Creating Animal-free Dairy

Perfect Day Protein in Frozen Desserts

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Perfect Day

What we love about milk

It's Delicious

Milk has an unparalleled ability to combine with and transform into amazing foods, sweet and savory.

It's Nutritious

The proteins in milk are some of the most bioavailable on earth.

It's Versatile

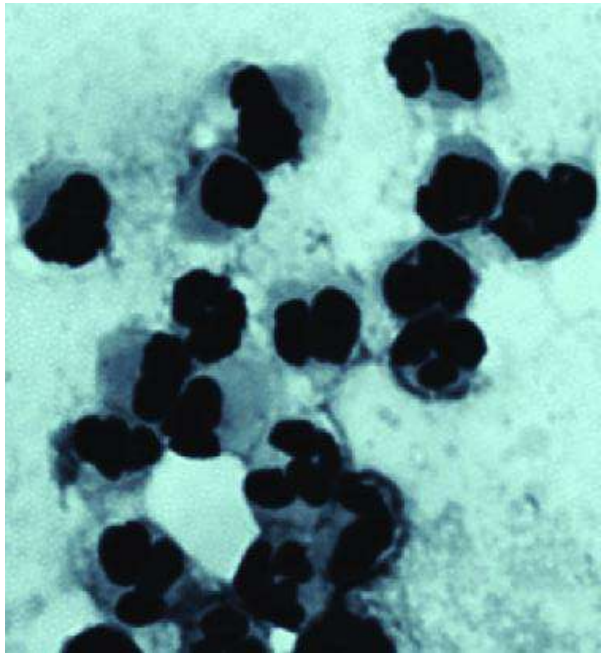
The complex functionality of dairy proteins gives milk abilities no other food can easily achieve.

What’s not great about milk

Planet Impact

Compared to most other whole foods, dairy has some of the most damaging impacts on the environment.

The Stuff In It

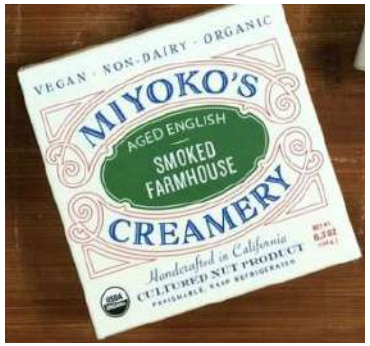


About 65% of the world’s population is lactose intolerant.

It’s Not For Me

A growing contingent of consumers are looking for plant-based alternatives.

