NEXT-GENERATION HEALTHY & SUSTAINABLE FOODS: PLANT-BASED MEAT, SEAFOOD, EGG, & DAIRY

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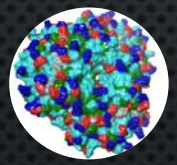
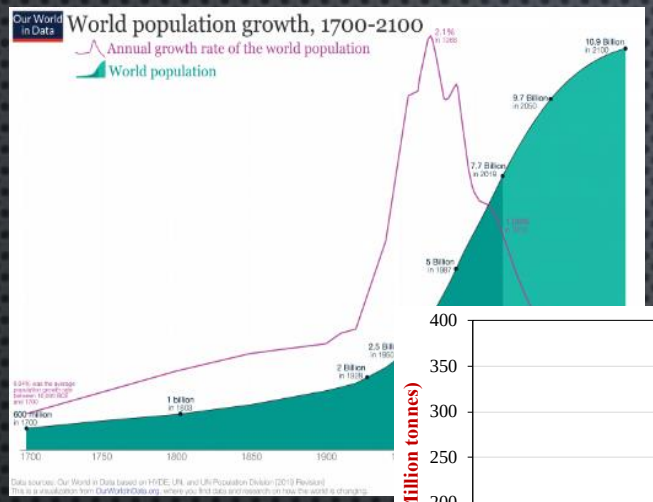
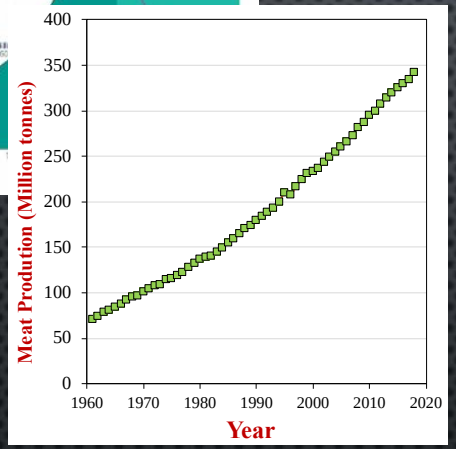
DEPARTMENT OF FOOD SCIENCE

UNIVERSITY OF MASSACHUSETTS







Challenges

- Growing population
- Land use, water use, pollution
- Greenhouse gas production
- Biodiversity loss
- Zoonotic disease
- Antimicrobial resistance

EAT-Lancet Commission Recommendation

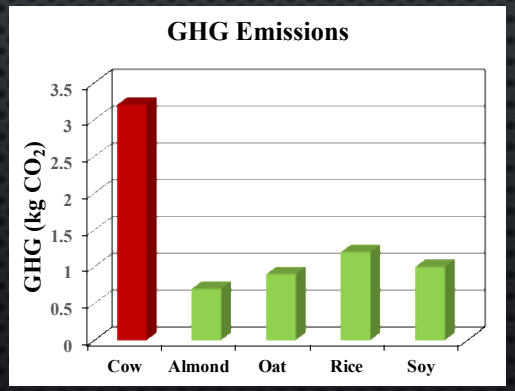
- Defined a healthy and sustainable diet based on planetary boundaries and nutrition knowledge
- Eat Less animal Foods!

Willet et al., Food in the Anthropocene: *The EAT–Lancet Commission* on healthy diets from sustainable food systems (2019)

PLANT-BASED FOOD: DRIVERS

Ethical

Environmental

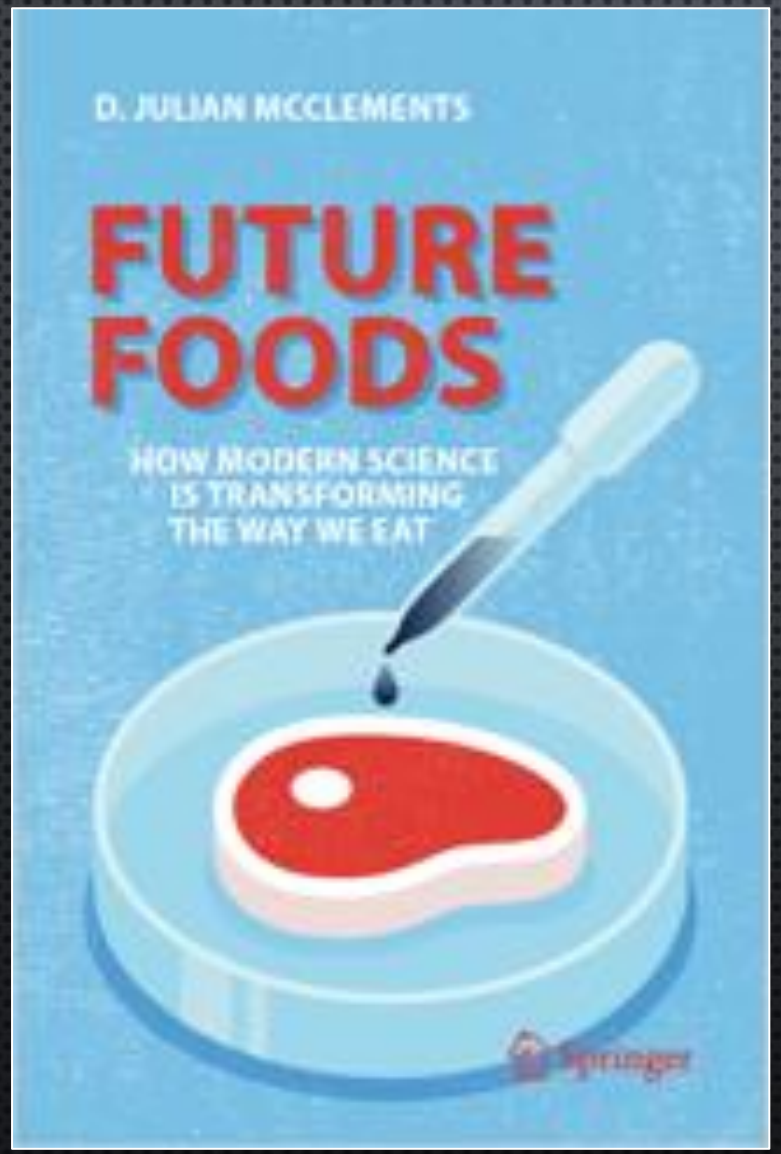


Health

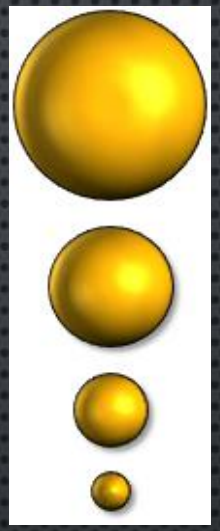
THE RISE OF ALT-PROTEIN FOODS:
MEAT, SEAFOOD EGG, AND DAIRY

$7 billion sales in 2020 (up 27%)

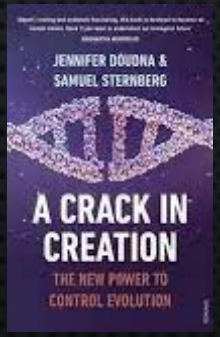
(Good Food Institute, USA)



2019



Food Nanotechnology



NEXT-GENERATION FOODS: DESIGNING FOR HEALTH

Ingredients

Water, Coconut Oil, Modified Potato Starch, Gluten Free **Oat** Fibre, Maize Starch, Salt, Modified Maize Starch, Calcium, Thickeners (Carrageenan, Guar Gum), Natural Flavourings, Acidity Regulators (Lactic Acid, Sodium Lactate), Colour (Carotenes).

Nutrition information	**Per 100g**
Energy	1297kJ/313kcal
Fat	25.9g
of which Saturates	21.6g
Carbohydrate	18.3g
of which sugars	0.1g
Protein	0.1g
Salt	1.6g
Calcium	150mg (19% RI)

Real cheese has about around 23% protein

NEXT-GENERATION FOODS: DESIGNING FOR HEALTH

Real salmon has about around 20% protein

Nutrition Facts

Serving Size: 1 slices (85g)

Amount Per Serving	
Calories 170	Calories from Fat 41
	% Daily Value*
Total Fat 4.5g	**7%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 610mg	**25%**
Total Carbohydrates 32g	**11%**
Dietary Fiber 9g	**36%**
Sugars 0g	
Protein 0.5g	
Vitamin A	0%
Vitamin C	0%
Calcium	2%
Iron	0%

* Percent Daily Values are based on a 2000 calorie diet.

INGREDIENTS: WATER, OLIVE OIL, KONJAC POWDER, PEA STARCH, POTATO STARCH, PEA PROTEIN, SEA SALT, ORGANIC AGAVE NECTAR, SEAWEED POWDER, FENUGREEK, ALGINATE(FROM SEAWEED), PAPRIKA, CALCIUM HYDROXIDE.

