





Challenges and strategies for formulating plant-based frozen desserts

IDFA- Ice Cream 2019
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Agenda

- Definitions
- Mix formulation considerations
- PSNF ingredient characterization
- Product development examples
- Other miscellaneous considerations
- Sample tasting!

Definitions

- **Mellorine-** lower cost imitation of ice cream. Uses nonfat milk solids along with fats other than milkfat (see 21CFR 135.130) *Considered ice cream in many locations outside the U.S.*
- **Plant-Based Frozen Desserts** – NO CFR DEFINITON. Generally excludes dairy, eggs, and other animal based ingredients
- **Plant-Based** = Dairy Alternative = Dairy-Free = Non-Dairy = vegan
- **Plant-Based** = P-B
- **Plant-Based "milk" =** P-B liquid, suspension, etc.

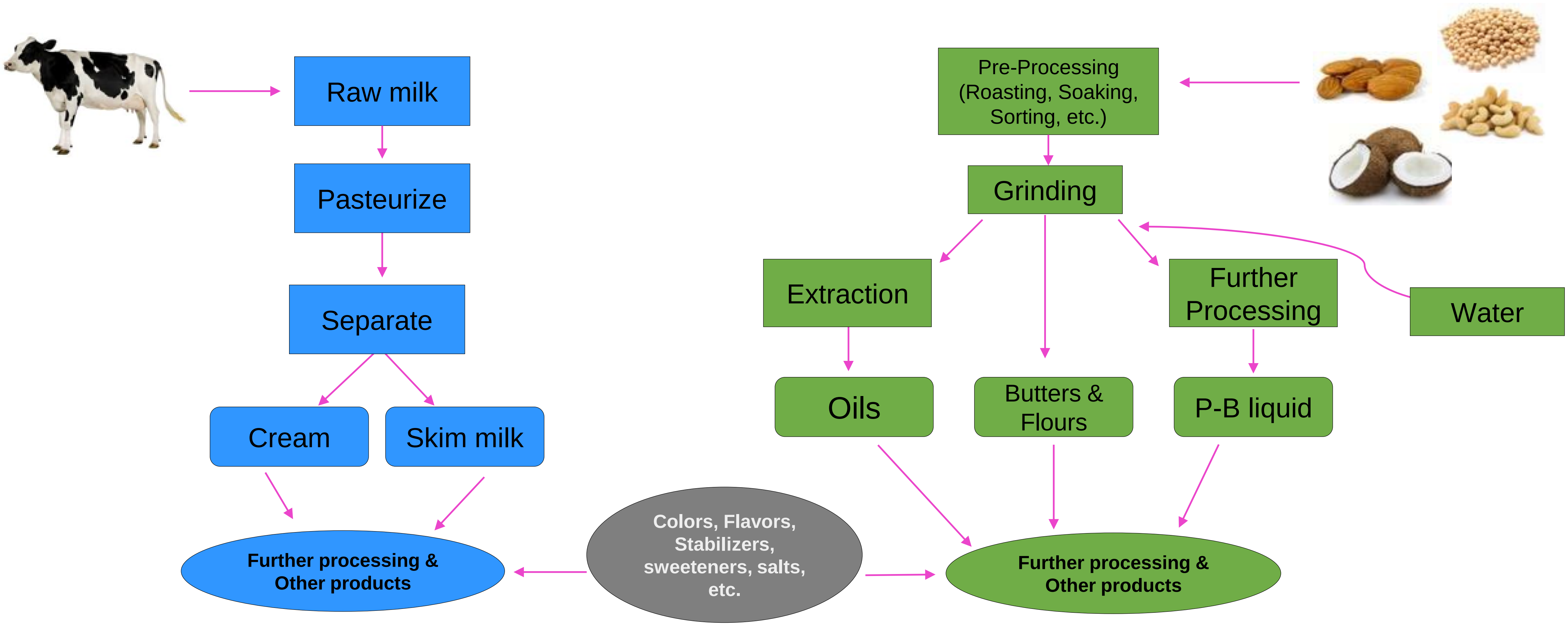
Mix formulation considerations

Formula Approach: Dairy vs. Plant Based

- **Dairy vs. P-B comparison is helpful**
  - > Use knowledge of dairy Ice Cream as a foundation; adjust formulas to accommodate plant ingredient variation

- **What's different?**
  - > **Cream, skim mi**lk, *sugar*, **egg yolk**, *vanilla extract*
  - > ***Milk, cream, buttermilk***, *corn syrup*, ***whey***, *sugar, mono-& diglycerides, guar gum, locust bean gum, carrageenan, natural flavor*
  - > **Almond "milk"** *(water, almonds), sugar*, **coconut oil**, *corn syrup, less than 2% of*: **pea protein**, *Stabilizer (locust bean gum, guar gum), mono - & diglycerides*, **peanut oil**, *salt, natural flavors*
  - > ***Organic coconut "milk"*** *(Organic coconut, water, organic guar gum), organic agave syrup, organic fair trade cocoa (processed with alkali), organic vanilla extract*

Complex source considerations



Ingredient categories

Fats and oils

- **Dairy – Milk fat solids**
  - ***Sources***: *Cow milk*
  - ***Emulsions*** *- Cream, milk, condensed milk, butter, etc.*
  - ***Dry –*** *Dried cream, whole milk solids, buttermilk solids, etc.*
  - ***Fats*** *- AMF*

- **Plant – Plant fat & oil solids**
  - ***Sources***: *legumes, grains, kernels, seeds, nuts, and fruits (ex. Soy, Peanut, Palm, Palm kernel, Corn, Sunflower, Safflower, Canola, Flax, Coconut, Cocoa butter, Avocado, Almond, Cashew)*
  - ***Emulsions****- Coconut "milk" & cream, margarine, etc.*
  - ***Dry*** *– Flour, meal (may have oil partially expressed)*
  - ***Butters*** *– ground nuts and seeds (raw or roasted)*
  - ***Fats*** *– solid at room temp (saturated fats). Refined, bleached, deodorized (RBD) or virgin*
  - ***Oils*** *– liquid at room temp (unsaturated fats). Refined, bleached, deodorized (RBD) or virgin*

Ingredient categories

Solids non-fat

- **Dairy –Milk solids-non-fat (MSNF)**
  - ***Sources****: Cow milk*
  - ***Fluid –*** *Skim, Condensed milk, whey, retentate, etc.*
  - ***Dry –*** *NFDM, whey solids, MPI, permeate, Buttermilk, etc.*
- **Plant –Plant solids-non-fat (PSNF)**
  - ***Sources:*** *legumes, seeds, nuts, grains, roots/tubers, fruits and marine (ex. Soy, Pea, Hemp, Potato, Canola, Chia, Flax, Peanut, Faba, Coconut, Cocoa, Almond, Cashew, Oats, Algae, Avocado)*
  - ***Dry*** *- Flour, defatted flour, meal, concentrates, isolates, hydrolysates*
  - ***Butter*** *– ground nuts and seeds (raw or roasted)*
  - ***Fluid*** *– suspensions (aka: “milks”) such as almond, oat, and cashew*

Ingredient categories
Other

- **Sweeteners & bulking agents**
  - Similar sources in both dairy and plant formulation
    - CRITICAL EXCEPTION- lactose in dairy
- **Flavors**
  - Similar sources in both dairy and plant formulation
- **Stabilizers/ emulsifiers**
  - Similar sources in both dairy and plant formulation

Critical ingredient differences

5 examples

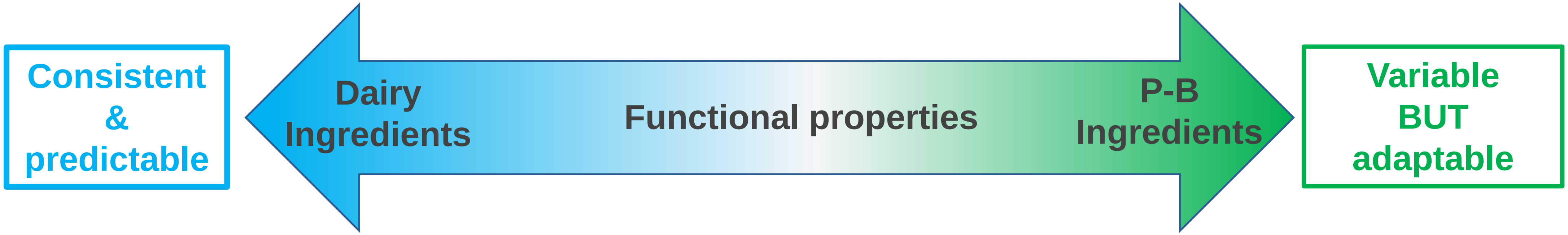
		PLANT			DAIRY	
COMPOSITION	Units	Defatted Soy Flour	Cashew Butter	Pea Protein Isolate	NFDM	MPC 50
Protein	g/100 g	50	19	80	34	50
Total Fat	g/100 g	1	50	1	1	1
Total Carbohydrates	g/100 g	34	28	3	51	37
Dietary Fiber	g/100 g	19	3	2	0	0
Lactose	%	0	0	0	51	37
Sugars	g/100 g	15	3	0	51	37
Total Solids	%	92	95	95	96	96
Solids Not Fat	%	91	45	94	95	94
Relative Sweetness	g/100 g	7	6	0	7	5
Sucrose Equivalence	g/100 g	28	6	2	52	36
Ash	%	7	3	6	10	8
Sugar/Ash Ratio		2	1	0	5.1	4.6

Plant solids contain a variety of sugars, starches, fibers, fats, minerals and proteins that can influence functional ingredient properties

