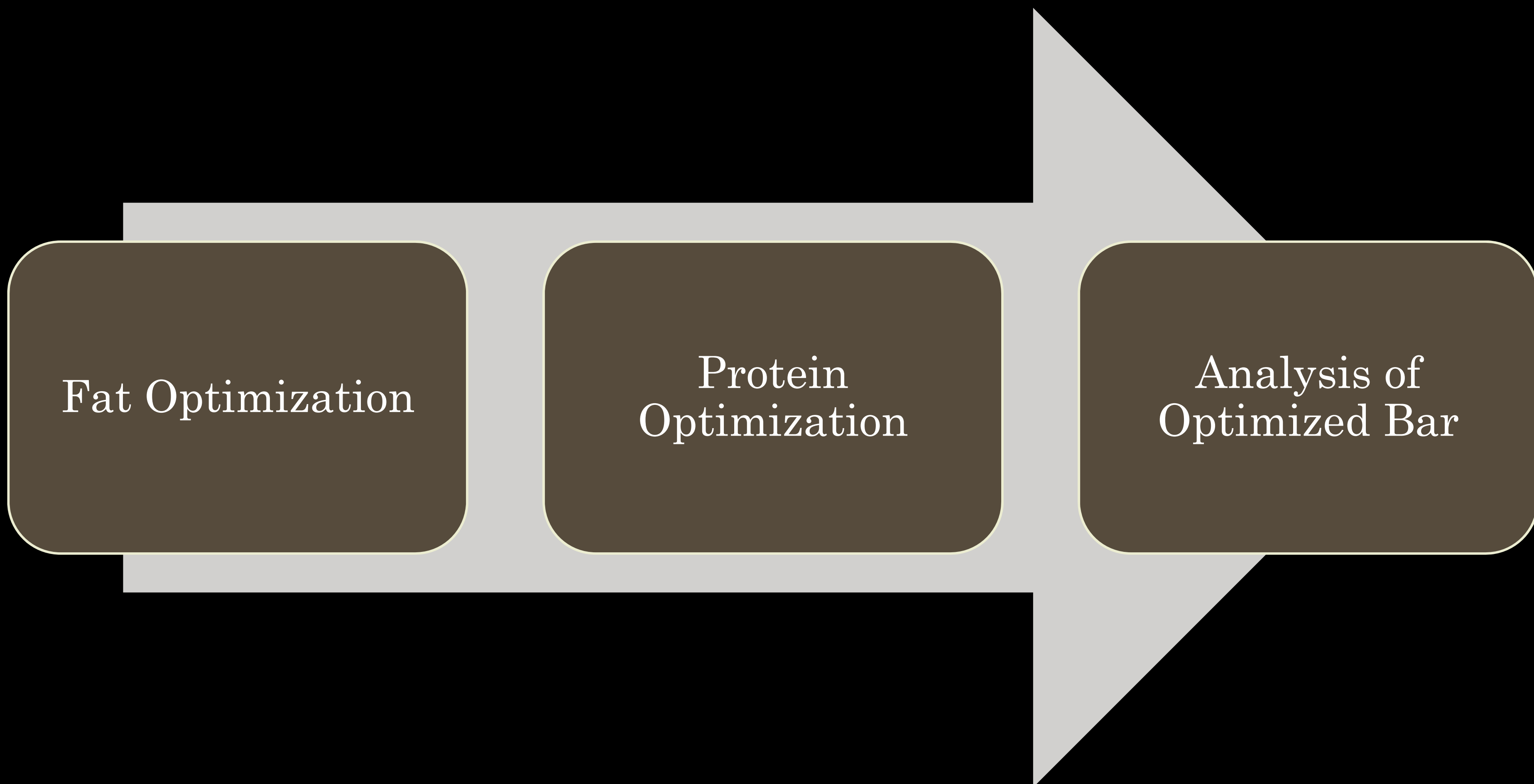
What Affects Caloric Density?