ALT CHEESES



ALT YOGURTS & MILKS

SOY

COCONUT

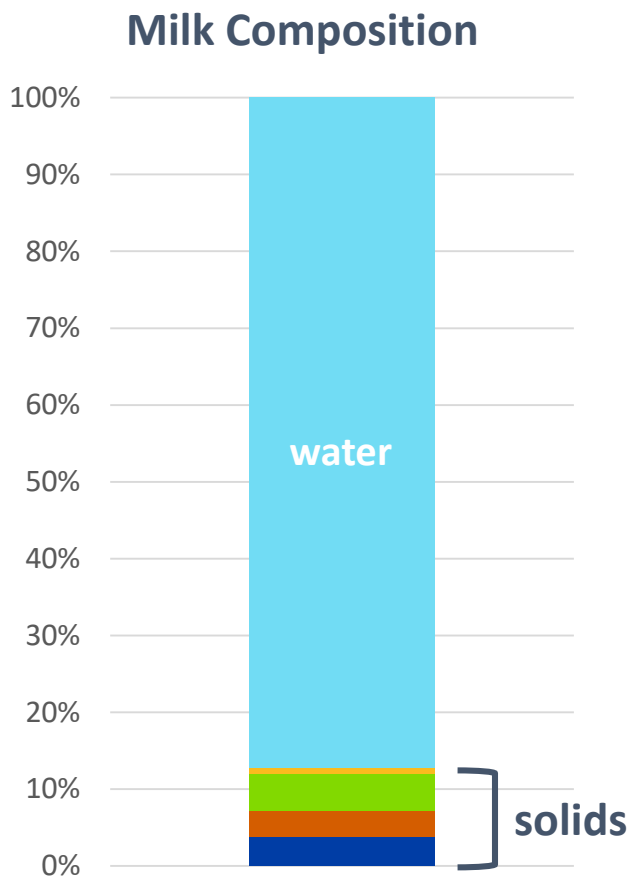
ALMOND

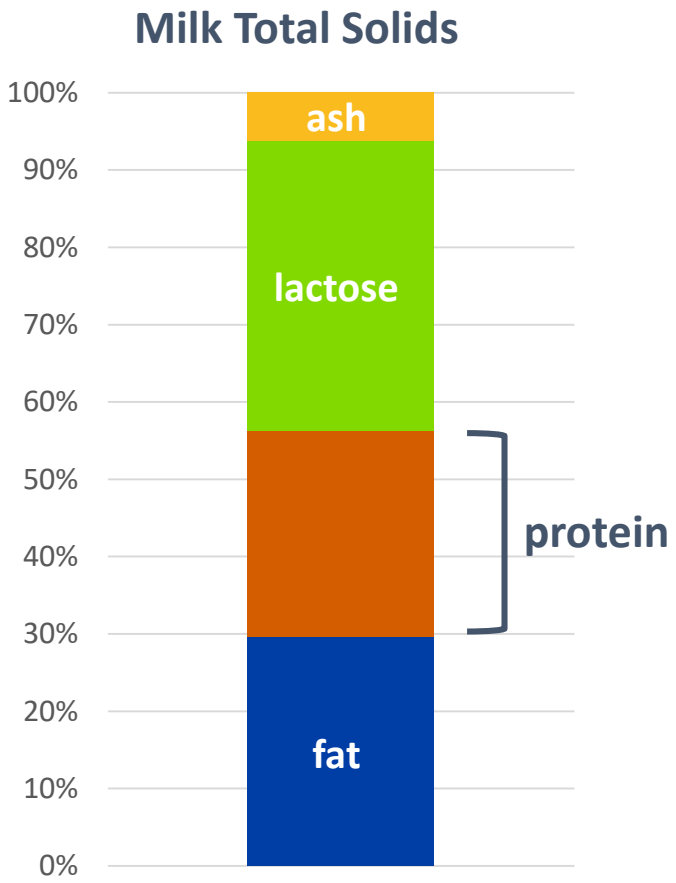
PEA

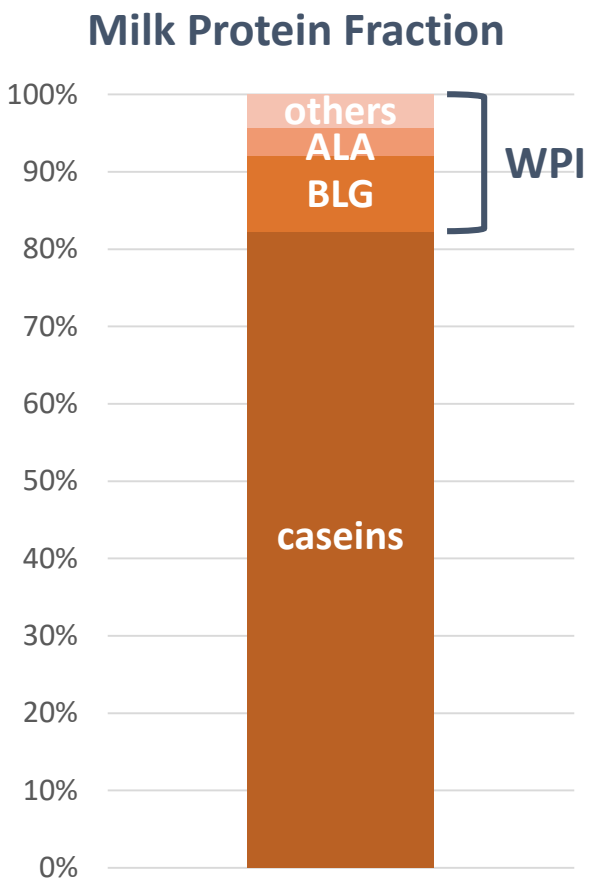
How dairy works… as an industry

Like any complex raw material, milk is separated, refined and sold as a multitude of value-added products and ingredients. ***By far the most desired of these are the proteins***, because they are the secret to milk's incredible ***nutrition, flavor and versatility.***

It takes a lot of milk to make dairy proteins!







Need 320 L of milk to get 2 kg WPI !

In other words, a 7000 L tanker truck is, at best, 160 kg of whey protein isolate!

Perfect Day's process

1. Flora

First, we took milk's essential genes and added them to microflora, tiny organisms from nature that can produce large amounts of pure protein.

2. Fermentation

Now our flora can use fermentation to convert plant sugar into milk proteins – whey and casein – that are nutritionally identical to those that come from cows.

3. Foods You Love

Finally, we can whip up all kinds of delicious animal-free dairy products for an entirely new generation of foods.

There are two kinds of milk today.

ANIMAL MILK

(including 2%, 1%, skim, etc)

- Animal protein
- Not vegan
- Dairy allergen present
- Nutritious
- Can do stuff in food*
- Unsustainable

NON-DAIRY MILK

(including soy, almond, coconut, etc)

- Plant protein
- Vegan
- No dairy allergen present
- Less nutritious
- Needs stabilizers, gums, etc to do stuff in food*
- Sustainable

* "Can do stuff in food" here means useful ingredient functionality – things like foaming, emulsifying, gelling, water binding… etc.

If I told you about a new animal-free milk, you would assume it's...

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(including 2%, 1%, skim, etc)

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- Plant protein
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- Sustainable

But in our case, that’s not quite right.

PERFECT DAY MILK

(or cheese, or yogurt, or whey protein...)

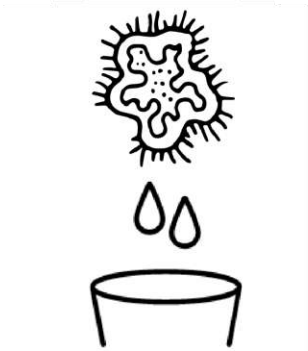
- Animal protein
- Vegan
- Dairy allergen present
- Nutritious
- Does stuff in food
- Sustainable

It’s not from plants...

But in our case, that’s not quite right.

PERFECT DAY MILK

(or cheese, or yogurt, or whey protein...)