Critical ingredient differences continued

Key functional properties

- ✓ Freezing point depression (sucrose equivalence)
- ✓ Buffering capacity (resistance to pH change)
- ✓ Emulsification performance
- ✓ Viscosity contribution to the mix formulation
- ✓ Protein digestibility, amino acid profile, and anti-nutrition factors
- ✓ fatty-acid composition (texturizing & stability considerations)

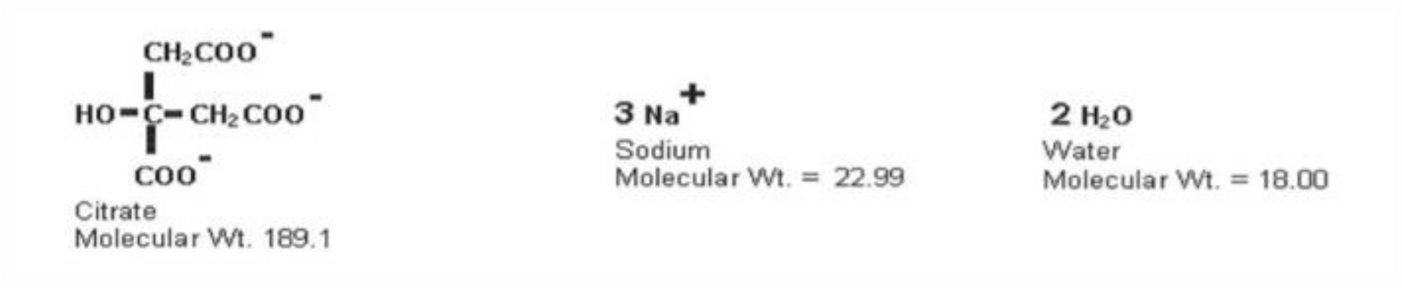


Key functional properties in P-B ingredients will be harder to predict due to their variable composition and processing

Impact of composition on FPD

Freezing point depression (FPD)

- P-B ingredients contain highly variable amounts of sugars, minerals, and buffering salts from processing (may not be labeled!)
- Sugars, minerals, and buffering salts contribute to **Sucrose Equivalence (SE)** and thus **freezing point depression (FPD)**
  - **Non-ionic species**: SE = (Sucrose molecular weight / molecular weight species)*100g
  - **Ionic species**: SETOT= SE1+SE2+… = (%Ion 1 * SE Ion1)*100+(%Ion 2 * SE Ion 2)*100…..
- Example: **Trisodium citrate**
  - 100g sodium citrate is equivalent to 466g sucrose in its ability to depress the freezing point



Example courtesy of Owl Software

Impact of composition on FPD continued

Soy formula examples

Generic Soy Frozen Dessert –
Bakigen® Soy Flour

	%
Defatted Soy Flour	4.0
Safflower Oil	8.9
Sweetener (sugar, corn syrup)	22.6
Bulk Ingredients (tapioca solids)	3.3
Stabilizer/emulsifier	0.4
Water	60.8

note: 2% protein

Generic Soy Frozen Dessert –
Soymilk

	%
Soymilk Powder	4.4
Safflower Oil	8.0
Sweetener (sugar, corn syrup)	22.6
Bulk Ingredients (tapioca solids)	3.3
Stabilizer/emulsifier	0.4
Water	61.2

note: 2% protein

Generic Soy Frozen Dessert –
Cornerstone® Soy Protein

	%
Soy Protein Concentrate	2.6
Safflower Oil	9.0
Sweetener (sugar, corn syrup)	22.6
Bulk Ingredients (tapioca solids)	4.2
Stabilizer/emulsifier	0.4
Water	61.2

note: 2% protein

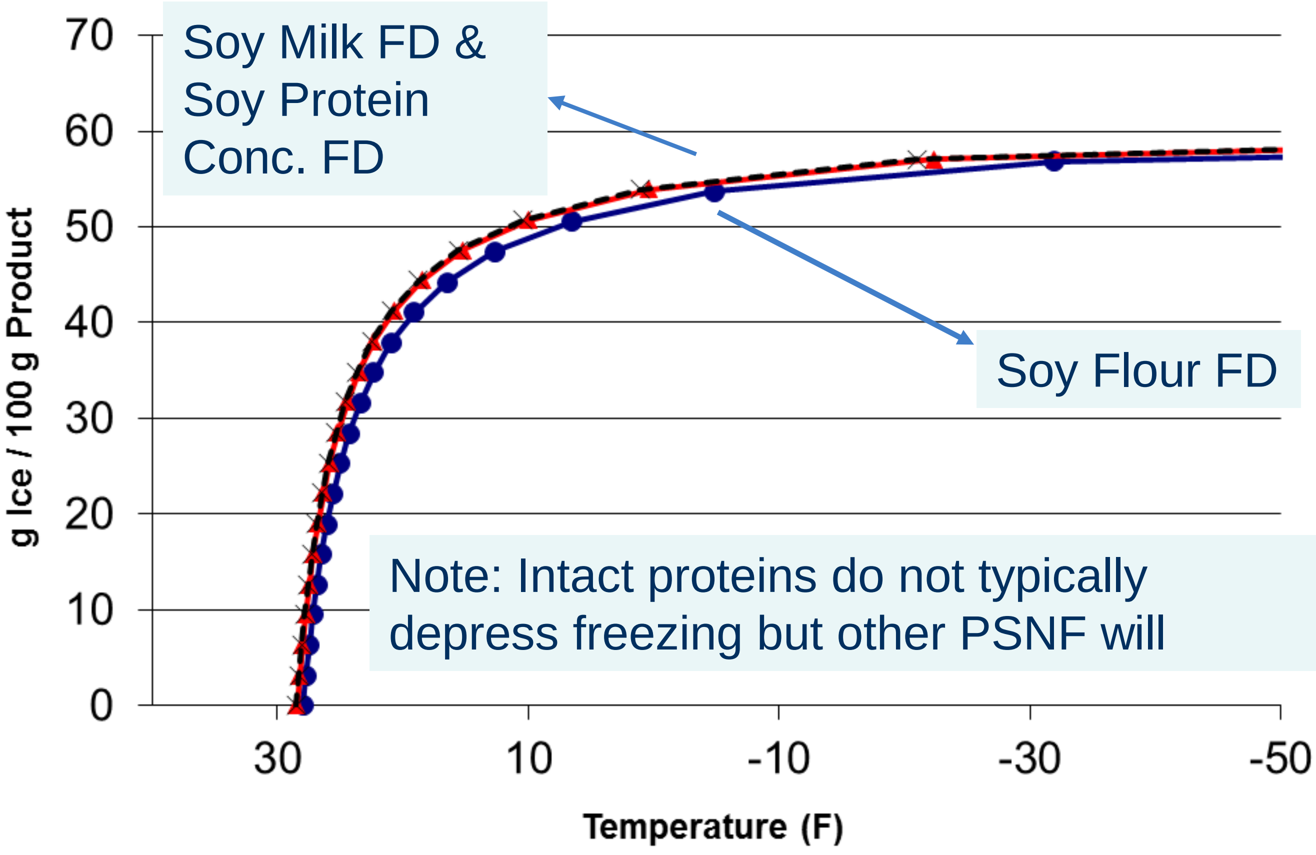
Impact of ingredients on FPD continued

Soy flour sugars examples

Specific sugar	% of soy flour sugars	% of total soy flour	molecular weight	Specific Sucrose eq. (per 100g sucrose)	Total SE contribution
rhamnose	2.76	0.40	164	208	0.83
fucose	0.46	0.07	164	208	0.14
ribose	0.46	0.07	150	228	0.15
arabinose	11.06	1.60	150	228	3.65
xylose	4.61	0.67	150	228	1.52
pinitol	4.15	0.60	194	176	1.06
mannose	4.15	0.60	180	190	1.14
galactose	35.02	5.08	180	190	9.64
glucose	37.33	5.41	180	190	10.28
TOTAL	100.00	14.50			28.42

Impact of composition on FPD continued

Soy formula calculation example



Note: Intact proteins do not typically depress freezing but other PSNF will

Formula Name:	Soy Frozen Dessert - Soy Flour	Soy Frozen Dessert - Soymilk	Soy Frozen Dessert - Soy Concentrate
Soy Solids Not Fat (SSNF) (%)	3.6	3.3	2.4
Sucrose Equiv (%)	22.8	20.4	20.0
Fat (%)	9.1	9.1	9.2
Total Solids (%)	36.8	36.6	36.6
Mix Density(Lb/gal)	9.2	9.2	9.2
Freezing Point (F)	28.0	28.4	28.5
Difference	Reference	-0.50	-0.54
Freezer Exit Temperature (F)	22.0		
% Product Frozen	35.5	38.7	39.1
Difference (%)	Reference	9.0	10.2
Dipping Temperature (F)	10.0		
% Product Frozen	49.0	50.7	50.9
Difference (%)	Reference	3.6	4.0

A small change in SE translates into a big difference in the amount of product frozen at draw!