PLANT-BASED MEAT SEAFOOD

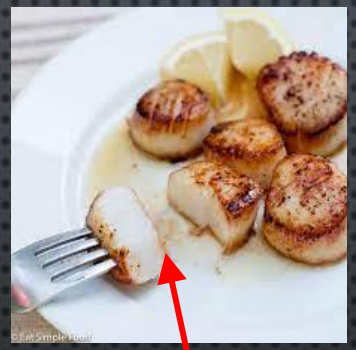
STRUCTURALLY COMPLEX SOFT SOLIDS

Mimicking Real Seafood:
Multisensorial Engineering

Sound
Bubbling & Evaporation

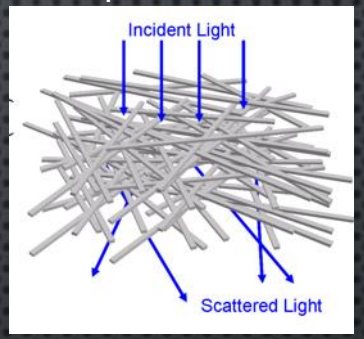
Texture
Small & Large Deformation

Mouthfeel
Breakdown/Texture-Time

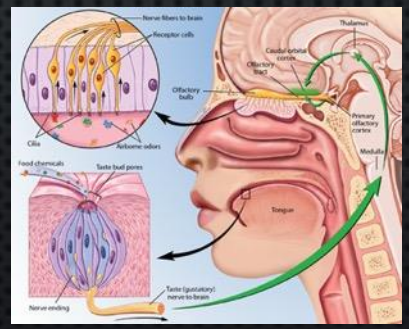


Microstructure
Organization

Appearance
Light Absorption & Scattering



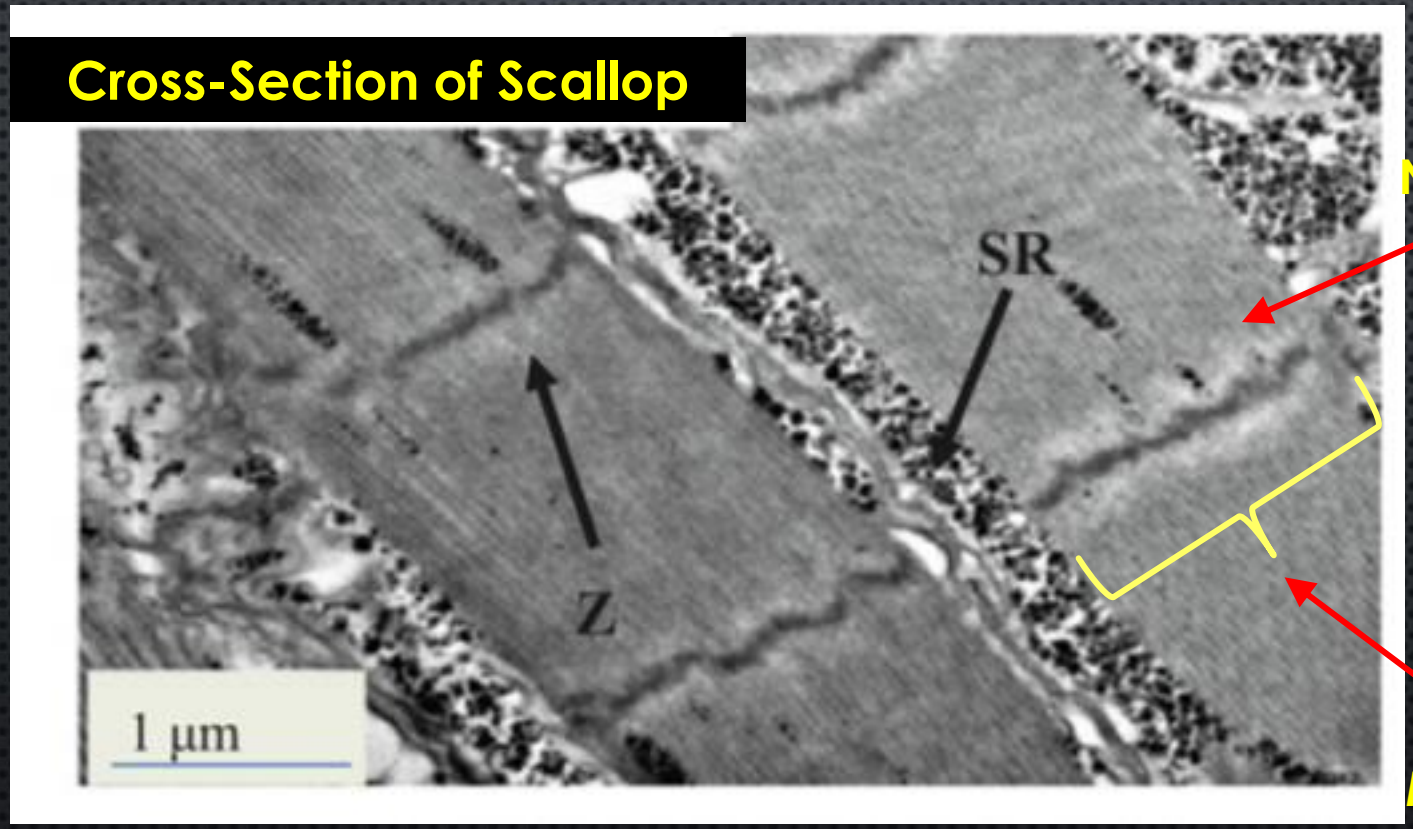
Aroma
Specific Volatile Profile



Taste
Specific Tastant Profile

What is the structural basis of deliciousness?

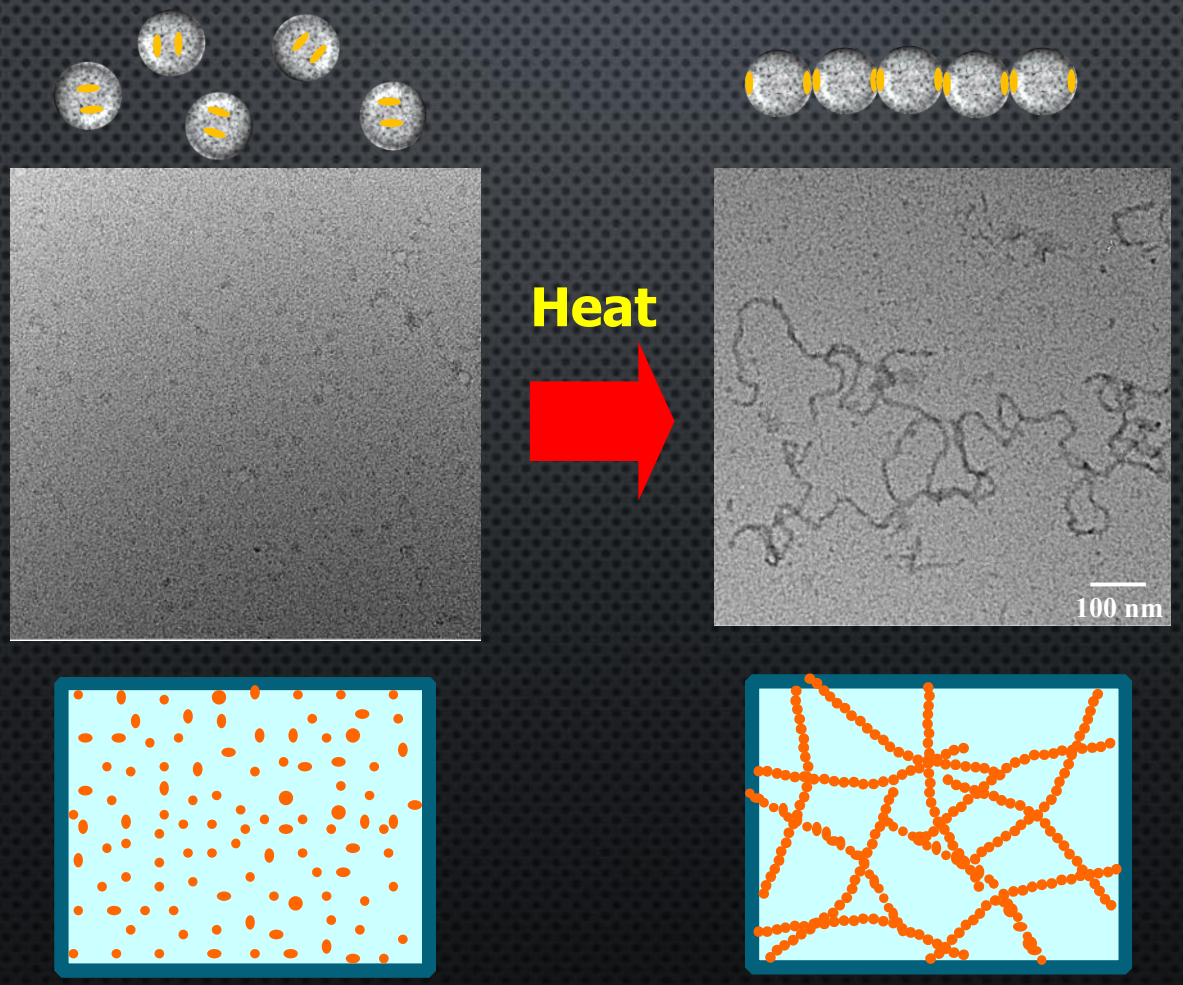
Creating Plant-based Scallop:
Mimicking Structural Architecture



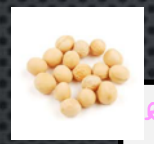
"Microstructural properties of pre-rigor scallop adductor muscle" Wei et al (2020). Effects of thawing methods on the biochemical properties and microstructure of pre-rigor frozen scallop striated adductor muscle. Food Chemistry, 319, 126559.

Mimicking Nanostructure:

Controlled Protein Denaturation-Aggregation

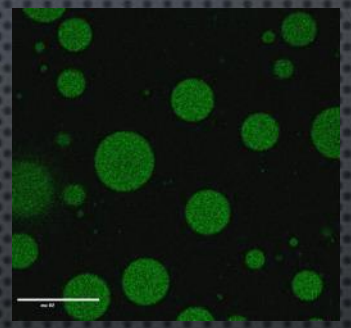


Mimicking Microstructure:
Soft Matter Physics Approach



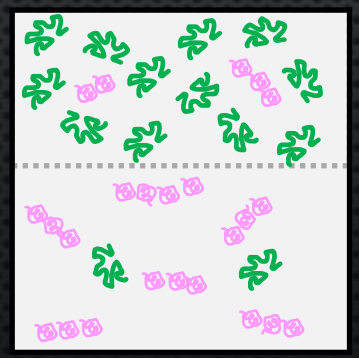
Pea Protein

Heat



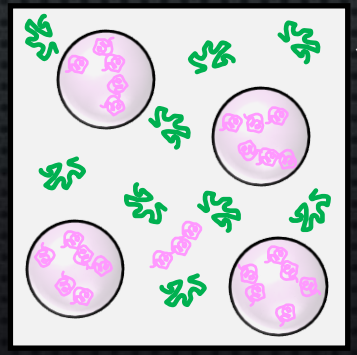
Combine

Pectin



Phase Separation

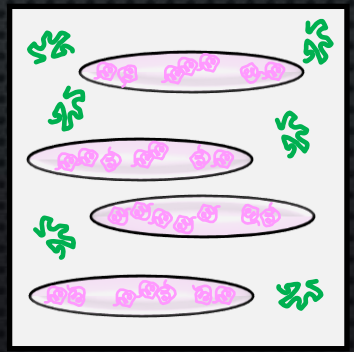
Mix



Structure Formation

Shear & Gel

Seafood-like Structure

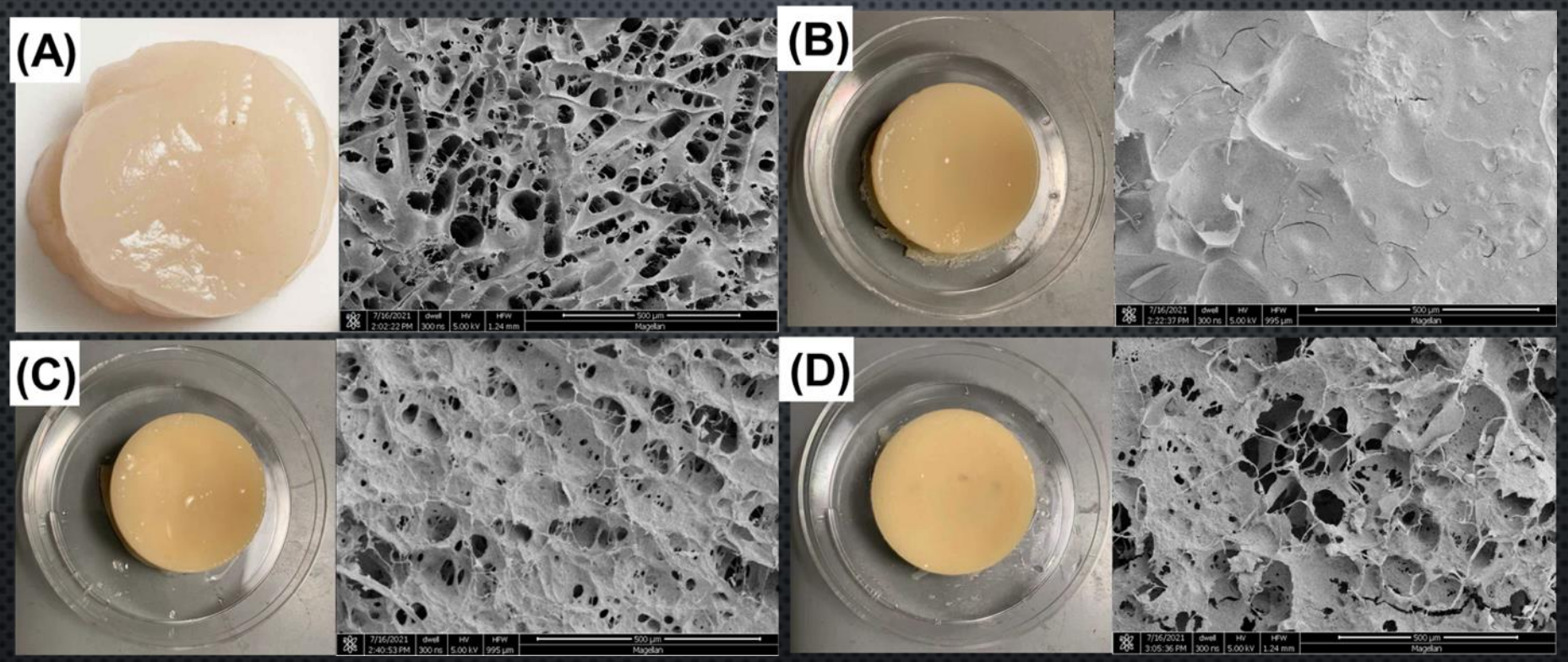


Fiber Formation

Structural Biomimicry

Scallop

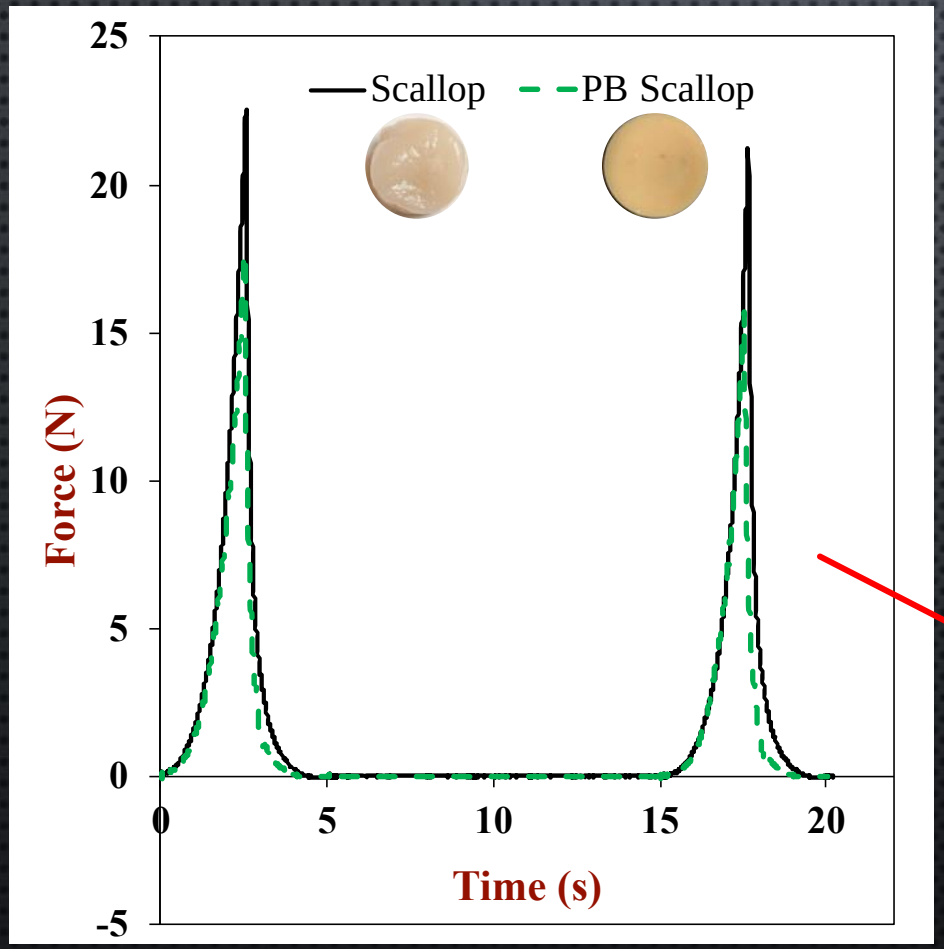
10% Pea Protein + 2% TG



10% Pea Protein + 0.5% Pectin + 2% TG

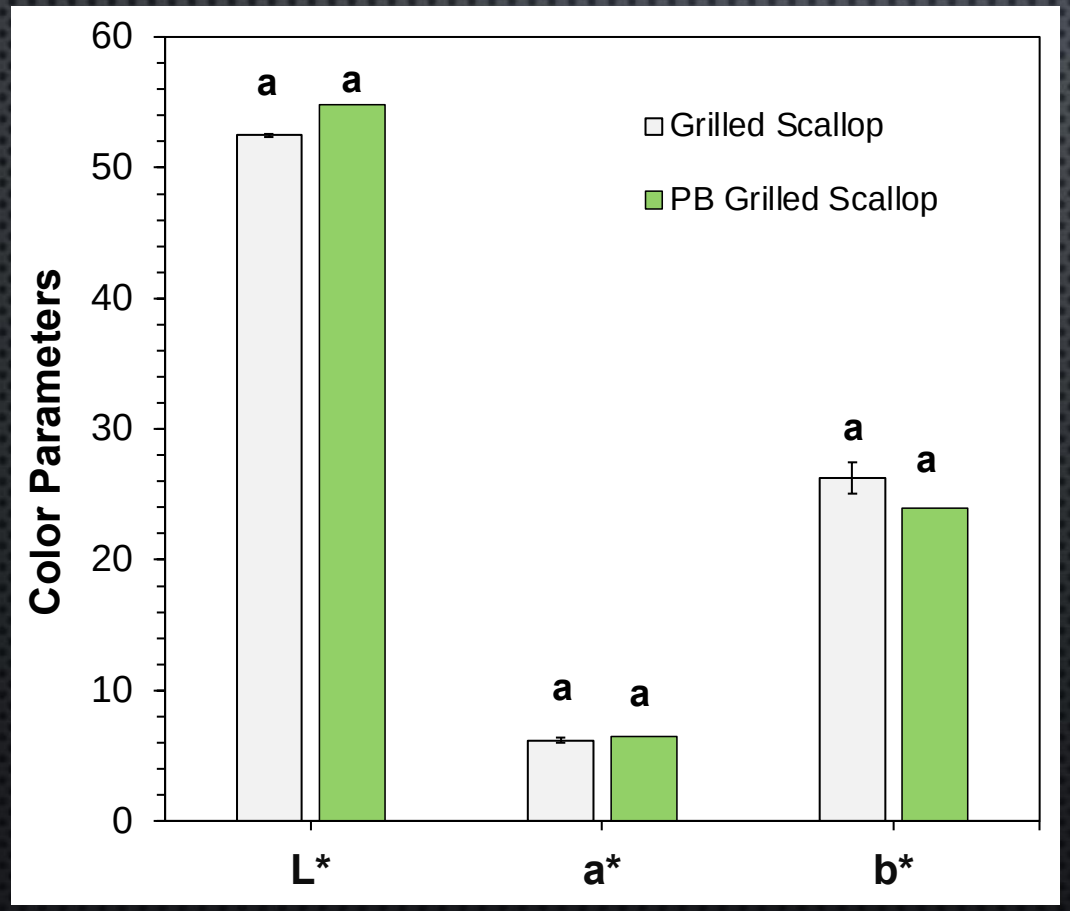
10% Pea Protein + 1% Pectin + 2% TG

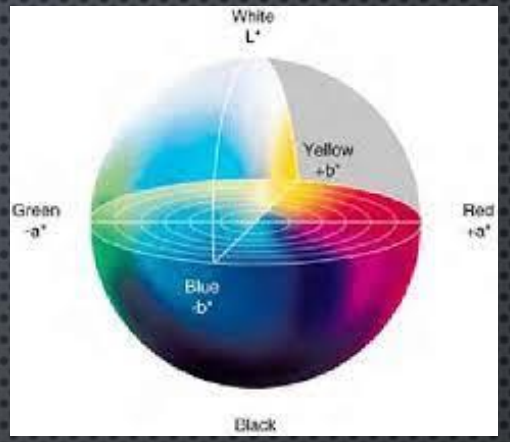
Textural Analysis



- Hardness
- Cohesion
- Springiness
- Chewiness

Color Analysis





PLANT-BASED SCALLOP

FUTURE WORK

SENSORY

- APPEARANCE, TEXTURE, TASTE

NUTRITION

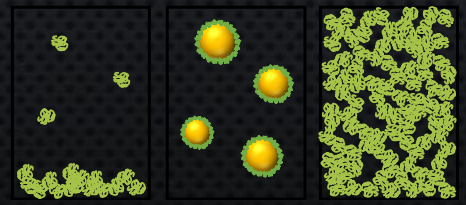
- NUTRITIONAL PROFILE
- DIGESTIBILITY

SUSTAINABILITY

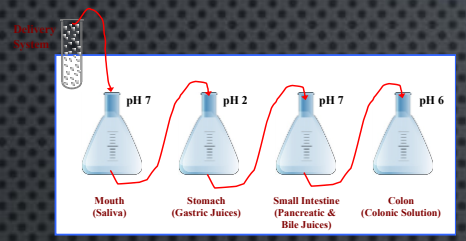
- ENVIRONMENTAL IMPACT

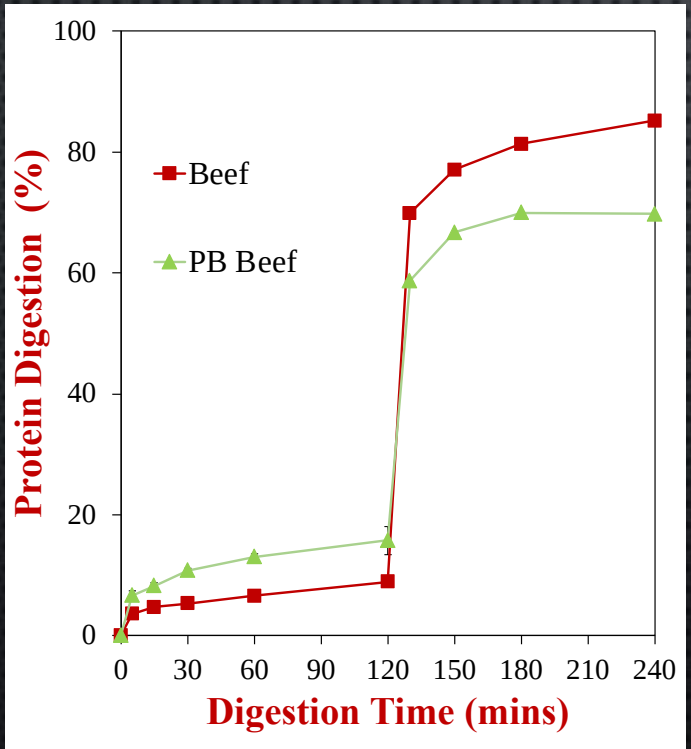
SOCIOECONOMICS

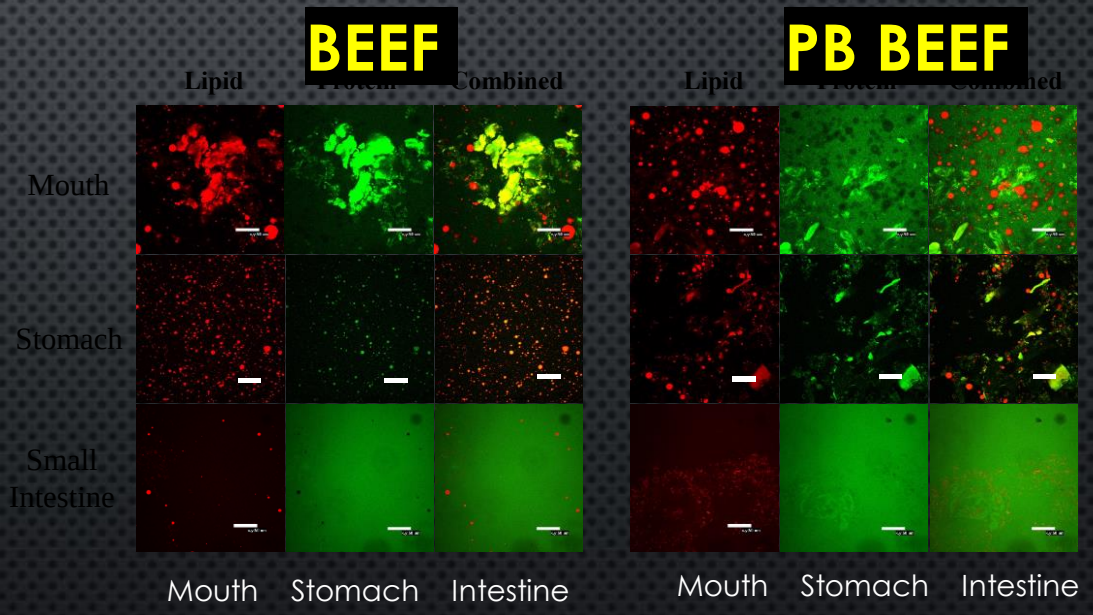
- COST AND SCALABILITY
- SOCIAL IMPACT



GASTROINTESTINAL FATE