- Animal protein
- Vegan
- Dairy allergen present
- Nutritious
- Does stuff in food
- Sustainable

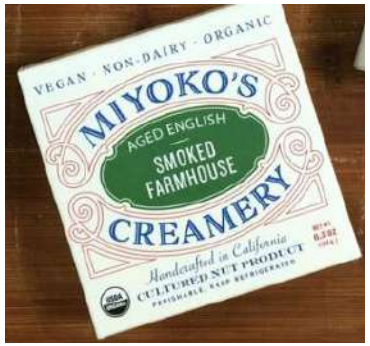
...but it’s also not from animals

We’re somewhere in between.

So Why Is This So Important?

How does this help us position our technology?

ALT CHEESES



ALT YOGURTS & MILKS

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Where can we raise the bar for these products?

	Main technical challenges for ingredient functionality
High protein, UHT beverages	**thermal stability,** age **gelation**, mouthfeel, color
Coffee creamer & “barista blends”	no feathering/clouding, **emulsion & heat stability**, **foaming** under hot/cold conditions
Cooking cream	**emulsion stability, heat stability**, pH stability in applications
Ice cream/frozen dessert	mouthfeel, creaminess, water binding, **freeze-thaw stability**, air cell stability,
Cream cheese	**emulsion capacity**, spreadability, mouthfeel, application in bakery
Yogurt & cultured products	**gel strength**, degree of syneresis, mouthfeel, fermentation rate
Egg replacement & baked goods	**gelation**, **air cell stability**, **foaming** capacity, **foam stability**

Dairy proteins can go into nearly any food in a grocery store!

Case study: Protein Functionality

Assuring flora-made proteins perform like their dairy counterparts.

Evaluating fundamental ingredient performance

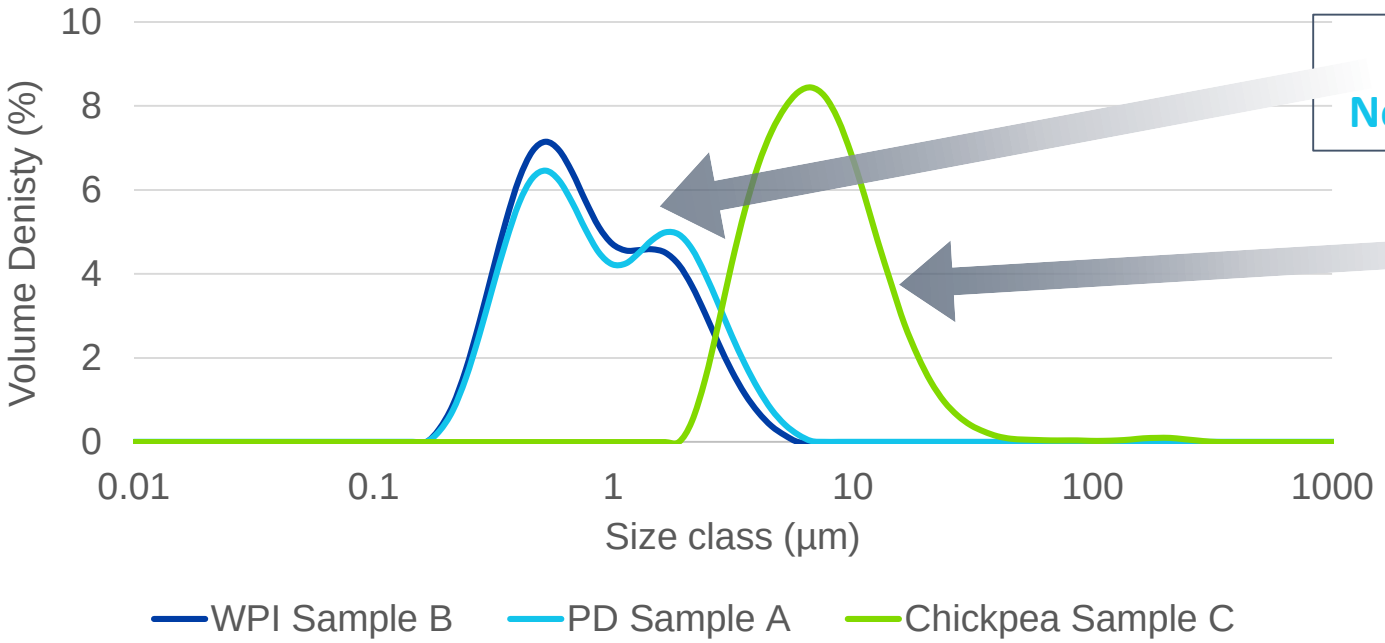
- Assuring flora-based, animal-free proteins perform like their dairy counterparts
- Types of functionality
  - Interfacial *(emulsification, foaming)*
  - Network formation *(gelation)*
  - Hydration *(solubility, heat stability, water binding)*

Non-animal Whey Protein

Commercial Whey Protein Isolate (WPI)