Plant protein nutritional considerations

Plant proteins and PDCAAS or DIAAS

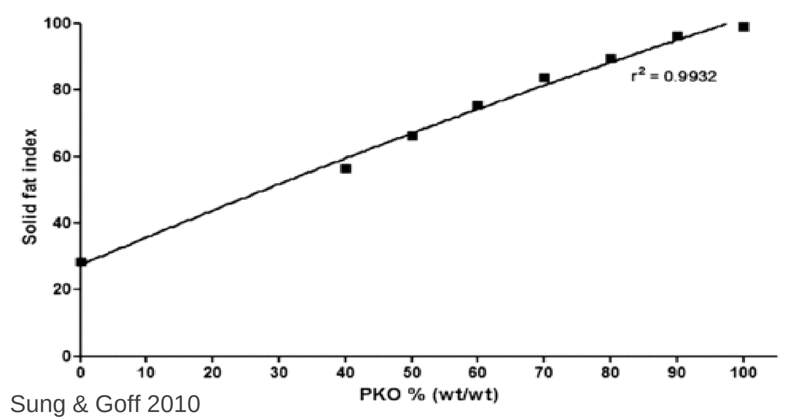
- Nutritional considerations become important for meeting product claims or regulations (high protein claim, school lunch program compliance, etc.)
- Protein nutritional completeness currently expressed by it's PDCAAS Score[1]
  - **PDCAAS** =**P**rotein **D**igestibility- **C**orrected **A**mino **A**cid **S**core
  - Index that ratios a protein's most limited amino acid relative to a reference, then weights that ratio by the proteins digestibility
  - Plant sources can be combined to improve scores
- Be aware of the newer, more accurate DIAAS System[2]
  - **DIAAS** = **D**igestible **I**ndispensable **A**mino **A**cid **S**core
  - DIAAS will likely replace PDCAAS in the future for all official purposes since it is more accurate, but this will take a long time.

Protein source	PDCAAS score 2013[3], %	DIAAS Score[3], %
Whey protein isolate (WPI)	97	100
Pea protein concentrate (PPC)	71	62
Soy protein isolate (SPI)	86	84
Wheat protein (WP, as wheat flour)	51	45
60:40, PPC:SPI *by protein*	77†	71†
7:93, WP:SPI *by protein*	89†	85†

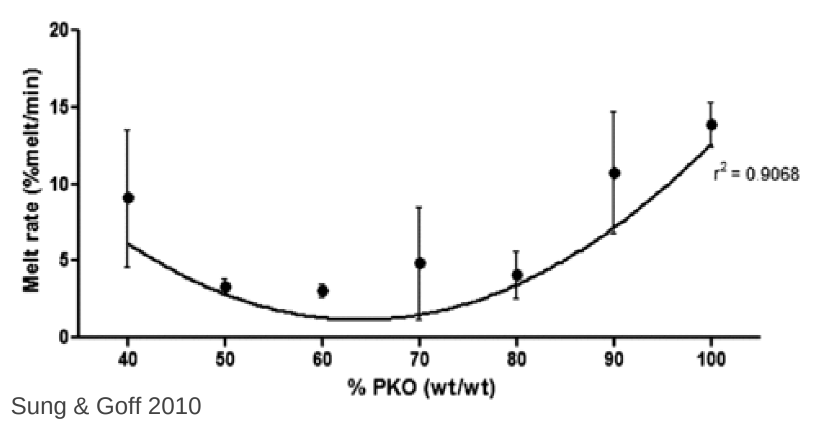
† - Calculated from values found in Mathai et al (2017), using guidance from FAO Food & nutrition paper 92 (2013)

1.) FAO Food & nutrition paper 51 (1991)
2.) FAO Food & nutrition paper 92 (2013)
3.) Mathai et al (2017)

Fat composition considerations



Sung & Goff 2010

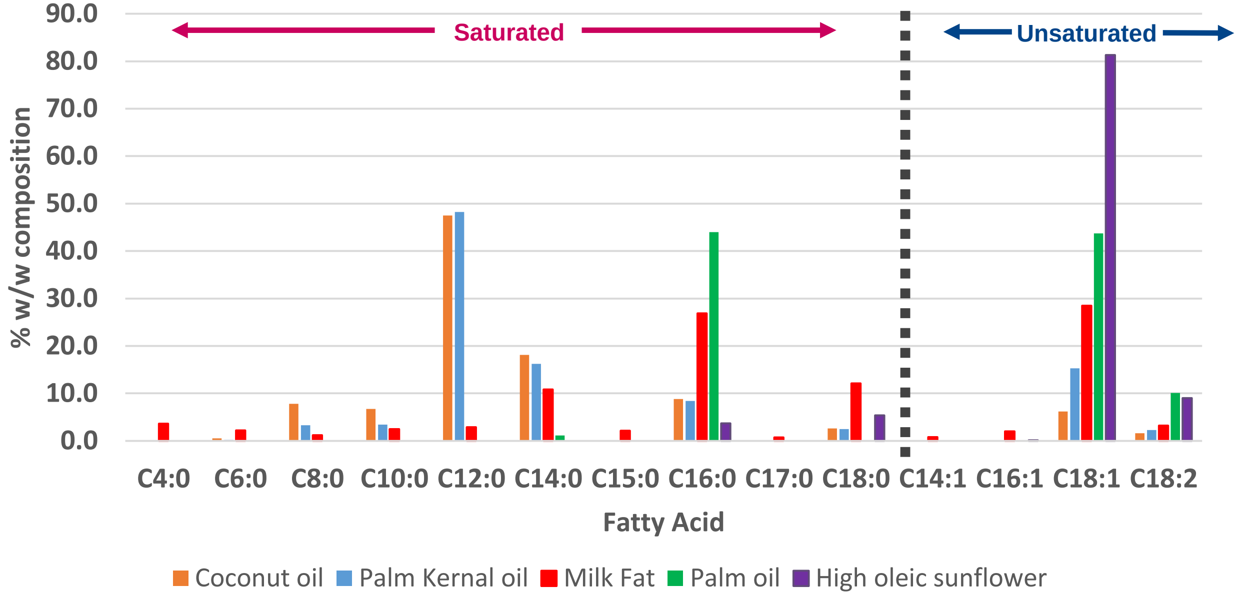


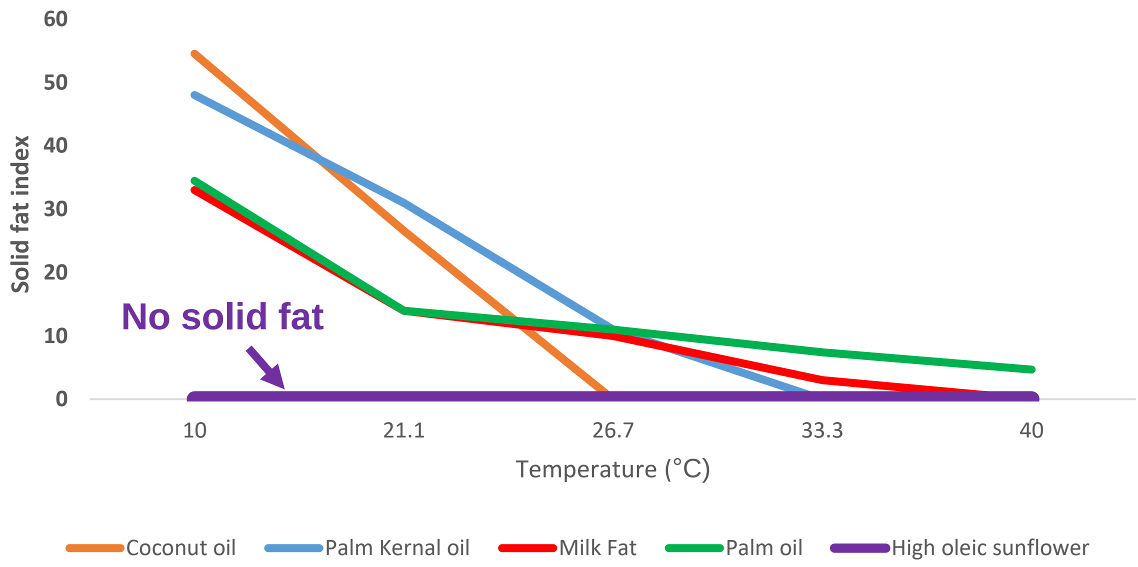
Sung & Goff 2010

Typical Data	Avg. Iodine value (degree of unsaturation)	Avg. Solid fat index @10C°	Crystallization Onset Temperature (°C)
Coconut Oil	10 [5]	54.5 [5]	15.0 [10]
Palm Kernel Oil	17.8 [5]	67.6 [5]	7.0 [9]
Milkfat	34 [5]	33 [5]	16-17 [6]
Palm oil	53 [5]	34.5 [5]	10.2 [9]
High Oleic Sunflower Oil	83 [5]	-	-45.8 [8]
Canola Oil	115 [5]	-	-17.1 [9]
Soybean Oil	131 [5]	-	-10.2 [9]

4.) Sung & Goff (2010)
5.) Fats & Oils, 3rd Ed, R Obrien, CRC Press, 2009
6.) Tomaszewska-Gras (2013)
7.) Howell et al (2003)
8.) Mettler Toledo (unknown)
9.) Applewhite (1994)
10.) Gordon & Rahman (1991)

Fat considerations cont.