Digestibility
Bioavailability

PLANT-BASED EGGS:
COMPLEX COLLOIDAL DISPERSIONS

> $27 million (2020)
(Good Food Institute, USA)

HEN'S EGGS:
FAMILIAR & VERSATILE

QUALITY

APPEARANCE, TEXTURE, MOUTHFEEL & TASTE

NUTRITION

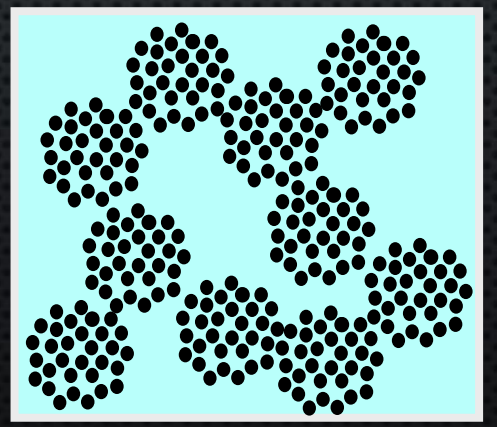
PROTEINS (12%), LIPIDS (10%), VITAMINS A, D, E, CHOLINE, IRON, AND FOLATE

VERSATILITY

MAYONNAISE, SALAD DRESSING, MERINGUE, DESSERTS, CAKES….

Protein Functionality:
Thermal Gelation

Heat-set
Irreversible
Opaque Gel



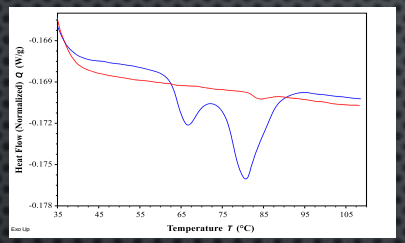
Physical Properties

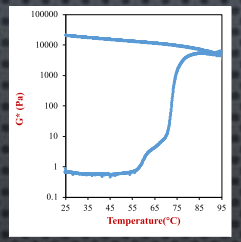
Appearance, texture, cookability, mouthfeel

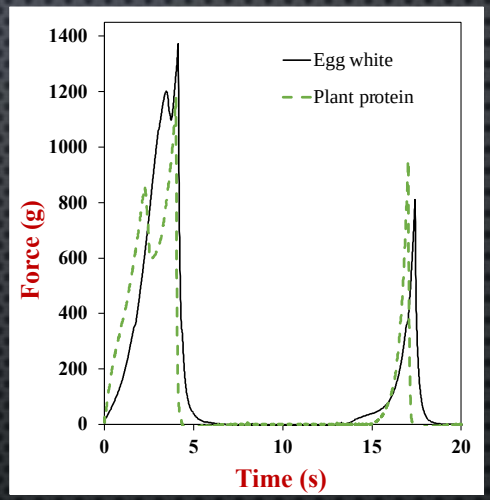
Mimicking Real Egg:
Physicochemical Characterization

Denaturation | Gelation | Texture | Appearance

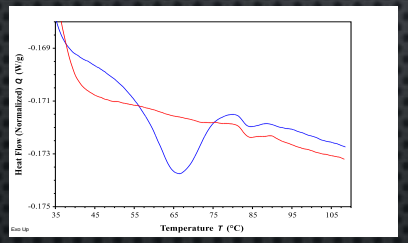
Egg

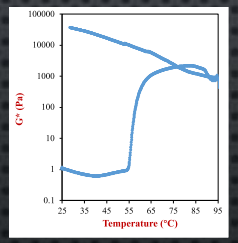




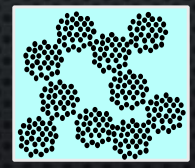


Rubisco Protein

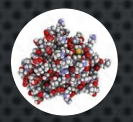




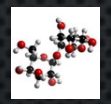
T_m
Unfolding



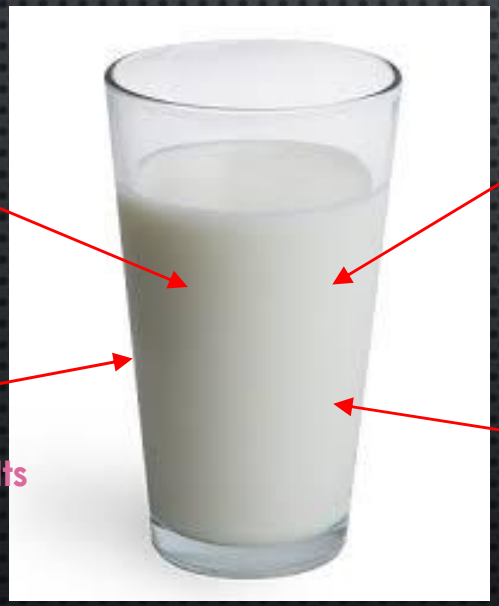
PLANT-BASED DAIRY
COMPLEX COLLOIDAL DISPERSIONS

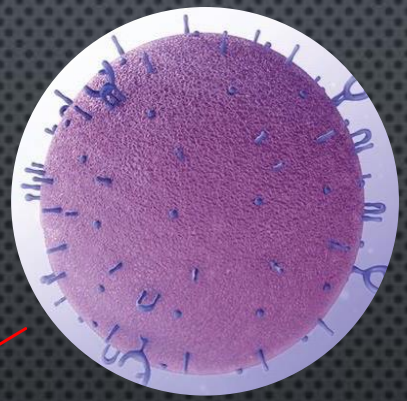


Whey proteins
(2-3 nm)



Sugars and salts
(1-2 nm)