Materials


Kellogg's
RICE KRISPIES
Goodness of a Simple Grain
QUAKER OATS
HERSHEY'S
COCOA
NATURAL
UNSWEETENED
RED PALM
oil
Liquid
Lecithin
Jif
CRUNCHY
Ocean Spray
CRAISINS
Dried Cranberries
Original
Karo
Domino
"We'll Always Be Your Sugar"
LIGHT BROWN
SUGAR
TOLL HOUSE

Optimization Approach



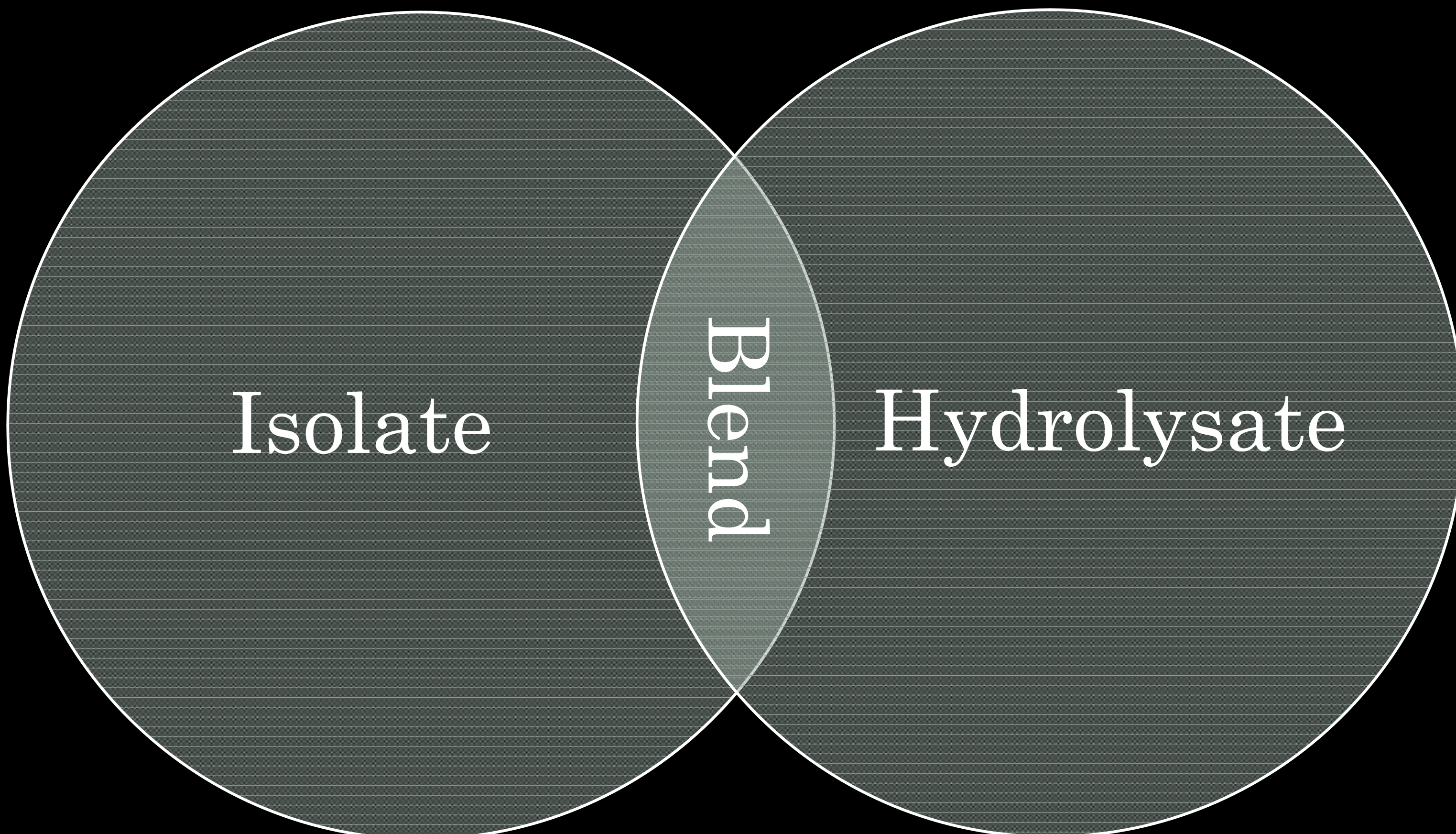
Fat Optimization - Methods

Recipe	% kcal from Fat	% kcal from Sat. Fat	Caloric Density
Original Bar	26%	9%	4.0
+ Coconut Oil	35%	19%	4.27