High temperature
Less saturated

Low — **Solid fat index** — **High**

Low temperature
More saturated

Diverse fatty acids
Less saturated

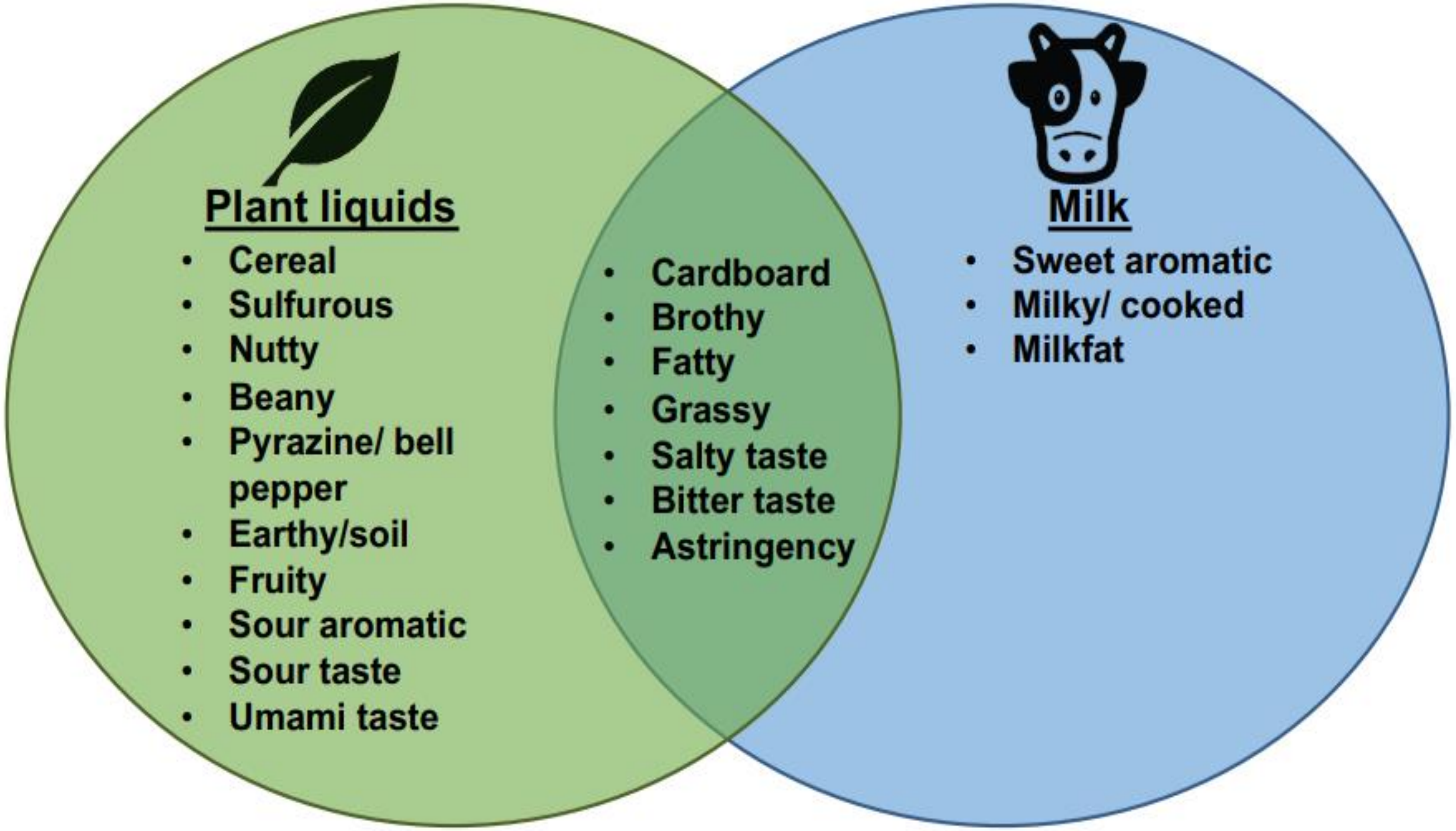
Broad — **Melt profile** — **Sharp**

Uniform fatty acids
More saturated

Figures adapted from: Fats & Oils, 3rd Ed, R Obrien, CRC Press, 2009

Plant ingredient sensory characteristics

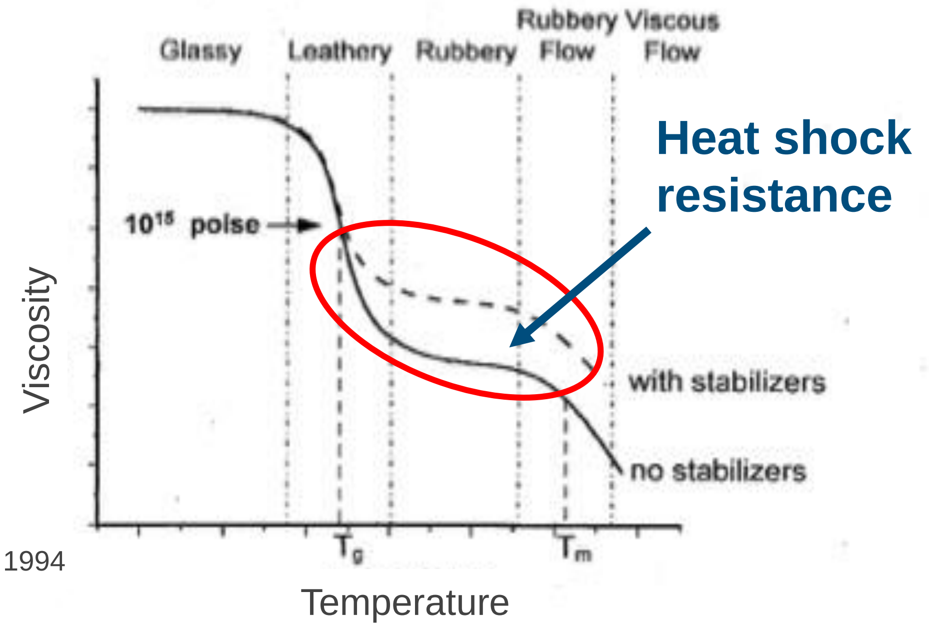
P-B ingredients have more flavor-variability relative to dairy; many ingredients have off-notes that must be masked or complemented.



Courtesy of Mary Anne Drake, North Carolina State University

Hydrocolloid usage

– **Still needed for P-B mixes**
  > Freeze-thaw stability
  > Slows ice crystal formation
  > Texture & “coldness” control
  > Slows melting

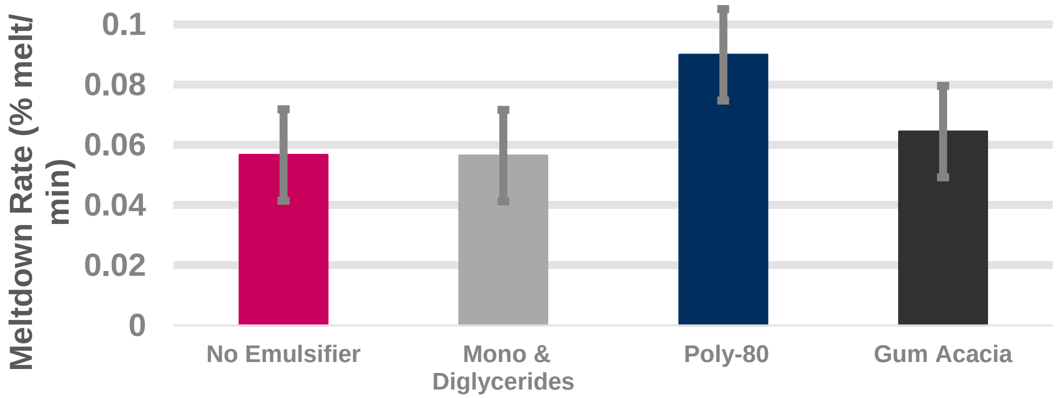


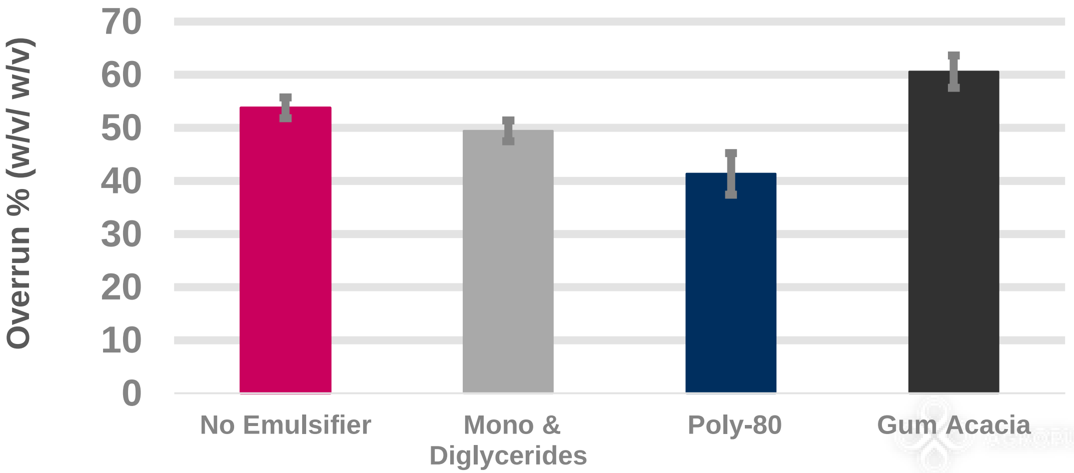
Adapted from Schenz 1994

– **Usage rate and type depends on base ingredients**
  > Similar types to dairy, but need to evaluate usage rate since P-B mixes are often naturally more viscous
  > May or may not need carrageenan (phase separation)

Emulsifier usage

- **Recall two key general functions in frozen desserts**
  - > Improve fat structuring via modification of the fat globule interface
  - > Stabilize air cells in the finished frozen product
- **Usage rate and type depends on base ingredients**
  - > Similar types to dairy, change usage rate depending on application
  - > May not need potent drying agents like poly-80 (see below)





Formulations: 36% total solids, 2.5% protein from pea, 10% fat (sunflower/ palm kernel), Guar/ LBG stabilizer. Error bars = 95% confidence intervals