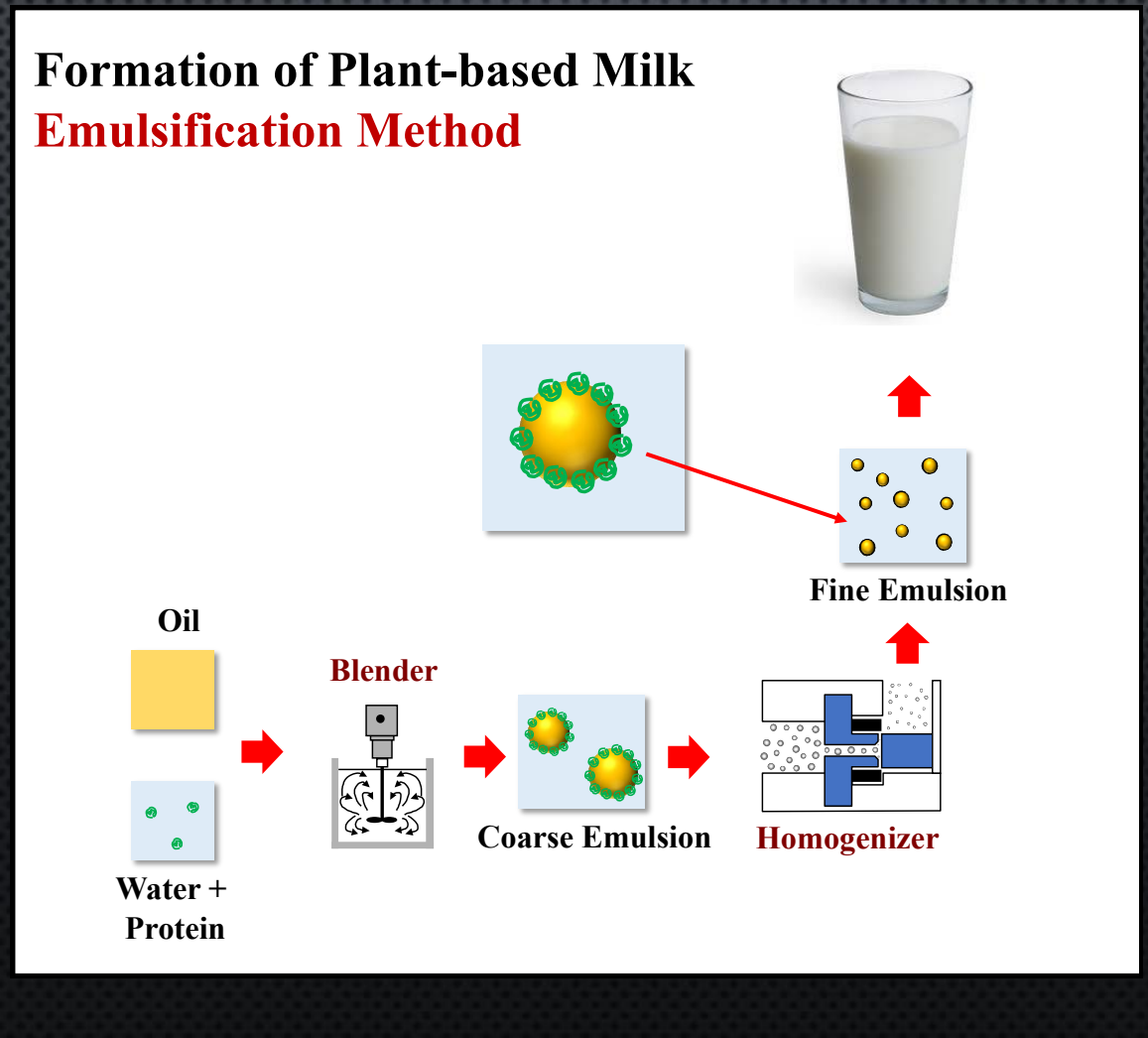


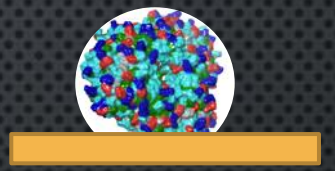
Milk Fat Globules
(1000-5000 nm)

Casein Micelles
(20-200 nm)

- Formulation
- Quality attributes
- Fortification
- Bioavailability
- Versatility