Chickpea Protein Isolate

Standard Protein Stabilized Emulsions



bimodal distribution
Non-animal WP & **WPI** very similar

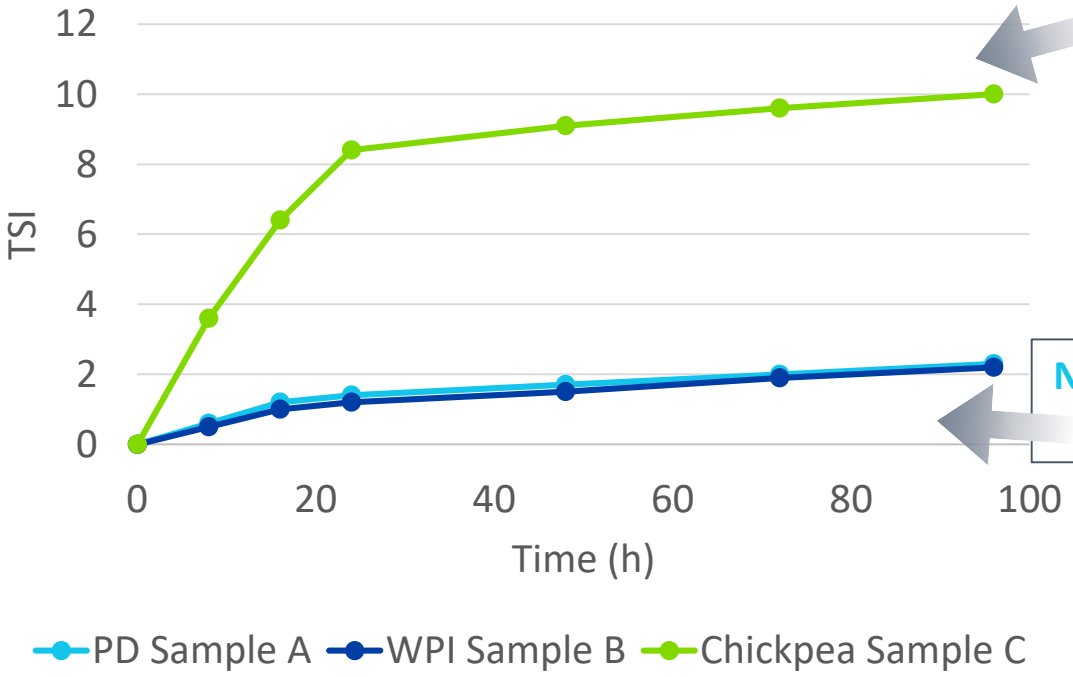
Chickpea protein = large size
suggests rapid destabilization

- One factor controlling emulsion stability: **dispersed phase droplet size**
- Can *predict*, but not fully *understand* destabilization mechanisms

4% total protein & 10% total sunflower oil. Mastersizer: Laser diffraction particle size analysis

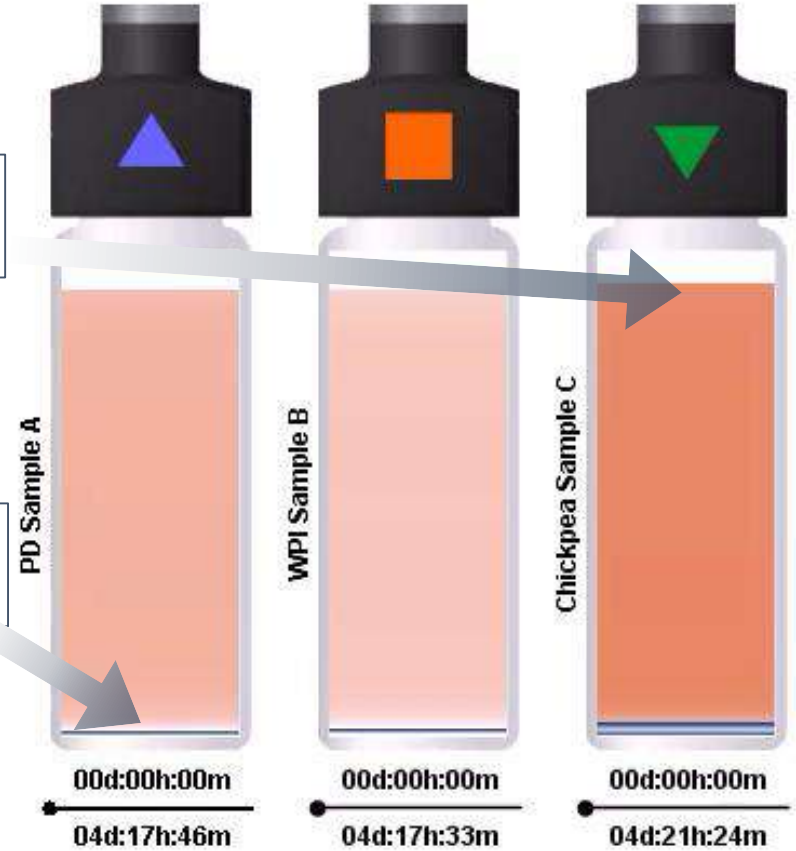
Turbiscan complements particle size data

- Combine Mastersizer data with Turbiscan to understand more about the ***time component***
- Useful for understanding destabilization mechanisms
  - Estimate ***emulsion creaming rate*** (distance/time)



chickpea protein = high TSI
creaming & clarification

Non-animal WP & **WPI** = low TSI
slight clarification



Foaming is a key interfacial property

- Critically important for many food applications
  - Barista blends, bakery, egg replacement, ***ice cream***
- Can assess foam strength with rheometer
  - Combine with ***foam destabilization rate*** from Turbiscan (e.g., change of mean interfacial area from %BS, drainage rate)