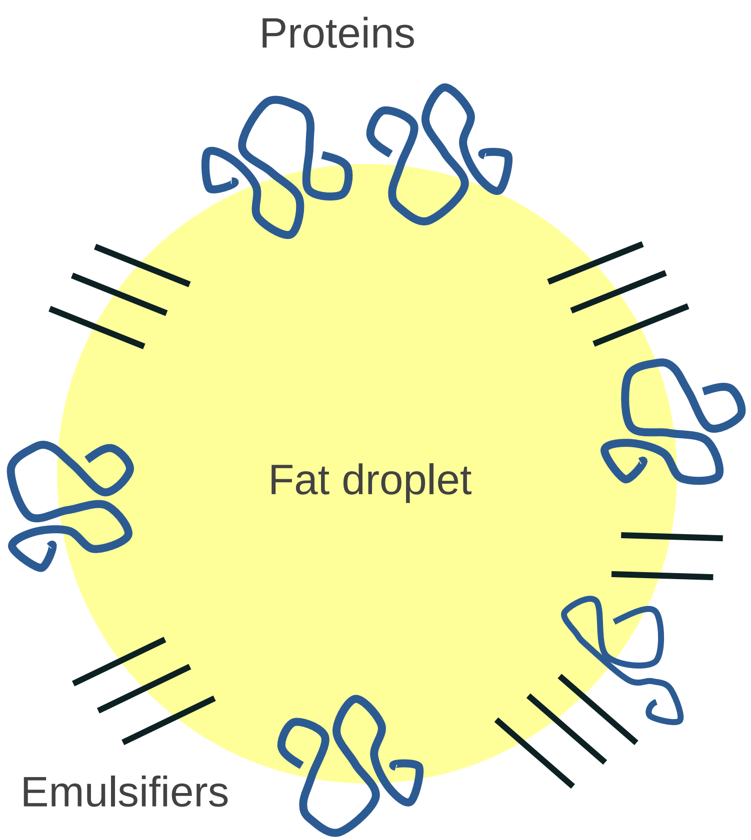
PSNF Ingredient Characterization

Protein characterization focus

- **Protein:fat** interaction is key in finished product characteristics like **melt rate, shelf stability, and textural quality** (11,12,13)

- **P-B fats/oils** seem easier; not difficult to characterize good sources for a given project.

- **P-B protein/ PSNF** ingredients are unpredictable; more effort put in to characterize and screen



11.) Daw & Hartel (2015)
12.) Amador et al. (2017)
13.) Goff, H.D. (1997)

Where to start: establish target audience

Narrowing the options

PSNF Sources	Clean label/ natural / non-GMO available ?	Good supply ? (multiple vendors)	Bland Flavor?	"Good" emulsification?	Soluble sources available?	Allergen-Free available?
Algal	Y	?	Y	?	Y	Y
Canola	Y	?	?	?	Y	Y
Oat	Y	?	Y	Y	Y	?
Rice	Y	Y	Y	?	?	Y
Pea	Y	Y	?	Y	Y	Y
Soy	?	Y	Y	Y	Y	?
Hemp	Y	Y	?	?	?	Y
Non-Pea Pulses (Lentil, chickpea, Faba)	Y	?	?	Y	Y	?

P-B protein characterization

Sensory descriptors

Protein Type	Flavor & Mouthfeel
Rice protein	Slightly sweet, slightly nutty, very gritty
Faba protein #1	Clean, slightly beany, slightly grassy, viscous
Faba protein #2	Clean, slight cereal, slight mouthcoating
Soy protein	Very clean, slightly nutty, fruity, viscous
Pea protein #1	Slight cereal, nutty, earthy, viscous and mouthcoating
Pea protein #2	Nutty, cereal, beany, brothy, mouthcoating and gritty
Cornerstone® Faba-pea protein	Slight cereal, slightly nutty, viscous and mouthcoating
Whey protein (reference #1)	Slightly milky, slightly barny, astringent
Milk protein (reference #2)	Slightly milky, slight cardboard, mouthcoating

P-B protein characterization continued

Heat stability

Comparing viscosity measurements taken pre/post heating are a simple way to predict heat stability during processing

Protein Type	Post heat % viscosity increase[a]
Rice protein	1.00
Faba protein #1	325
Soy protein	-23.0
Pea protein #1	24.3
Pea protein #2	1.50
Cornerstone® Faba-pea protein	240
Whey protein (reference #1)	2550
Milk protein (reference #2)	-25.0

a Measured on an RVA, 160 RPM, 30 min hydration @ 40° C, 10 min hold @ 90 C. Based on an 6.8% protein as-is, no pH adjustment

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P-B protein characterization continued

Emulsion separation resistance

***Emulsion Separation Rates**– the smaller the number, the more resistant the emulsion is to separation. May help identify sources with poor emulsification characteristics.*

Protein Type	Emulsion [a] Separation Rate [1] (% separation/ min)	Sediment Height (mm)	Weighted [b] Emulsion separation rate (%separation/ min)
Rice protein	*36.60 ±0.68*	*1.9*	*32.62 ±0.69*
Faba protein #1	*8.29 ±0.50*	*3.4*	*6.36 ±0.51*
Faba protein #2	*13.19 ±0.01*	*3.5*	*10.05 ±0.06*
Soy protein	*7.18 ±0.09*	*1.6*	*6.52 ±0.10*
Pea protein #1	*2.69 ±0.00*	*3.9*	*1.95 ±0.03*
Pea protein #2	*2.90 ±0.01*	*3.3*	*2.28 ±0.02*
Cornerstone® Faba-pea protein	*6.01 ±0.00*	*3.9*	*4.39 ±0.03*
Whey protein (reference #1)	*8.19 ±0.07*	*1.7*	*7.39 ±0.10*
Milk protein (reference #2)	*5.01 ±0.02*	*1.2*	*4.66 ±0.06*

[a] 2.5% Protein + 14% corn oil in DI water. Simulated HTST processing & colloid mill homogenization
[b] Weighted separation rate relative to sediment height proportion of total sample area measured.
[1] Measured via Analytical centrifuge (LumiSizer)

Key points

Protein screening

- Take a holistic approach to protein screening; no one attribute is a great predictor of final performance.
- A given protein source must:
  - > Meet defined product requirements
  - > Have acceptable flavor– it has to taste good
  - > Be soluble – can't have a gritty mouthfeel
  - > Survive processing – can't have it gel or flocculate with heating
  - > Emulsify – protein is the backbone of a frozen dessert, and it needs to be able to emulsify fats & oils
- Recall how variable P-B protein sources are

Product development Examples

Approach to applications testing
Considerations

- Little information is published on 100% P-B frozen desserts
  - Relevant publications to P-B applications testing:
    - Formulation of a true plant protein/ fat formula (14)
    - Hybrid non-dairy fats with dairy proteins (4,15)
    - Hybrid protein formulas (dairy and soy) (16)
- No standards of identity exist for P-B frozen desserts, so formulation options seem unlimited

4.) Sung & Goff (2010)
14.) Chan & Pereira (1992)
15.) Nadeem et al. (2010)
16.) Cheng et al. (2016)

Approach to applications testing

Define parameters

– Start with what is known: ice cream/P-B hybrid formulas
  - > *Select a formula composition – Often defined in project scope*
    - – **Fat level** 8-10% fat is typical [17]
    - – **Solid fat content** (60%-70% solid fat deemed optimal in **Mellorine** [4])
    - – **Protein** few guidelines for P-B ingredients
    - – **Total solids** 36% is low-average [17]
    - – **Stabilizer/emulsifier** Same stabilizers as dairy (guar, locust, carrageenan, etc.). Emulsifier selection changes with label requirements and actual need.
  - > *Testing* based on established dairy applications testing
  - > *Processing* based on established dairy processing

4.) Sung & Goff (2010)
17.) Goff & Hartel (2013)

Basic Processing


Agropur's pilot plant equipment

Hot water

High shear mixing

Proteins, sweeteners, stabilizers, bulking, etc.

Slurry

Mix, homogenize, pasteurize

Warm melted oils and/or butters

Finished mix

Age

Freeze

Harden

Finished Product

Testing

Possible applications tests to perform

The basics

- Viscosity
- pH
- Mix Separation
- Overrun
- Meltdown Rate
- Sensory
- Accelerated Shelf life
- Microbiological verification