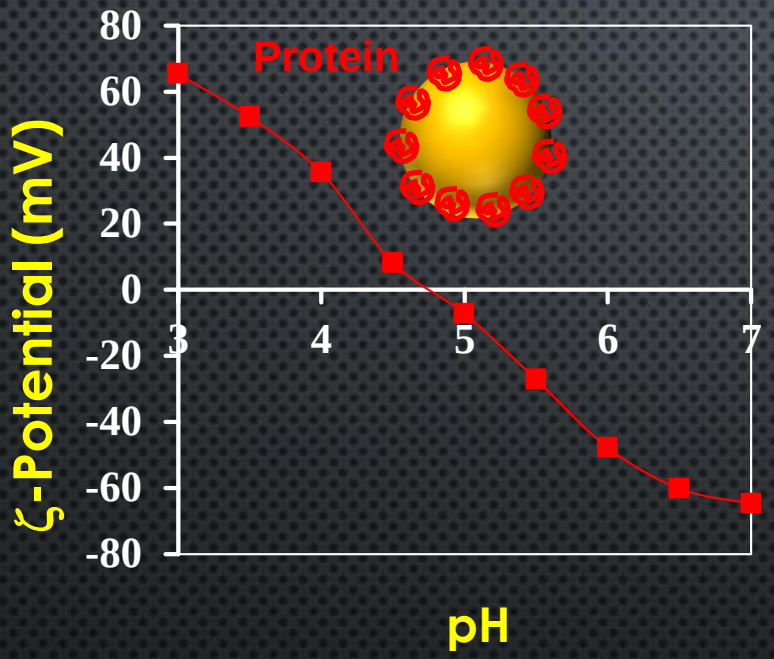
PLANT-BASED MILK
COMPLEX COLLOIDAL DISPERSIONS

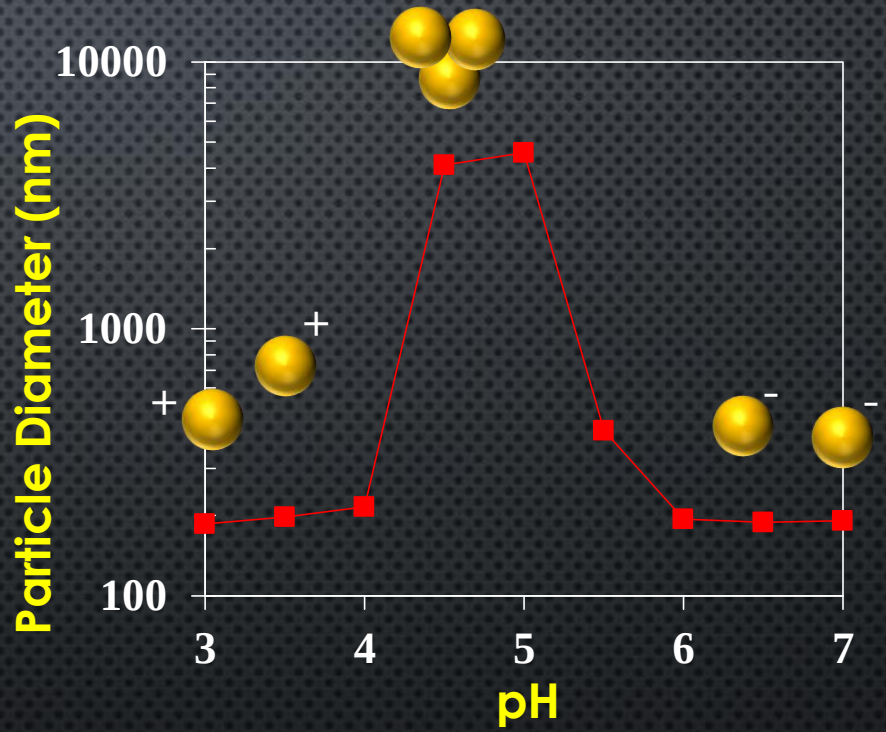


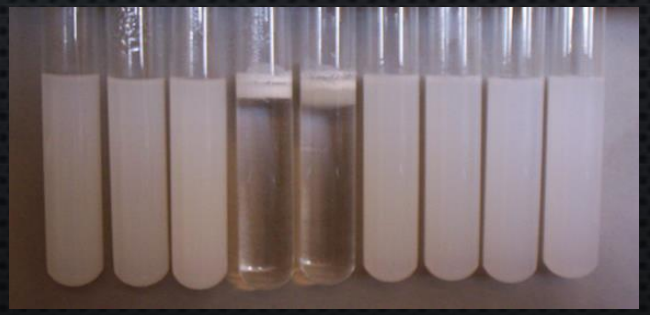


STABILIZATION BY MULTILAYER TECHNOLOGY

IMPROVE PH AND HEAT STABILITY

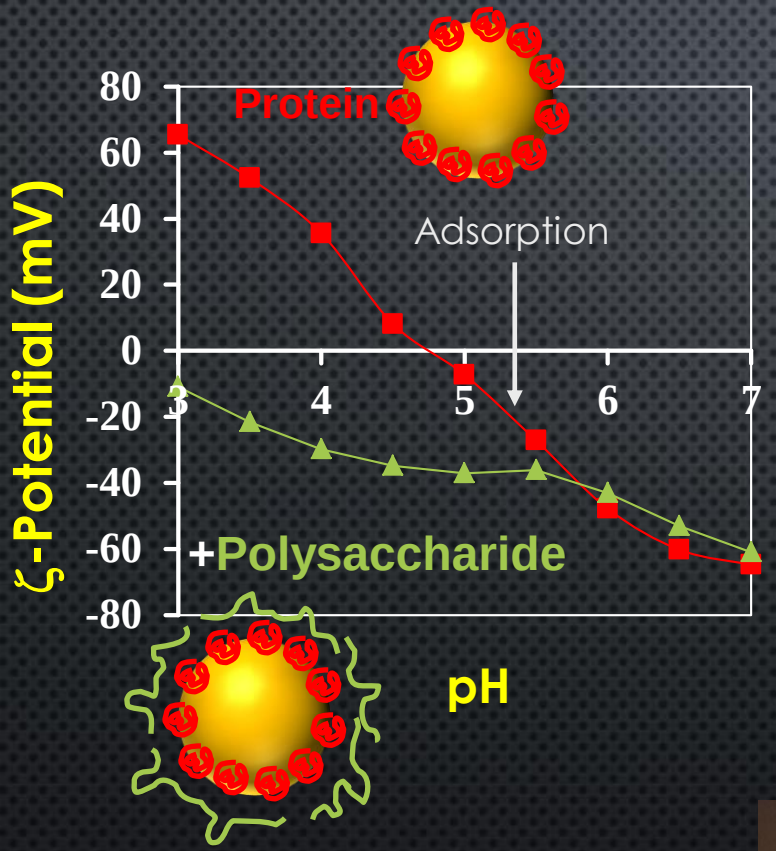


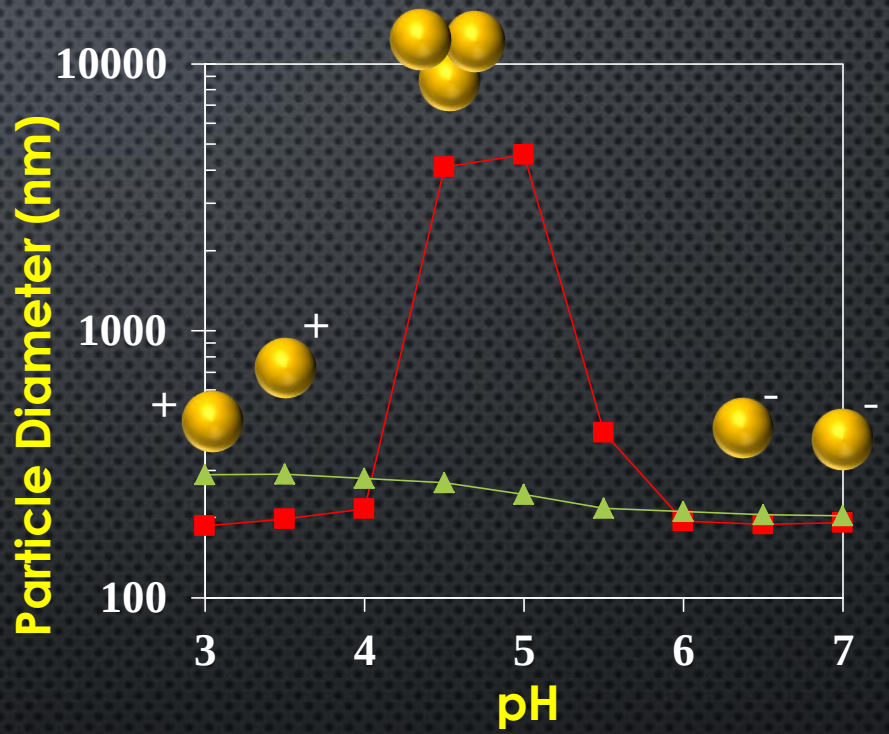


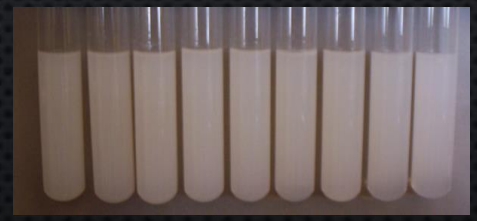


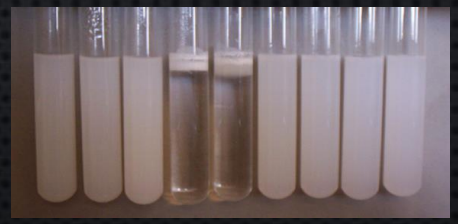
STABILIZATION BY MULTILAYER TECHNOLOGY

IMPROVE PH AND HEAT STABILITY





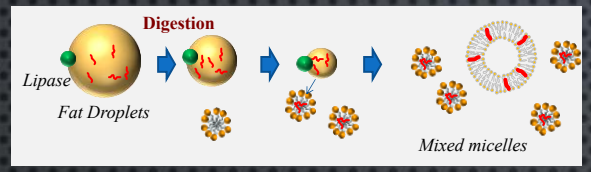


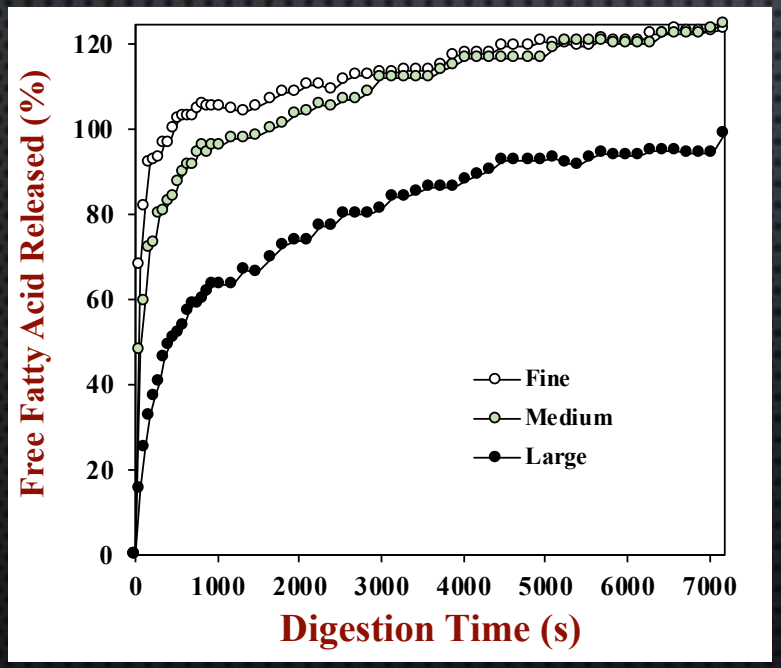


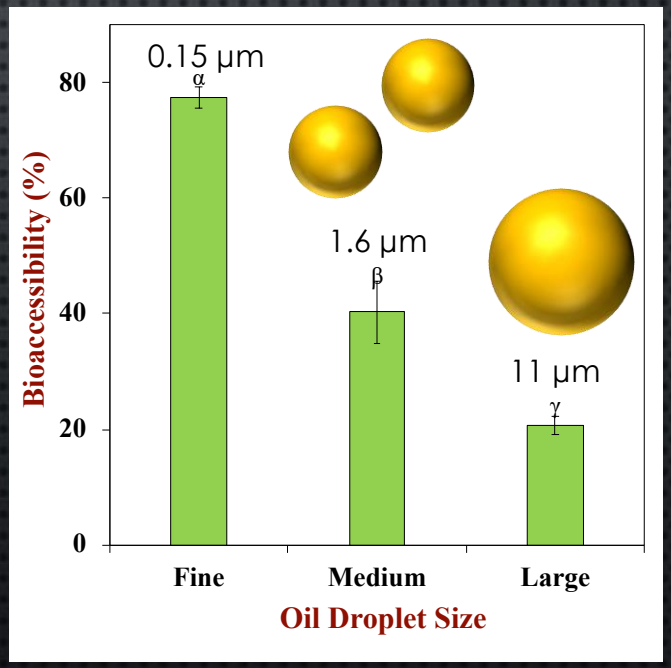
Protein +
Polysaccharide

Protein

PLANT-BASED MILK
VITAMIN FORTIFICATION

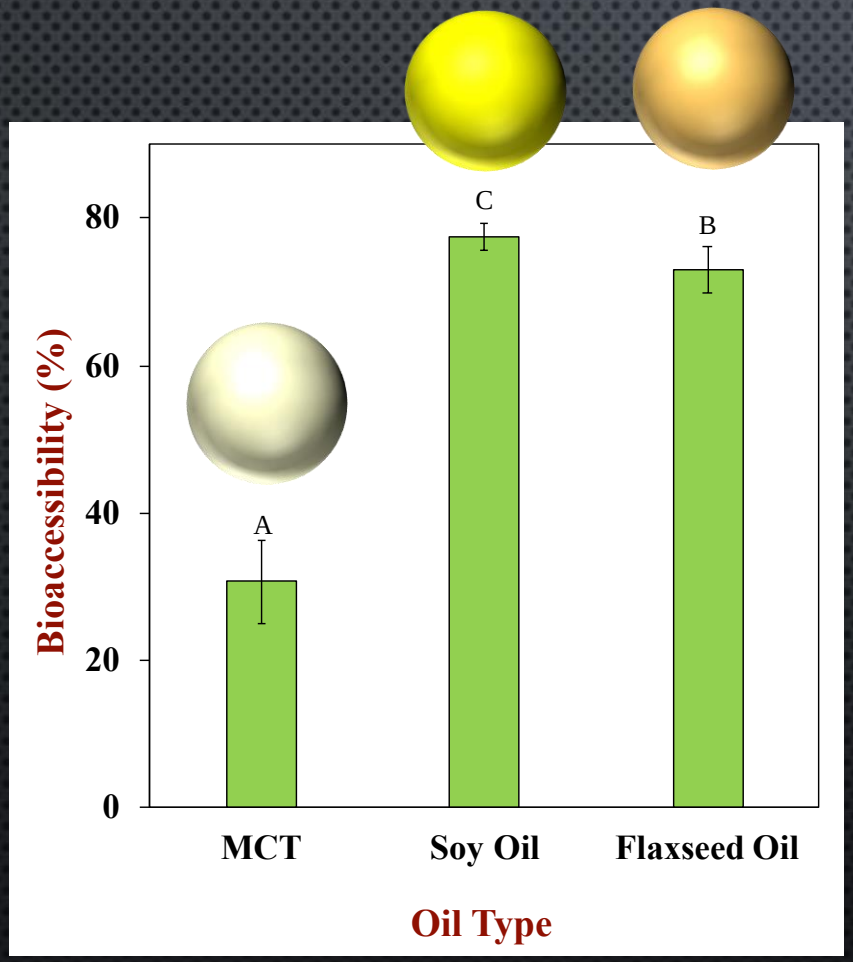




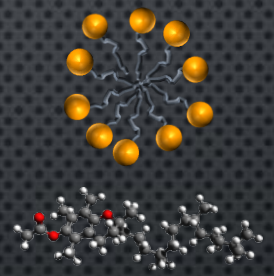


Vitamin E-loaded plant-based emulsions

PLANT-BASED MILK
VITAMIN FORTIFICATION

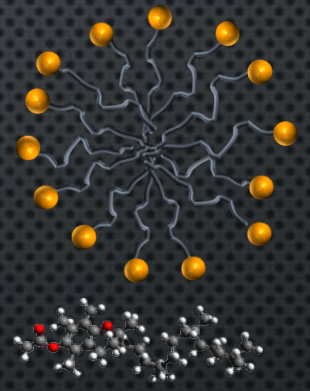


Small Mixed Micelles
(MCT)