+ Cocoa Butter	35%	16%	4.27
+ Palm Oil	35%	13%	4.32
+ Canola Oil	35%	9%	4.27
+ Palm/Canola Combo	35%	10%	4.31

Fat Optimization - Results

- High amount remained bound in food without oil loss
- Caloric Density increased to 4.3 kcal/g

Protein Optimization - Methods



Protein Optimization - Results

L to R: Isolate, 50/50 Blend, Hydrolysate

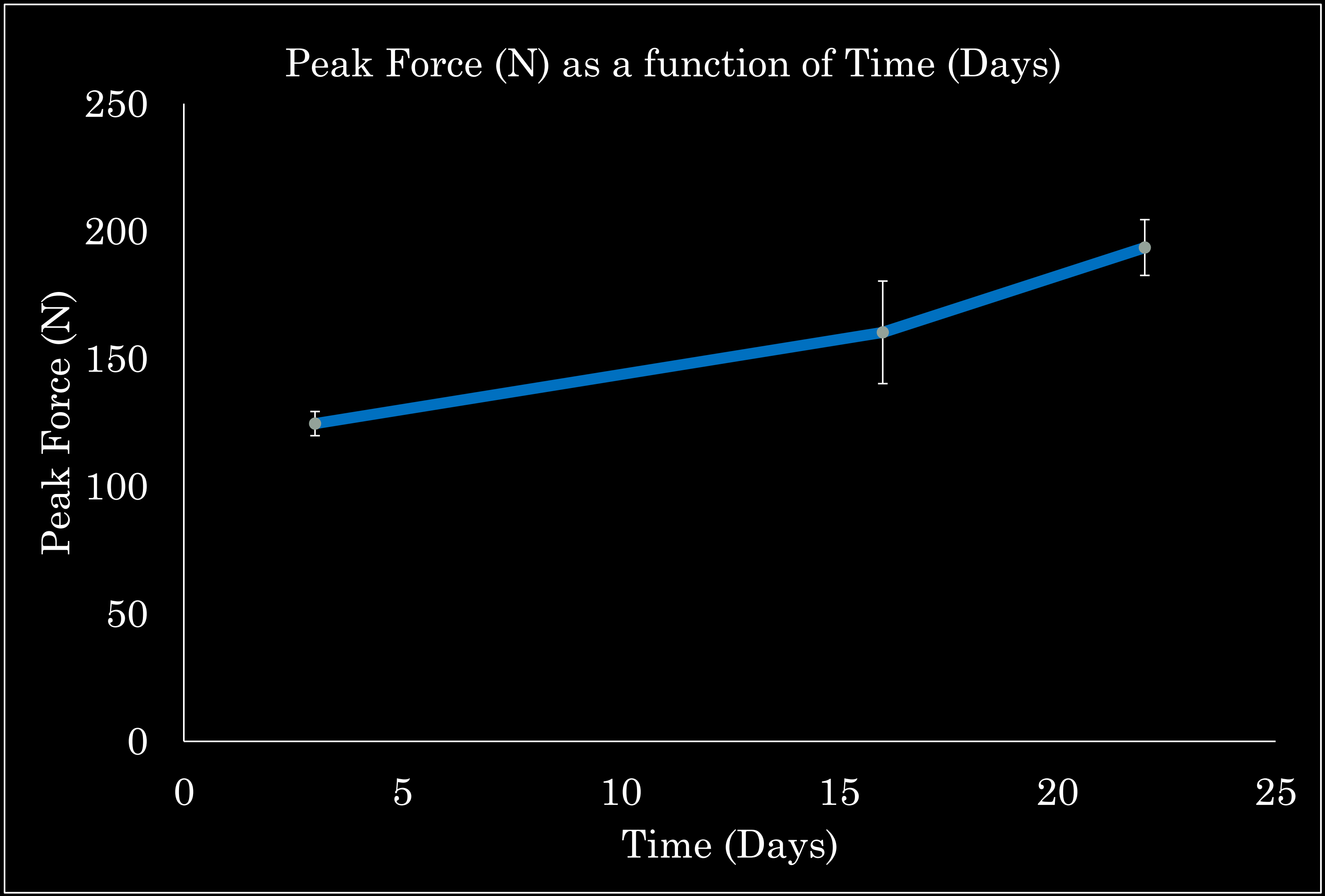
- 100% Isolate chosen as best formulation
- Caloric Density increased to 4.4 kcal/g