Advanced

- Mechanical Hardness
- Fat Destabilization
- Adsorbed protein
- Others

Example Study 1

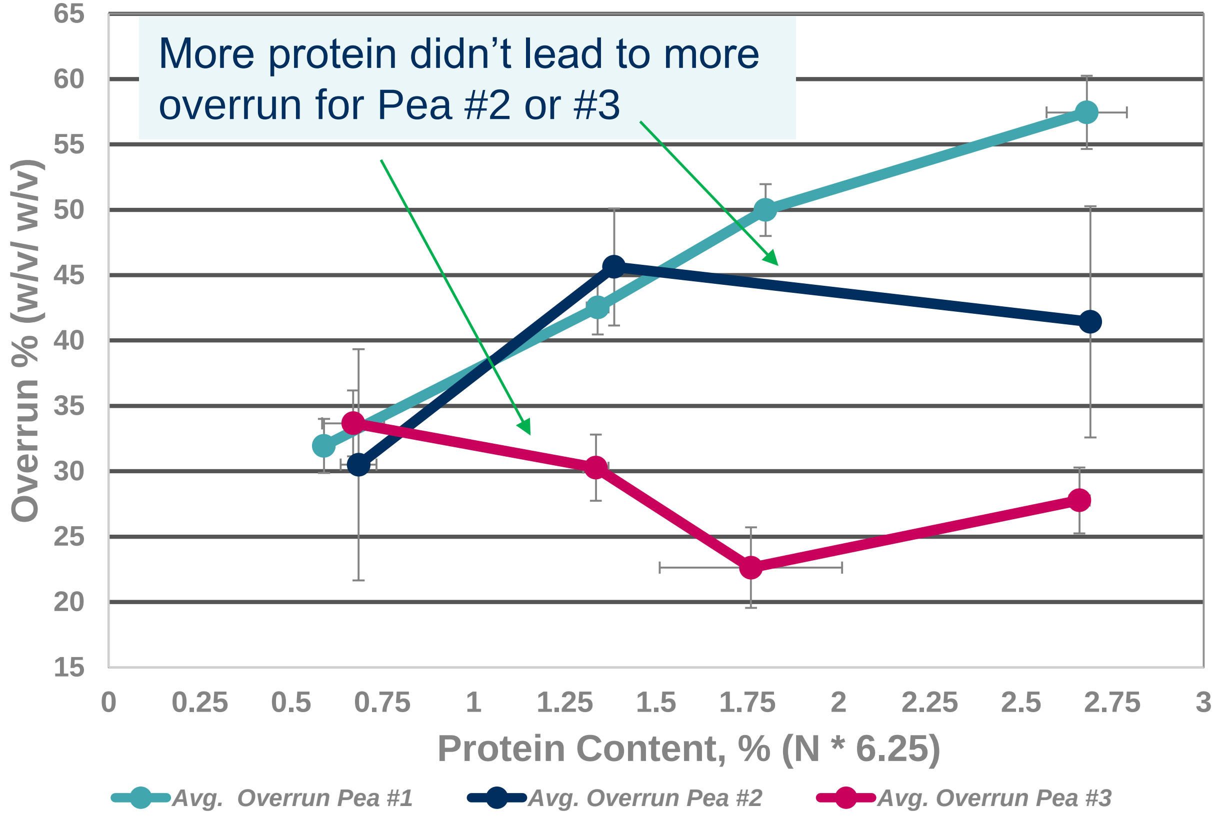
Protein source and inclusion rate

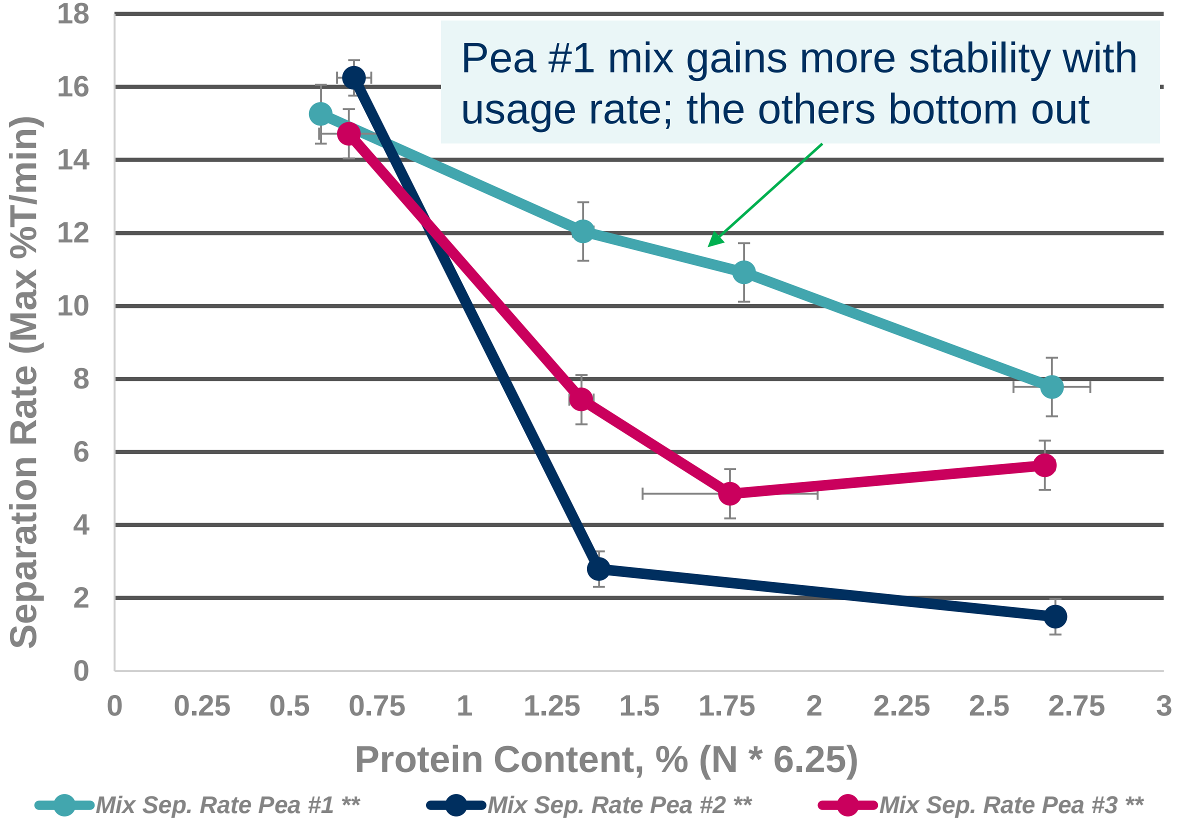
- **Objective** – Evaluate the variability between different pea protein sources on formula performance.
- Standardize formulations for:
  - > 36% Total solids
  - > 10% total fat from 65:35, Fractionated palm kernel: High Oleic Sunflower Oils
  - > Sucrose equivalence @22
  - > Stabilizer: Guar, LBG, mono & diglycerides, Poly 80
- Variables
  - > 3 pea protein sources
  - > Protein inclusion @ 0.5%, 1.25%, 1.75%, 2.5%

Example study 1: pea protein variable

Results

-Pea protein #1 at a use rate of 1.75% - 2.5% gave the best results in this system





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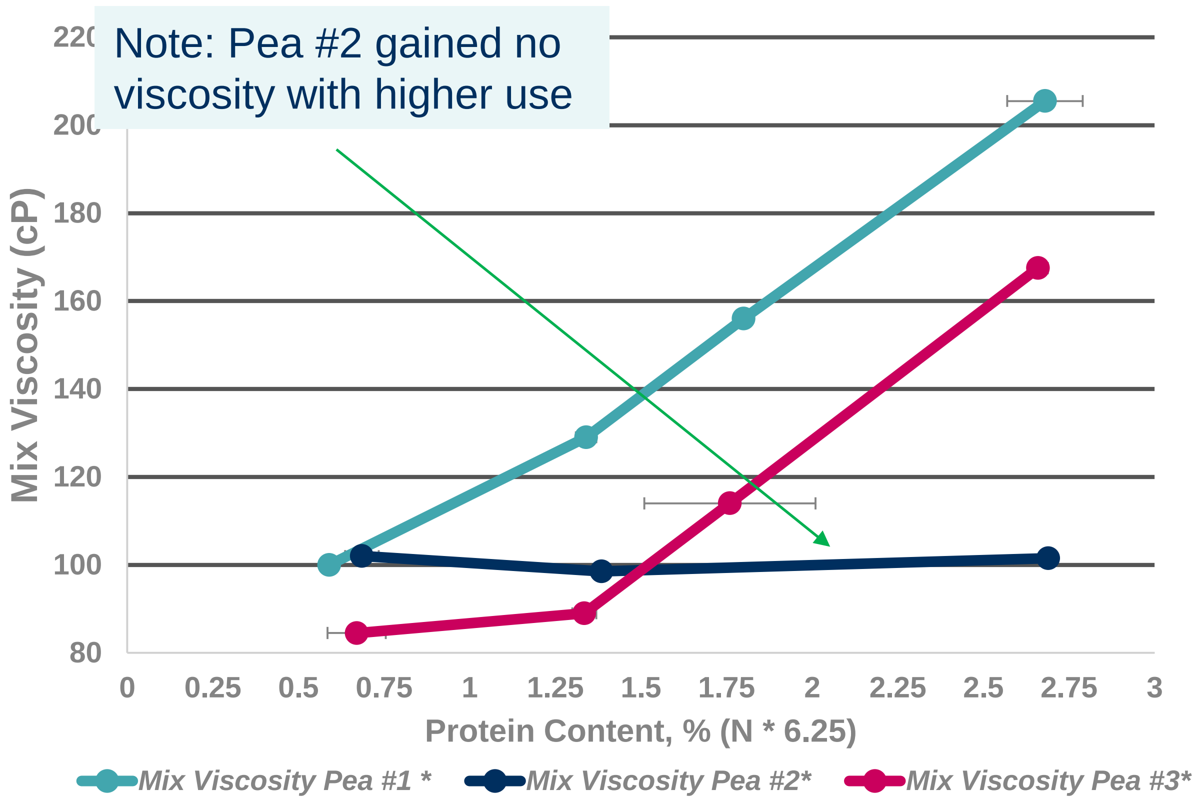
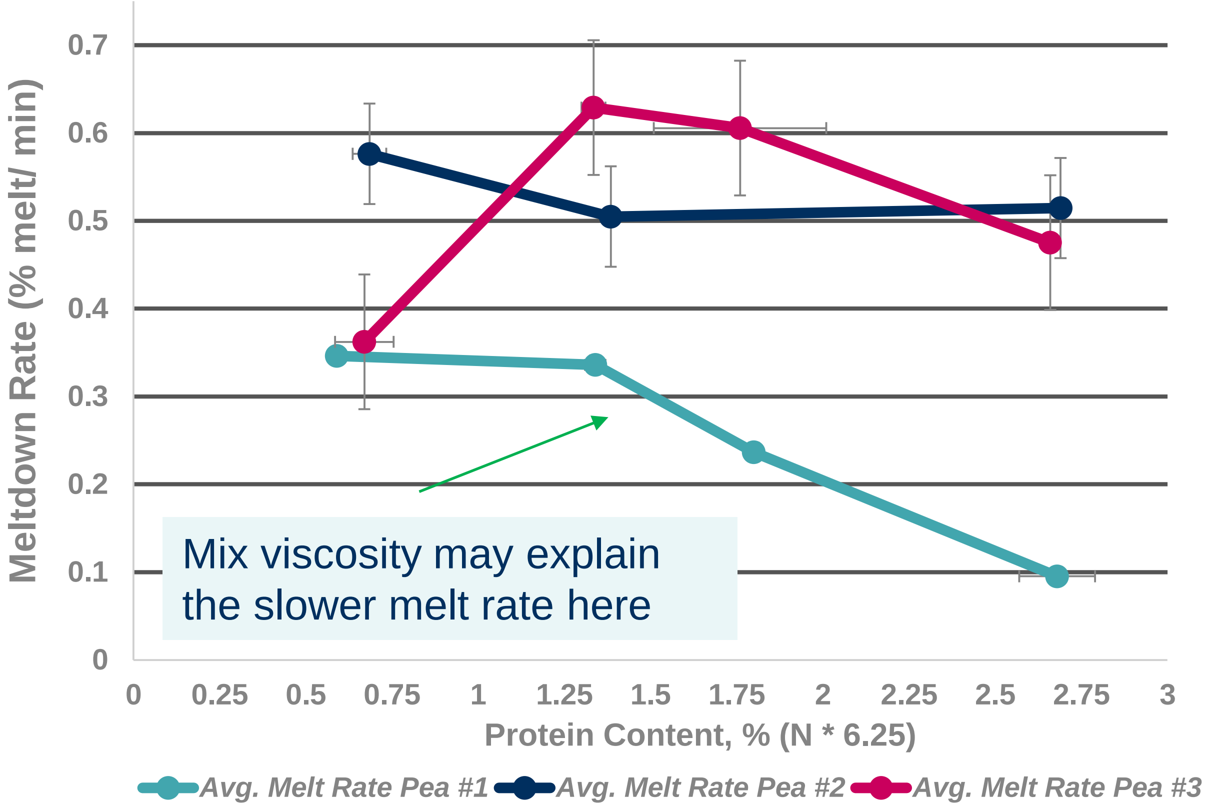
Vertical Error bars are 95% Confidence intervals