Too large to fit inside micelle

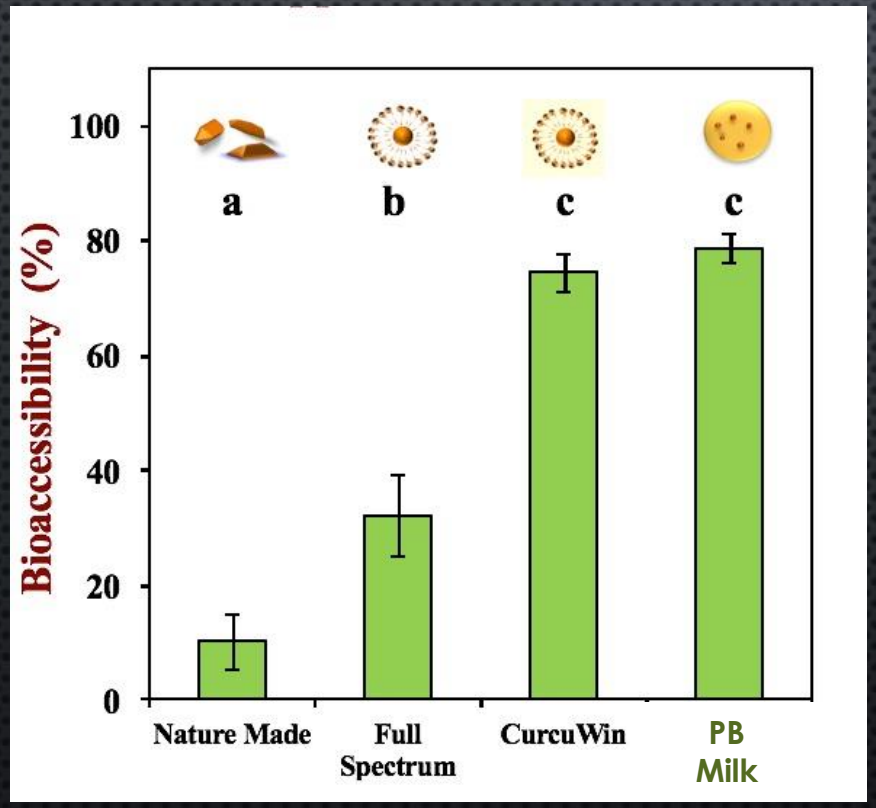
Larger Mixed Micelles
(Soy & Flaxseed Oils)



Fits in micelle

Vitamin E-loaded plant-based emulsions

PLANT-BASED MILK
NUTRACEUTICAL FORTIFICATION

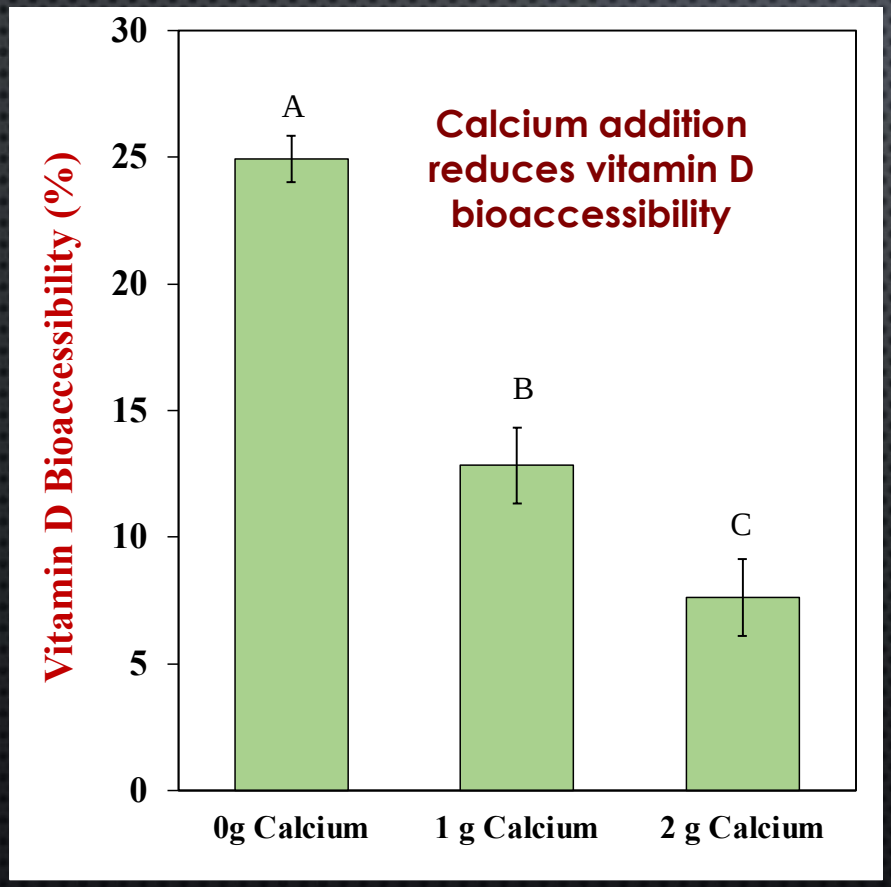


Bioaccessibility:

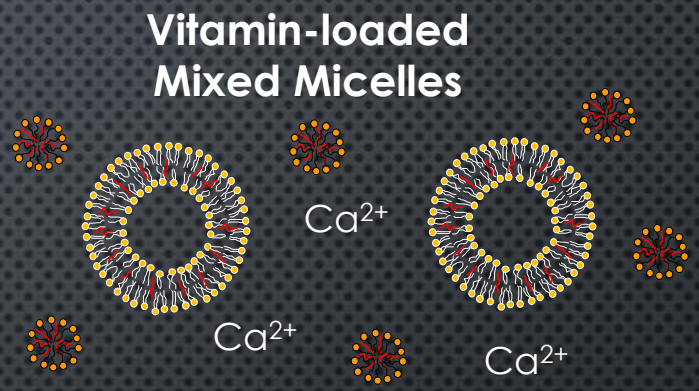
$23 $41 $9

Plant-based nanoemulsions give higher or equal bioaccessibility as commercial supplements