Vacuum Sealing

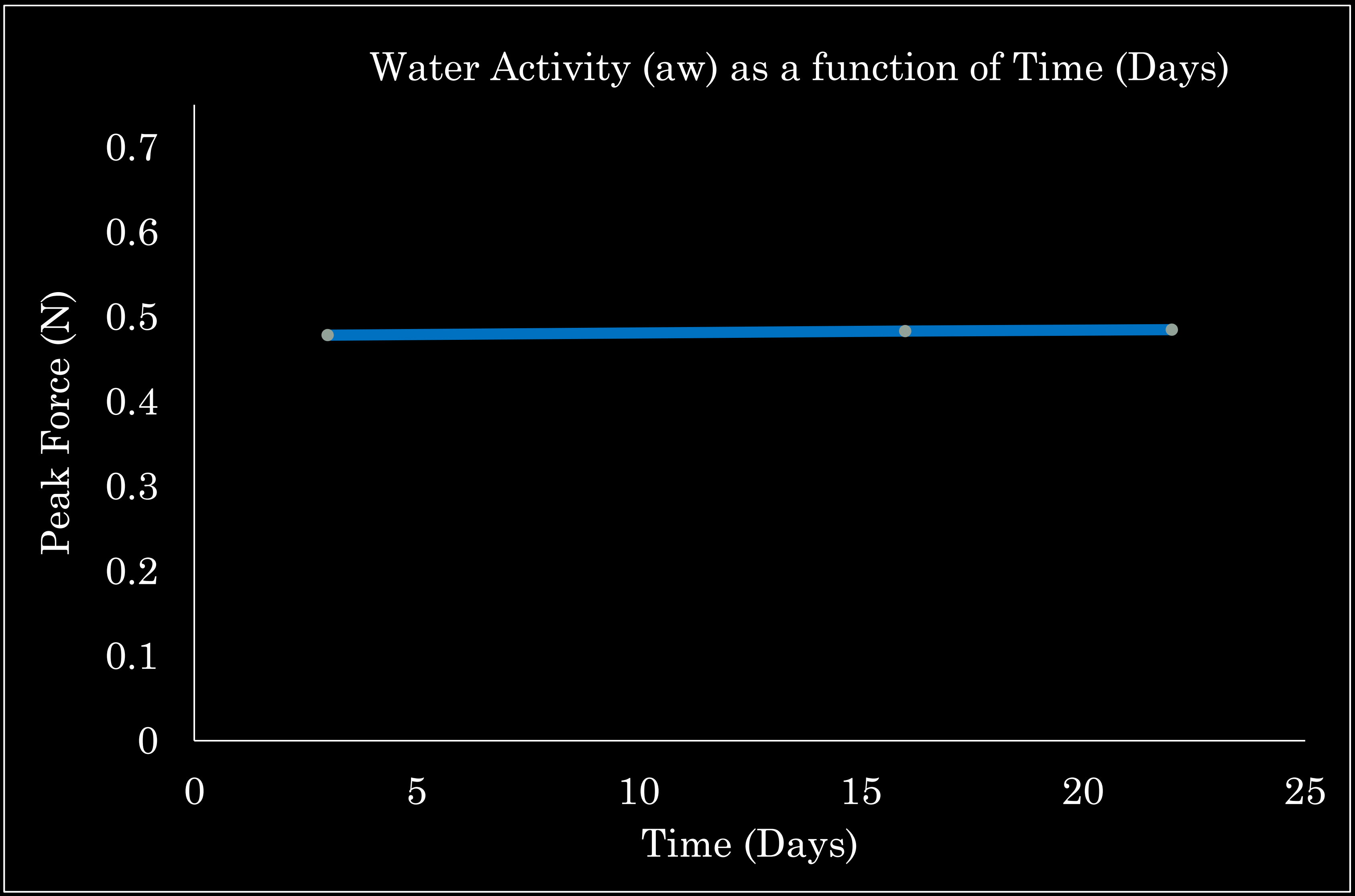
Breakfast Bar

Han Solo

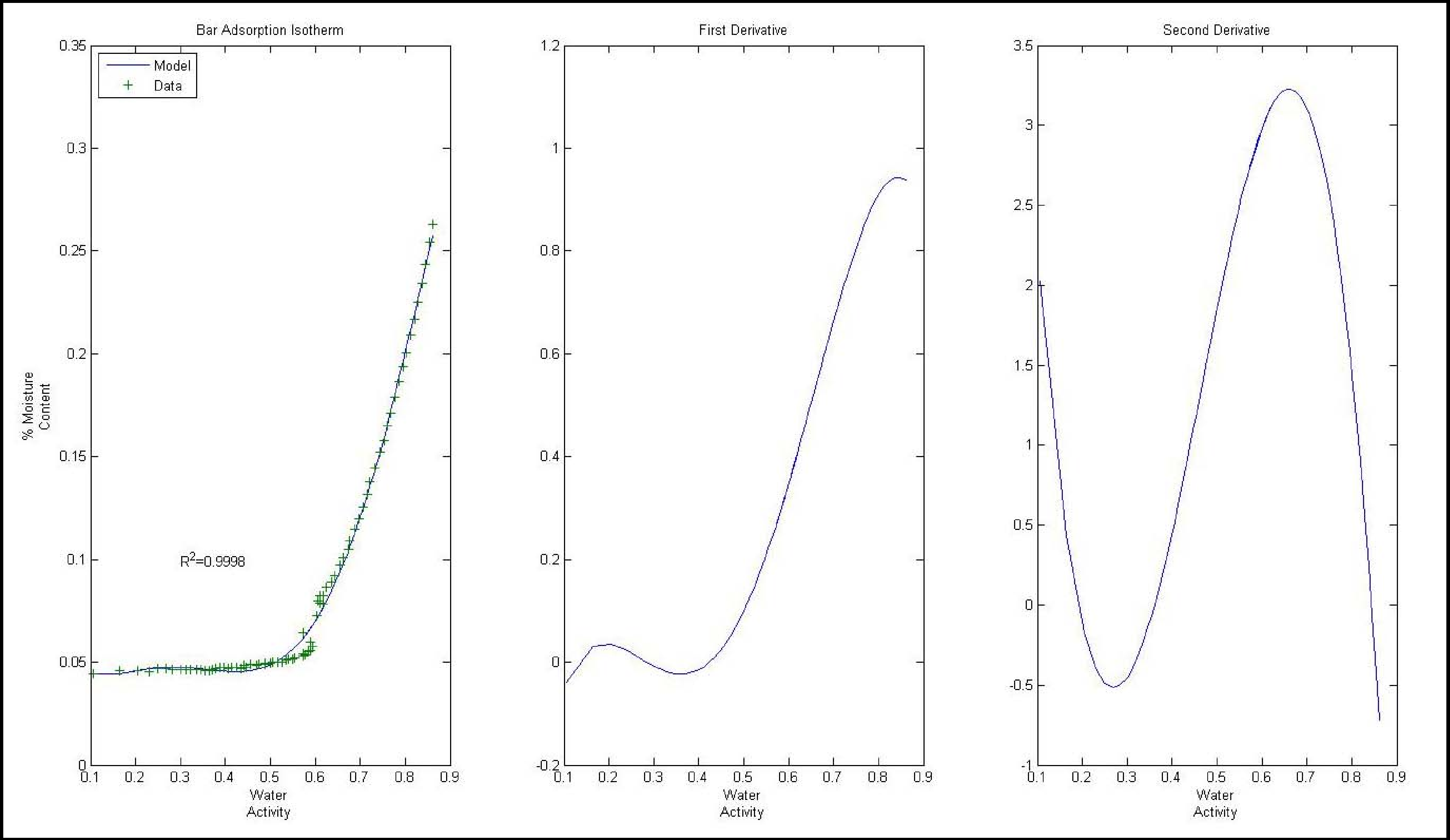
Texture Analysis



Water Activity Analysis



Moisture Sorption Analysis



Key Outcomes

Nutrition Facts
Serving Size 1 Bar (163g)

Amount Per Serving	
Calories 720	Calories from Fat 250
Total Fat 28g	
Saturated Fat 8g	
Trans Fat 0g	
Cholesterol 0mg	
Sodium 115mg	
Total Carbohydrate 96g	
Dietary Fiber 8g	
Sugars 43g	
Protein 26g	

- 8% Increase in Caloric Density
- 7% Increase in Mass Savings
- Well-liked in sensory (Score of 6.76, n=38)
- Fits NASA Nutritional Profile
- No Trans Fat
- Higher Protein
- Lower Simple Sugars