Example study 1: pea protein variable

Results continued





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Vertical Error bars are 95% Confidence intervals

Example study 1: pea protein variable

Conclusions

- Protein source & use level appear to impact key product characteristics
- By running defined applications tests, optimal combinations become evident
  - Pea #1 @ 2.5% looks best
- Pre-screening sources for sensory characteristics is advised – helps shorten number of pilot runs.

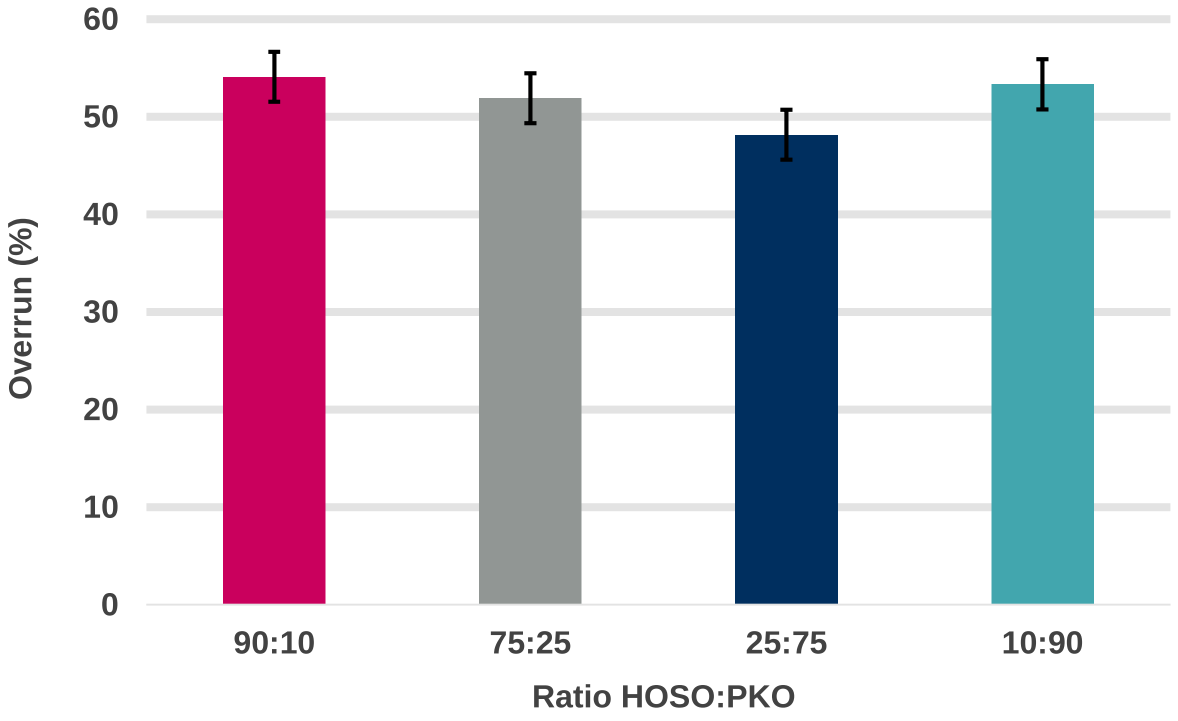
Example Study 2

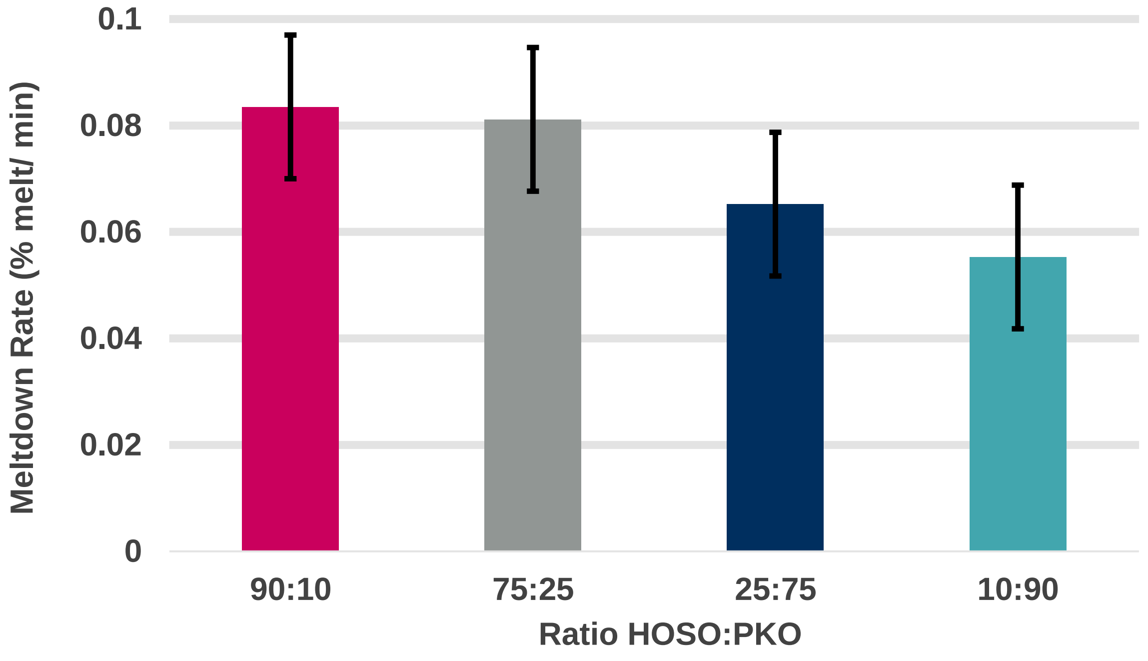
Solid fat content

- **Objective** –Evaluate solid/liquid fat ratios to find the optimum for a formula.
- Standardize formulation for:
  - 36% Total solids
  - 10% fat
    - High-Oleic Sunflower Oil (HOSO) = liquid fat
    - Fractionated Palm-Kernel Oil (PKO) = solid fat
  - 2.5% Pea protein
  - Sucrose equivalence @ 22
  - Stabilizer: Guar, LBG, Gum Acacia
- Variables
  - Blended fats at ratios of HOSO:PKO @ 90:10, 75:25, 25:75, and 10:90