	How much air does it hold?		How long does foam last?	How strong is the foam?
	Overrun (%)	**Air Phase Volume**	**$t_{1/2}$ (min)**	**Yield stress (Pa)**
PD WP Sample A	790	0.89	140	122
WPI Sample B	710	0.88	140	112
Chickpea Sample C	58	0.37	<1	0

Utilizing Functionality in Frozen Desserts

A comparison between WPI, Non-animal WPI, Pea Protein Isolate, and Oat Protein Concentrate

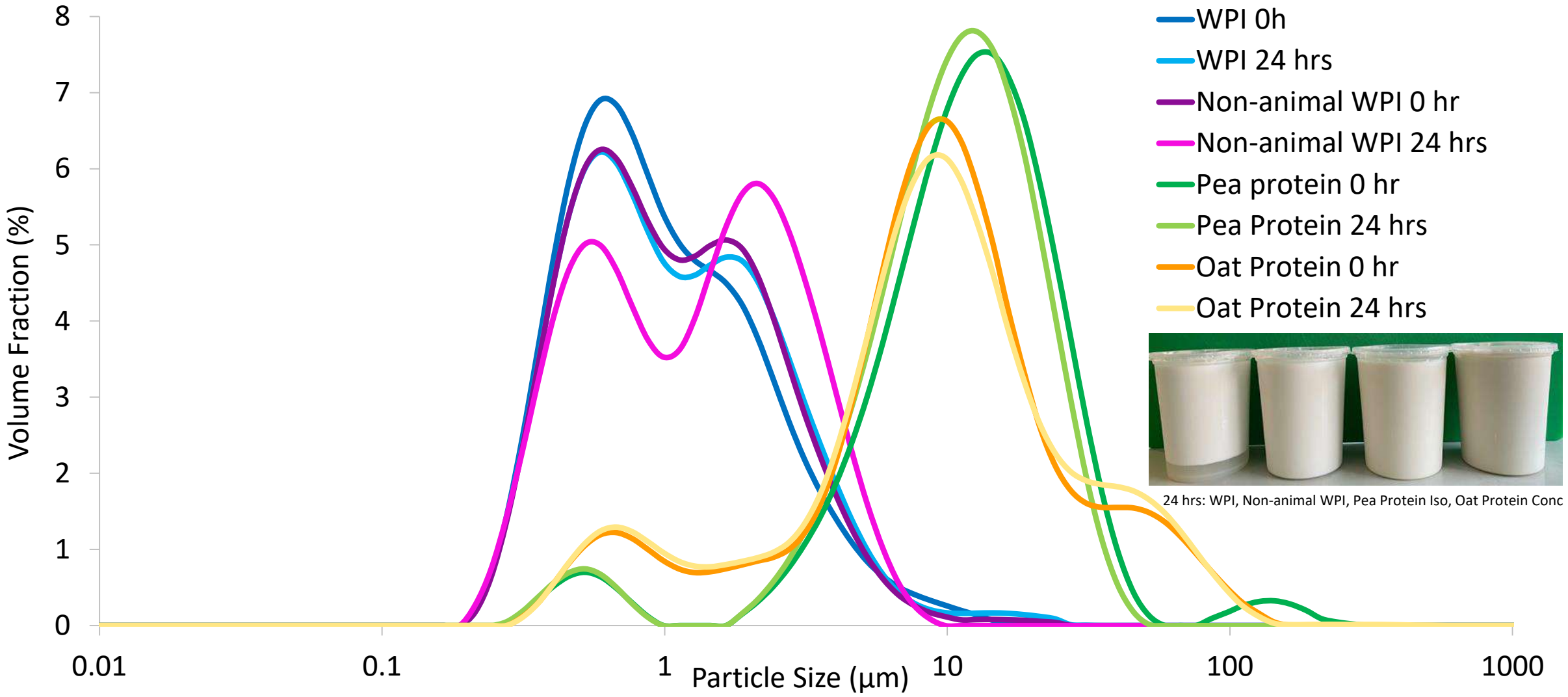
Performance of Proteins in Frozen Dessert App

Protein Source	% Protein	% Total Solids	% Fat
WPI	3	38.39	16
Non-animal WPI	3	38.31	16
Pea protein isolate	3	37.96	16.14
Oat protein concentrate	3	37.84	16.2