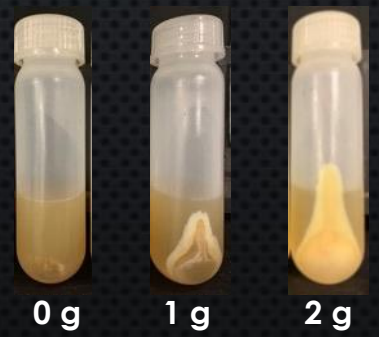
PLANT-BASED MILK
COMBINED FORTIFICATION



Vitamin D-fortified Almond Milk



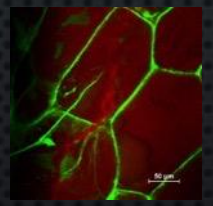
Calcium Soap

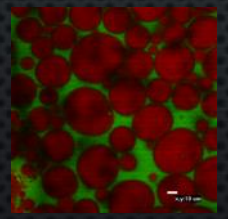


PLANT-BASED MEAT

Muscle &
Connective Tissue

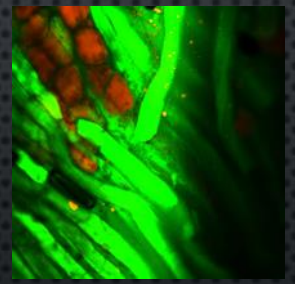
Adipose
Tissue



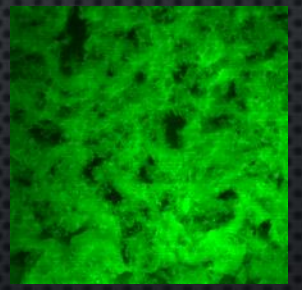


Animal-based

Plant-based



Animal-based



Plant-based

FUTURE WORK

SENSORY

- APPEARANCE, TEXTURE, TASTE

NUTRITION

- NUTRITIONAL PROFILE
- DIGESTIBILITY

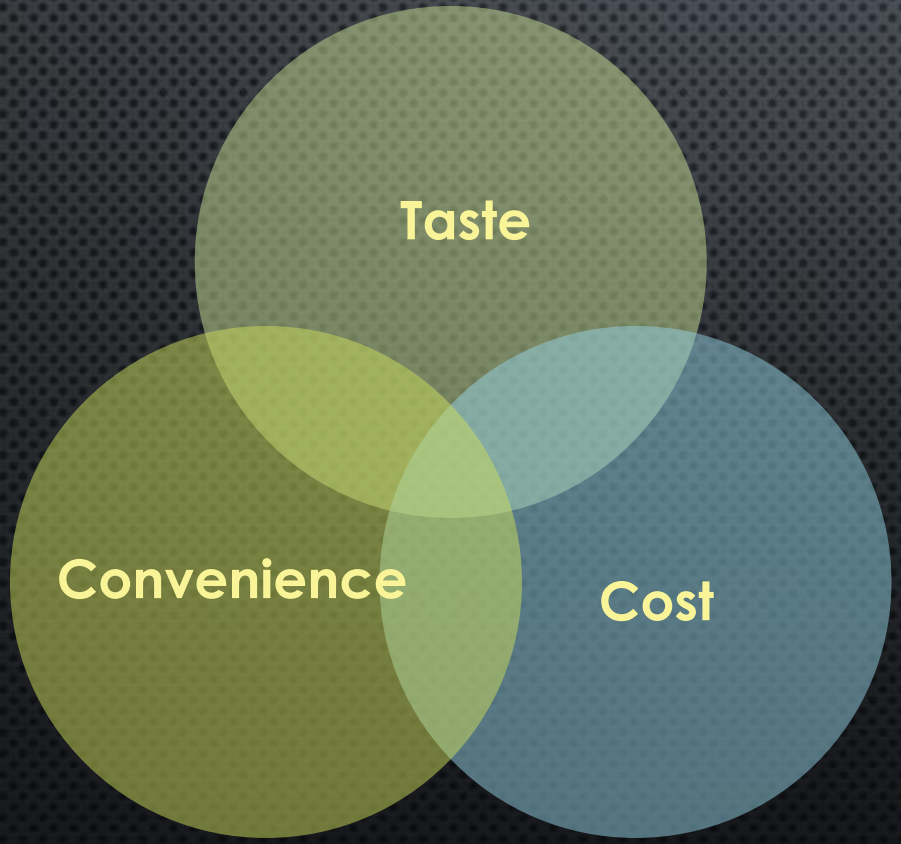
SUSTAINABILITY

- ENVIRONMENTAL IMPACT

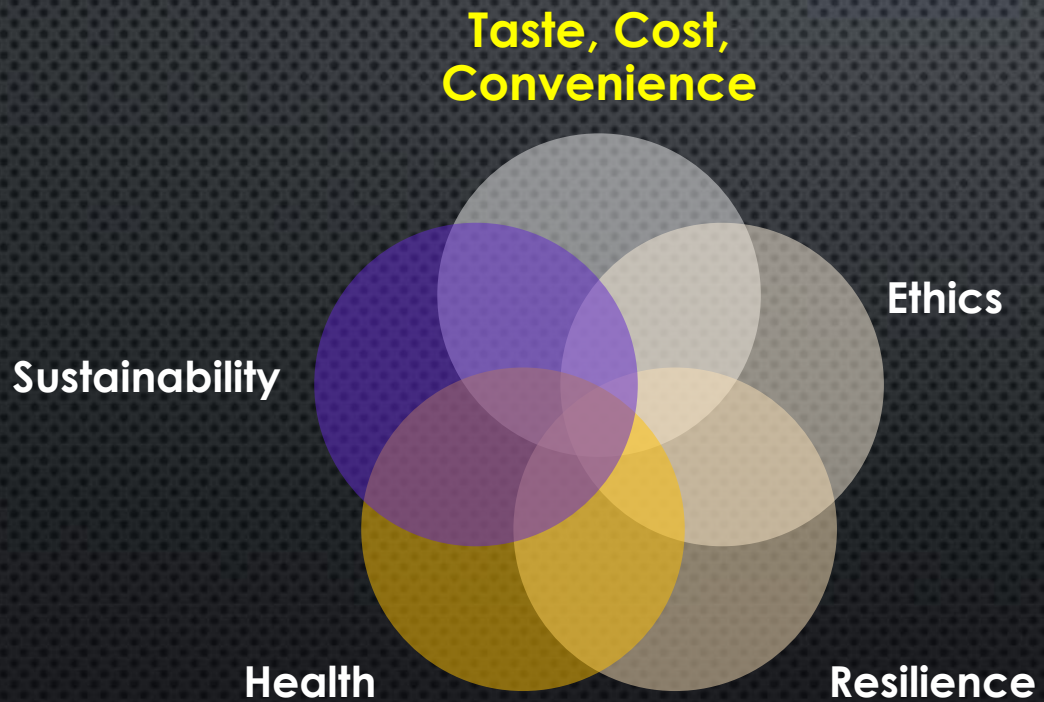
SOCIOECONOMICS

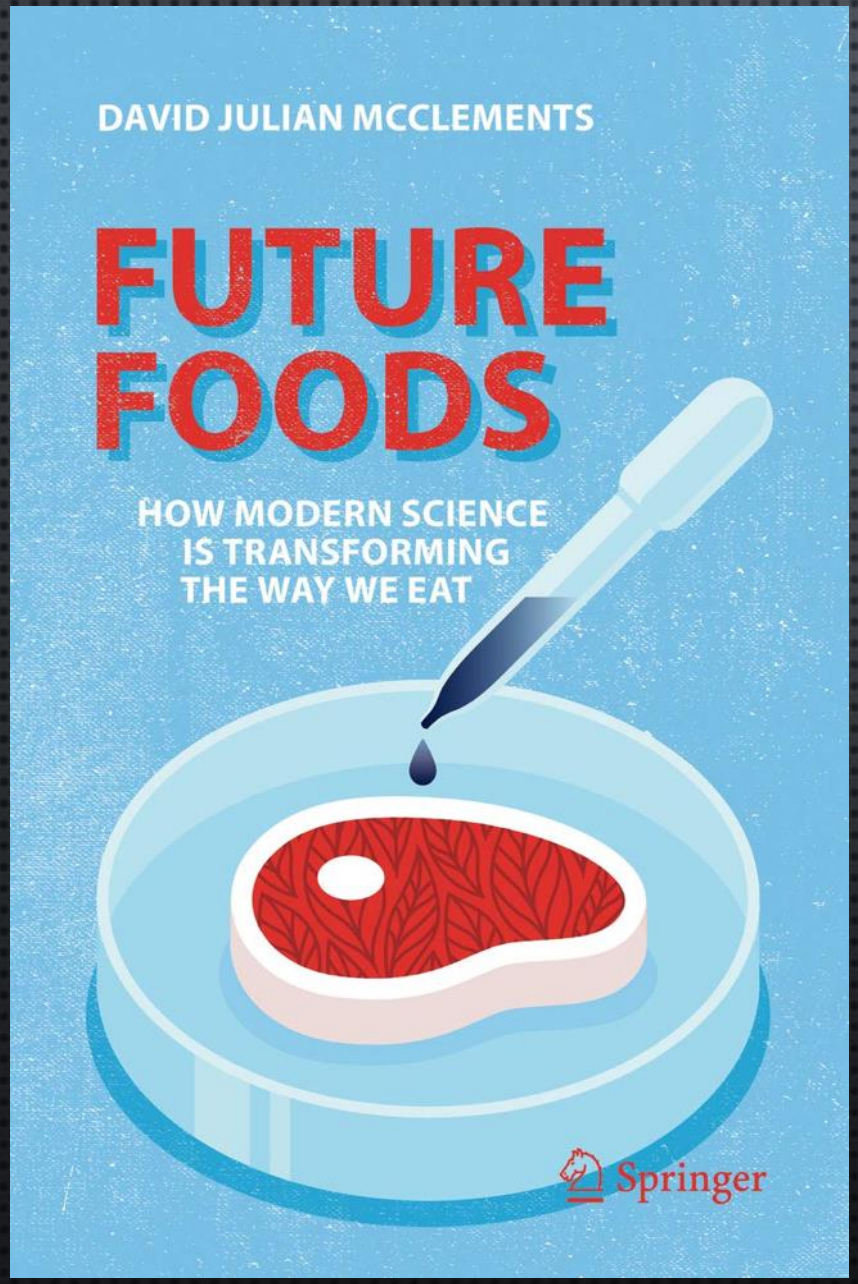
- COST AND SCALABILITY
- SOCIAL IMPACT

FOOD SCIENCE & ENGINEERING:
THE OLD PARADIGM

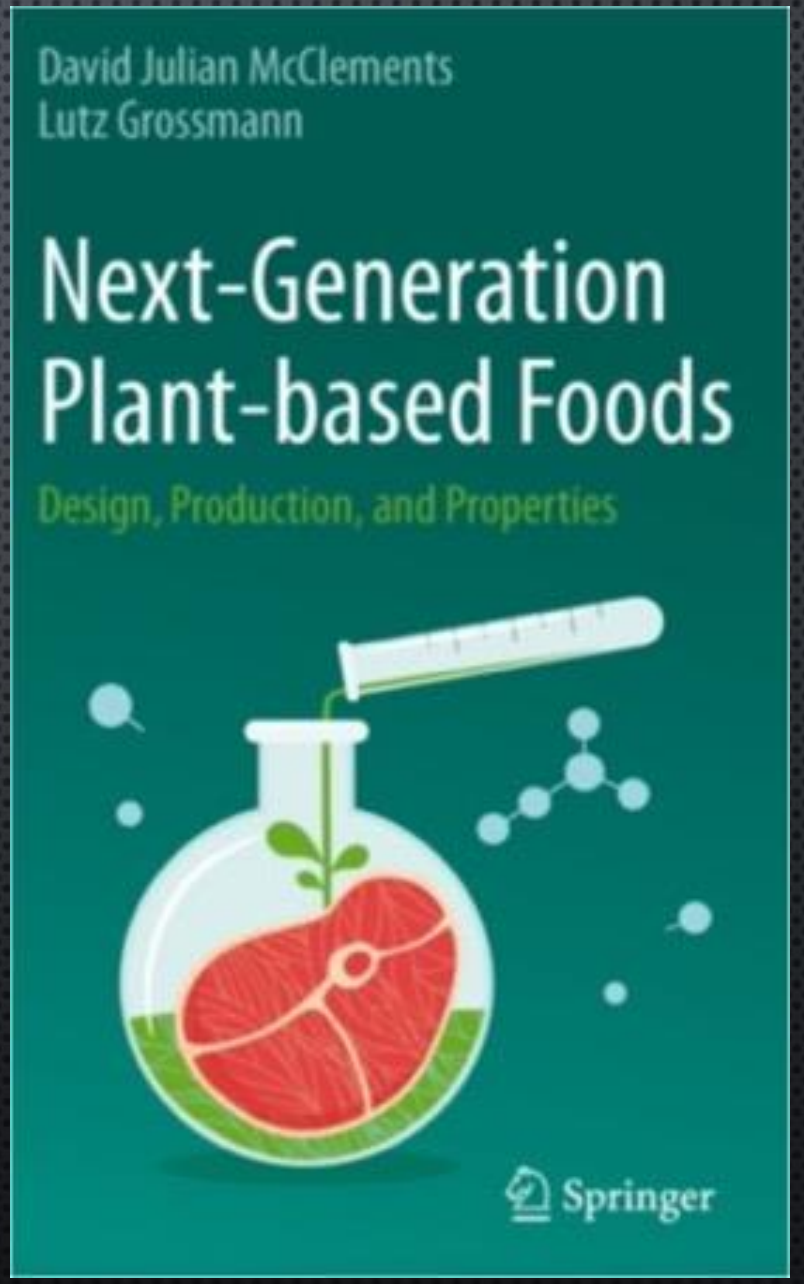


FOOD SCIENCE & ENGINEERING:
THE NEW PARADIGM





2019



Last week

ACKNOWLEDGEMENTS

NSF

UMASS AMHERST

NASA

USDA

THE GOOD FOOD INSTITUTE