Example study 2: fat/oil ratio evaluation

Results



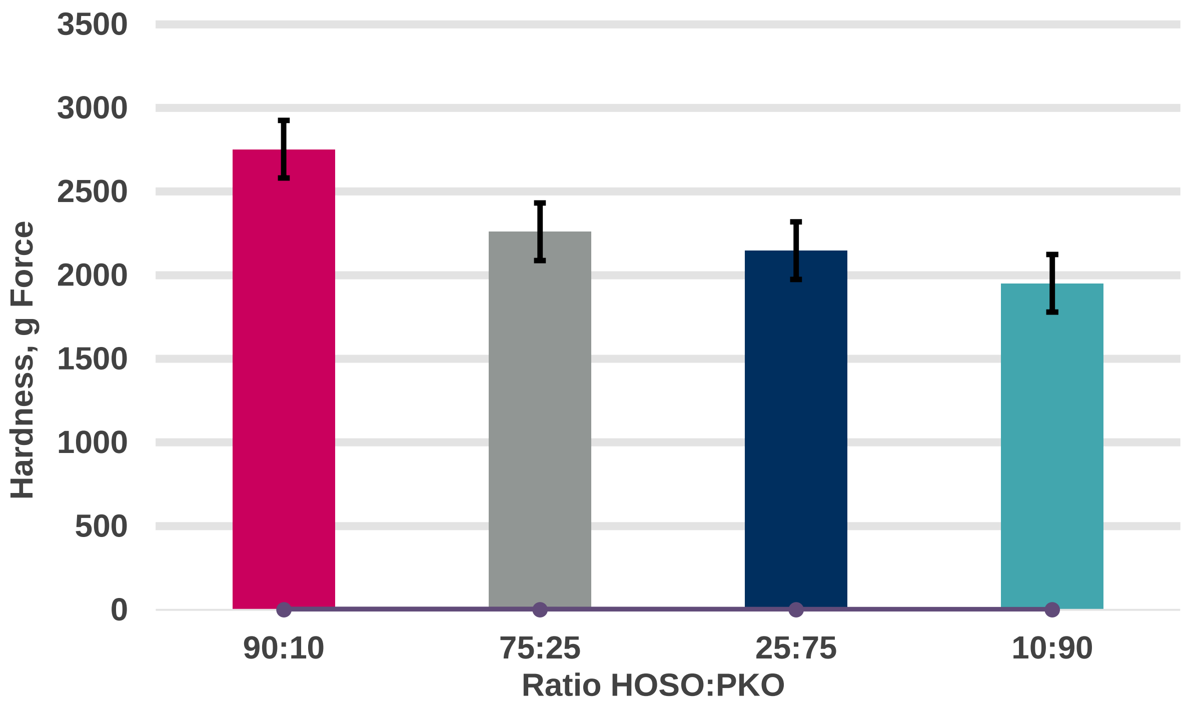


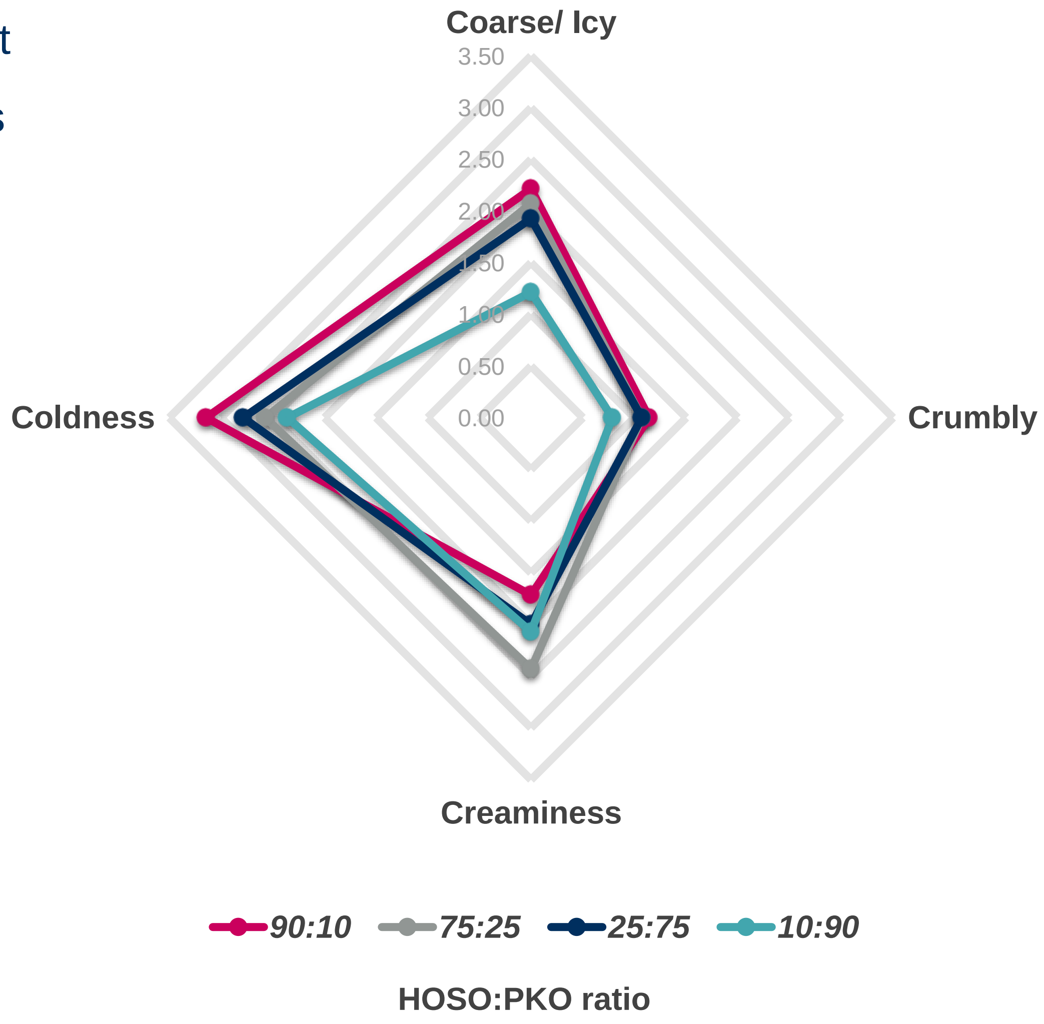
Vertical Error bars are 95% Confidence intervals

Example study 2: fat/oil ratio evaluation

Results continued

- Trend shows that a higher ratio of solid fat results in a softer product
- Sensory implies that more solid fat may make desserts that are less cold, less icy, and less crumbly.





Vertical Error bars are 95% Confidence intervals. Sensory results are non-statistical

Example study 2: fat/oil ratio evaluation

Conclusions

- Decreasing liquid/fat ratios affects texture and eating characteristics
  - > Overrun was not significantly changed by oil/fat ratio
  - > Firmness and meltdown rate negatively correlated with solid fat ratio
  - > Decreased iciness and cold sensation associated with increasing solid fat

Other miscellaneous considerations

Using P-B liquids("milks"), creams, and butters

- Avoid using these as the basis for a formula
  - > Difficult to standardize or source
  - > Not as much flexibility to fine-tune like using refined fats/oils and protein isolates
- Instead, use them as secondary ingredients as needed to:
  - > Differentiate product
  - > Add flavor
  - > Mask & complement off notes from other base components (eg: use nut butter to complement pea protein earthiness; use coconut cream to mask soy beany flavors)
- Consider availability, storage stability, and practicality in use when selecting
  - > Butters & creams may be more economical to purchase and store than "milks"

Sample tasting!

Disclaimer!!

Samples contain soy and tree nuts (cashews). Samples may contain wheat. Manufactured in a facility that handles milk, wheat, egg, soy, tree nuts, and peanuts

Hand out ballots and samples now

SAMPLE#: 740

Please check only one box that represents your response (X)

Please rate your overall acceptability of this sample

Dislike Extremely				Neither Like nor Dislike				Like Extremely
☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9

SAMPLE#: 727

Please check only one box that represents your response (X)

Please rate your overall acceptability of this sample

Dislike Extremely				Neither Like nor Dislike				Like Extremely
☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9

SAMPLE#: 236

Please check only one box that represents your response (X)

Please rate your overall acceptability of this sample

Dislike Extremely				Neither Like nor Dislike				Like Extremely
☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9

ADDITIONAL COMMENTS

Using 3 words or less, describe the following attributes for each sample in the space provided

	Sample #		
Attribute	**740**	**727**	**236**
Flavor			
Color			
Mouthfeel			
Aftertaste			

Check a box indicating your relative preference for each sample

Describe the flavor, color, mouthfeel, and aftertaste of each sample in your own words

Sample summary

General label: Water, sugar, coconut oil, cashew butter, sunflower oil, tapioca syrup solids, PSNF (pea protein and/or faba bean protein or soy protein), salt, mono & diglycerides, locust bean gum, guar gum, carrageenan

PSNF Source	Total PSNF in mix (%)	Total protein in mix (%)	Total PSNF cost in mix (USD/100 gallons mix)[1]	Allergens	Mix total fat target (%)	Overrun target (%)	Mix total solids (%)	Fresh mix viscosity (Zahn #3, sec)	Melt rate (%/min.)
#727- Pea protein	3.52	2.50	$102	None	10.00	80	38.47	~46	0.027
#740- Cornerstone ® Faba-pea	4.15	2.50	$68	May contain soy & wheat	10.00	80	39.22	~35	0.041
#236 - Soy protein	3.36	2.50	$65	Soy	10.00	80	37.51	~31	0.035

(1) Does not include cost of cashew butter, a fixed expense equal for all mixes

Summary

- **Screen P-B ingredient sources** before selecting
  - > Wide variation in sensory, composition, functionality, and forms available
  - > Applications testing assists in screening when ingredient variations are not well understood
- **Remember, basic ice cream formulation parameters apply**
  - > Sucrose equivalence, freezing point, solids not fat, protein, oil/fat ratios, etc.
  - > Composition of ingredients impacts the formula: protein, fats, carbohydrates (sugars and fibers), salts, and buffers, etc.
  - > Not all proteins are created equal!
- Formulation studies to understand ingredient interactions will translate into quality finished product!

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KEY COR DAR

BiPRO ISO Chill

Possible Ingredient Sources at Agropur Ingredients:

- **Cornerstone®** –functional plant, dairy, and animal proteins
- **Keystone®** – hydrocolloids and emulsifying ingredients
- **Darigen®** – Custom, complete formula bases
- **ISO Chill®** – low-temperature microfiltered whey protein isolate & concentrates
- **BiPRO®** – ion exchange whey protein isolates

Thank you for your time today, do you have any…

questions?