Left to right: WPI, Non-animal WPI, Pea Protein Isolate, Oat Protein Concentrate

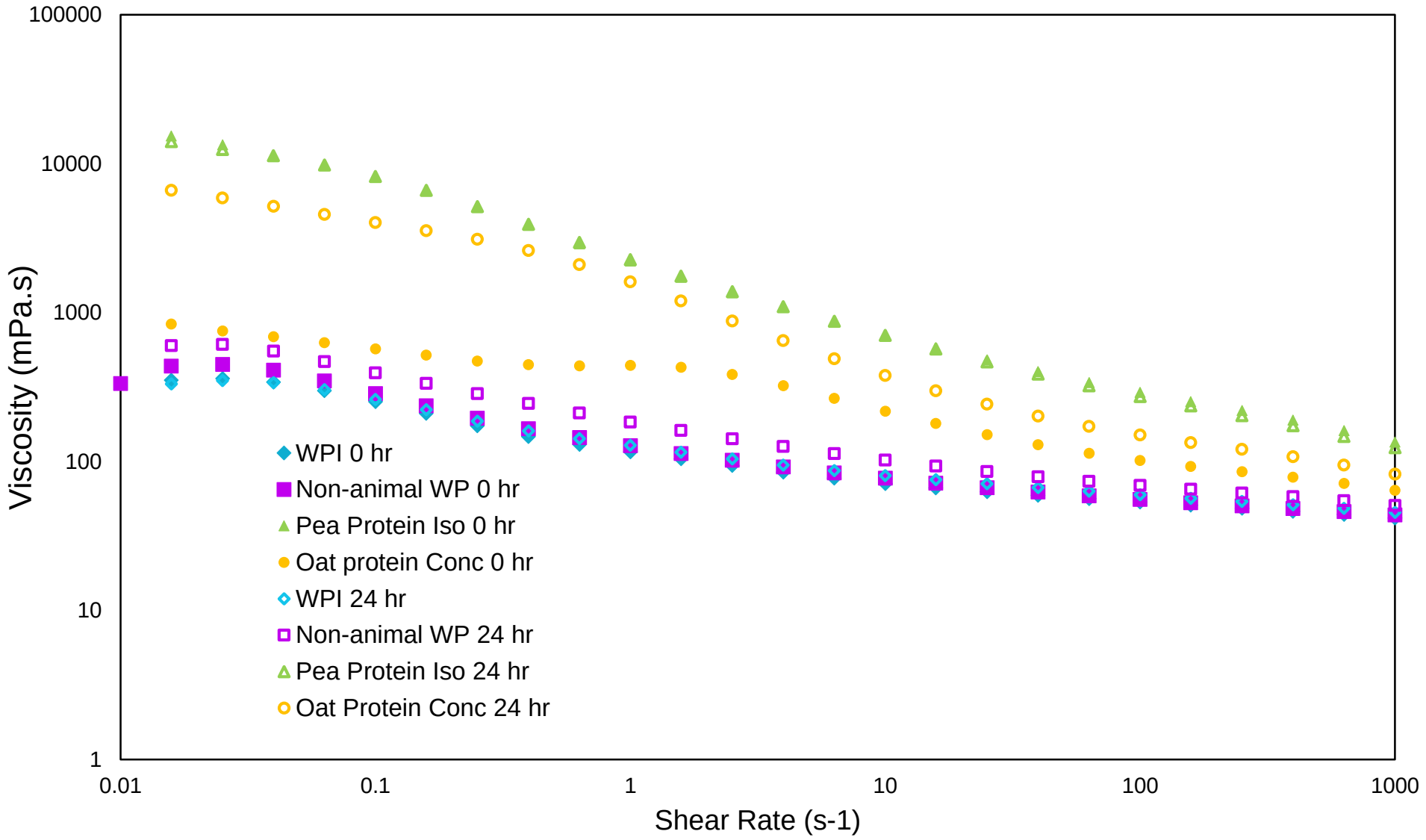
Property Measured	Method
Emulsion Stability	T = 0 & T = 24 PSD + Image
Mix viscosity	Shear rate sweep rheometer
% Overrun	Weight of fix volume, liquid mix vs frozen
Fat destabilization	PSD of melted frozen dessert
Hardness	Penetration test TxTa
Sensory	Panel