- Water Activity is Below Glass Transition Point
- Next: Examine Shelf-Life Limitations

NASA Cost Savings

- 2021 EM-2 Mission will carry meal-replacement bars
- Given that launching 1 kg costs ~$65k…
- And given two weeks of breakfast meals…
- And given two crew members…
- And given a bar is eaten for every breakfast…
- <u>NASA has potential to save ~$727,000</u>

Photo Credit: NASA

#FoodScience

Mass Savings Calculation w/o Pkg

$$\%MS = 1 - \frac{735.96 * m_{bar}}{304.13 * kcal_{bar}}$$

Where

m_{bar} = mass of bar in grams

$kcal_{bar}$ = bar kilocalorie content

%MS = mass savings (off original)

Mass Savings Calculation w/ Pkg

$$\%MS = 1 - \frac{\frac{735.96 * m_{bar}}{kcal_{bar}} + 16.5}{379.11}$$

Where

m_{bar} = mass of bar in grams

$kcal_{bar}$ = bar kilocalorie content

%MS = mass savings (off original)

735.96 = kcals per average breakfast

16.5 = weight of bar packaging

379.11 = weight of average breakfast (including packaging)

NASA Cost Savings

Launch Cost per kg (USD)	$ 65,000.00
Weight of 1 breakfast meal (kg)	0.37911
Length of flight (days)	14
Number of crew members	4
Weight of regular breakfasts (kg)	21.23016
Cost of flight breakfasts (USD)	$ 1,379,960.40
Mass of Breakfast Bar (kg)	0.1795
Weight of bar replaced breakfasts (kg)	10.052
Cost of bar replaced breakfasts (USD)	$ 653,380.00
TOTAL SAVINGS TO NASA (USD)	$ 726,580.40