Emulsion stability 24 hours FDD Mix

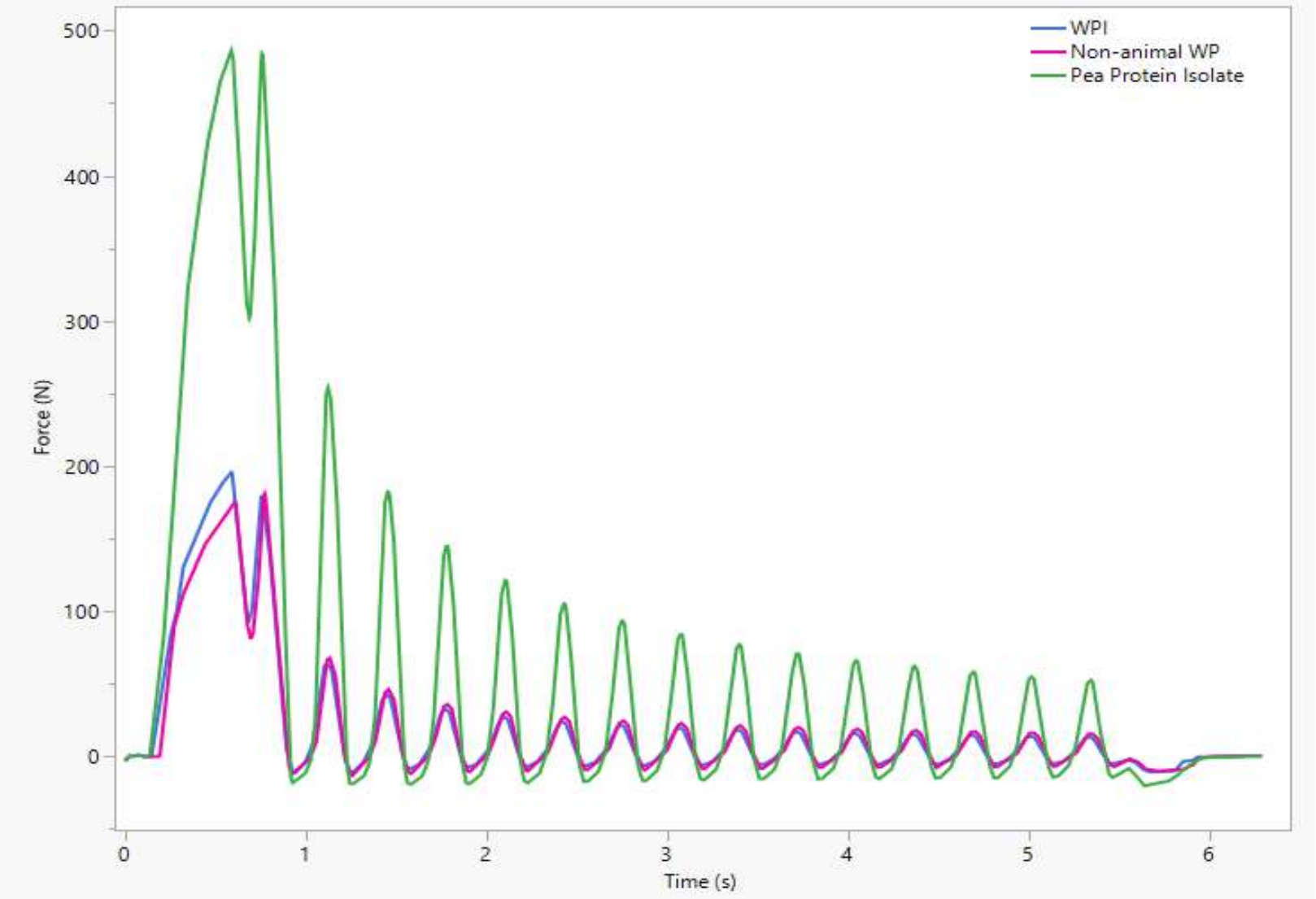


24 hrs: WPI, Non-animal WPI, Pea Protein Iso, Oat Protein Conc

Mix Viscosity Before & After Aging

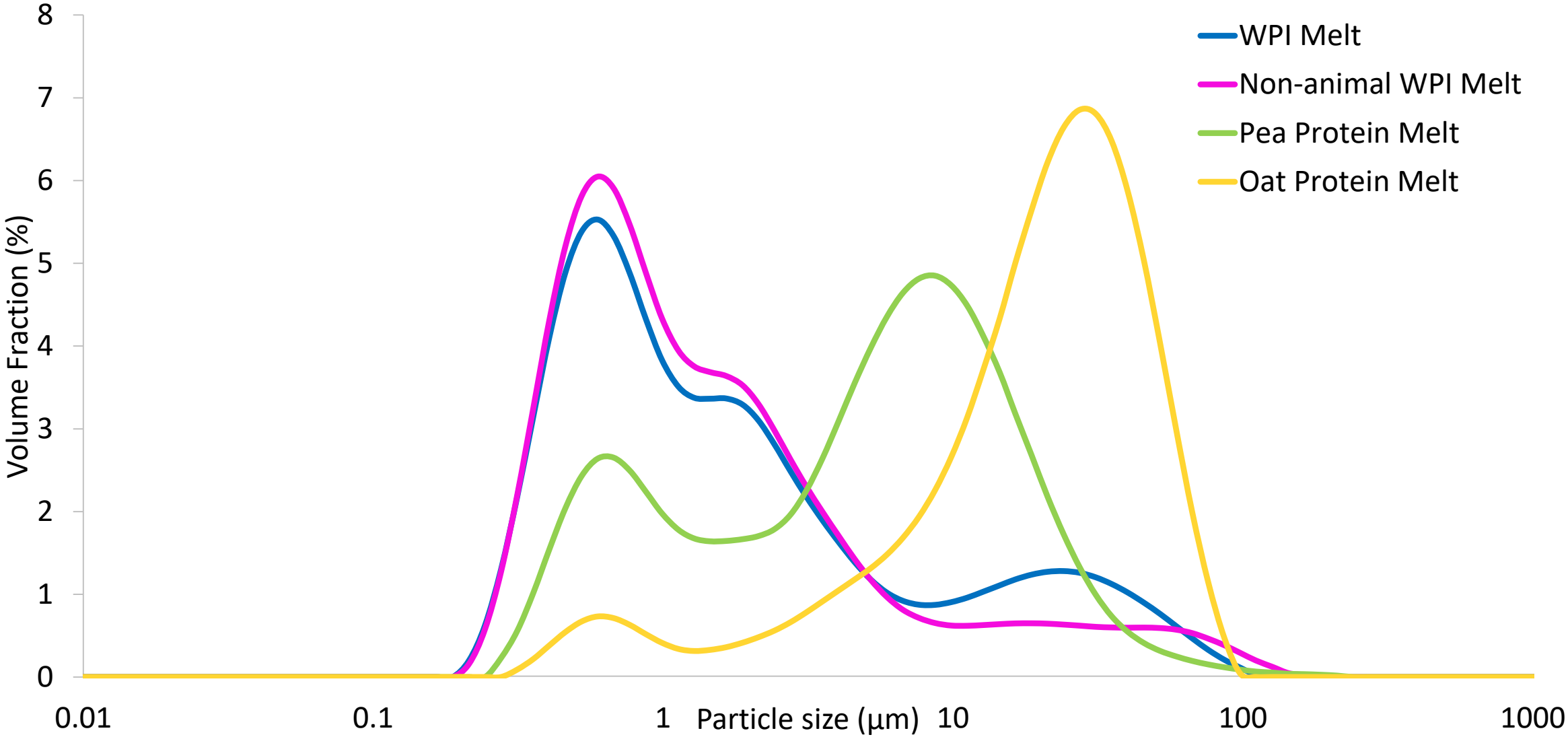


%Overrun and Hardness

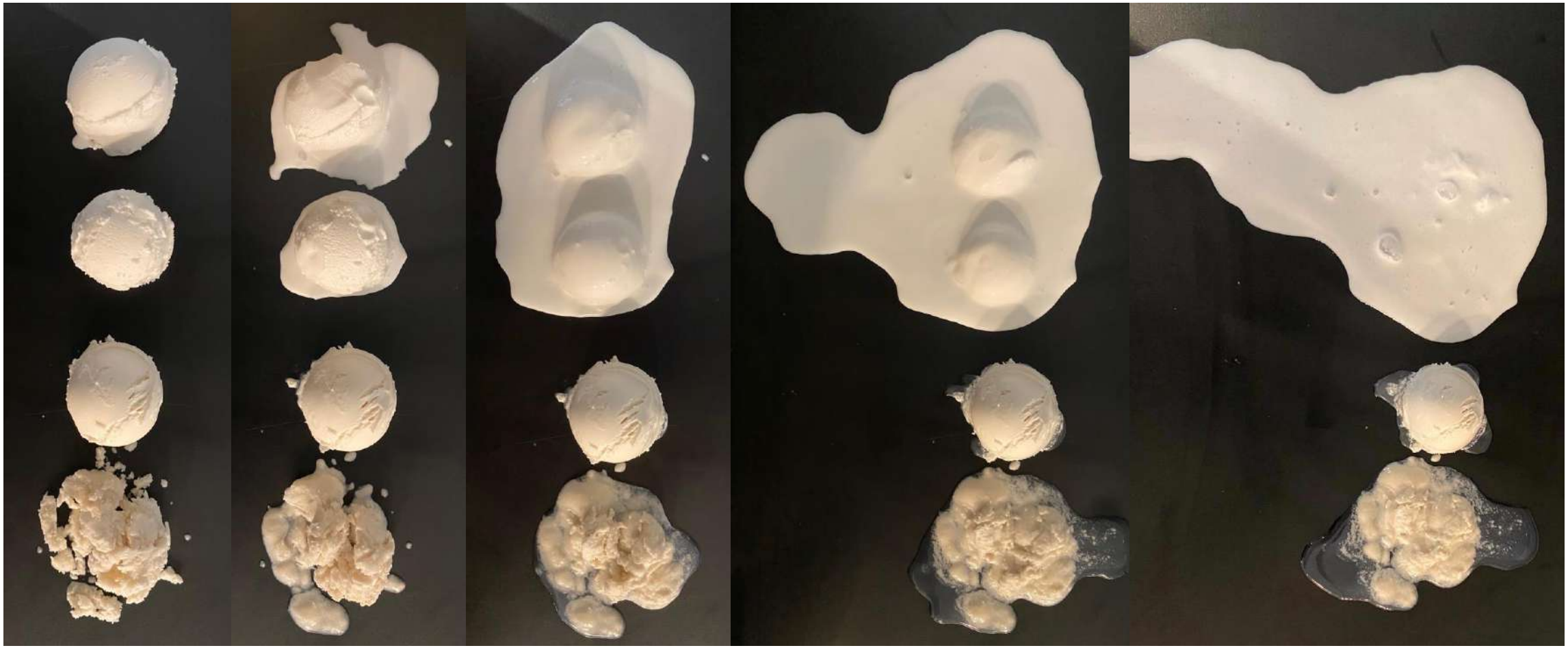


Protein	% OR
WPI	26
Non-animal WP	30
Pea Protein Isolate	11
Oat Protein Concentrate	8

Fat Destabilization in Frozen Dairy Desserts



Sensory & Melt



Left to right: t = 0 m, t = 10 m, t = 20 m, t = 30 m, t = 40 m
Top to bottom: WPI, Non-animal WPI, Pea Protein Isolate, Oat Protein Concentrate

High performing, animal-free dairy proteins

- Animal free whey protein performs like animal-made WPI ***because they're the same proteins!***
- No surprise, plant proteins are limited by poor functionality
  - Poor hydration (solubility), clarity, interfacial activity
- Two interesting avenues for our ingredients:
  - ***An alternative to dairy (i.e., flora-based foods), or…***
  - ***Improved functionality in plant-based products!***
- Many other ways to assess ingredient functionality, but the end goal is always the same:

Offer code: BraveDairy20

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Perfect Day™

- ✓ Scaling up our technology
- ✓ Partnering with brands
- ✓ Educating consumers