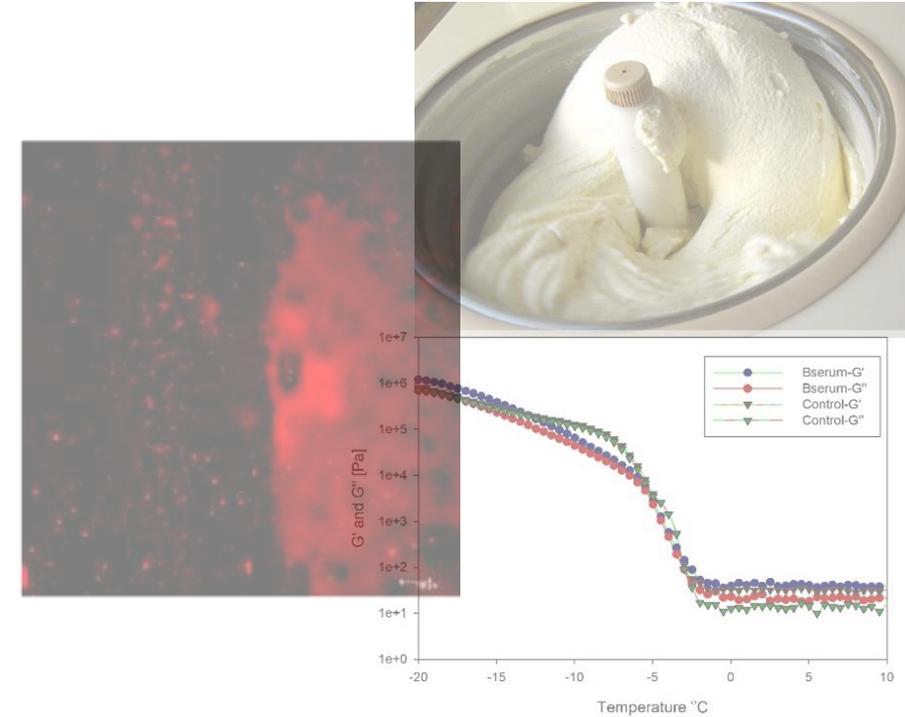


Utilization of dairy by-products in Ice-cream Manufacturing

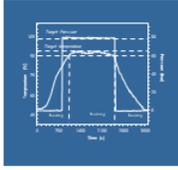
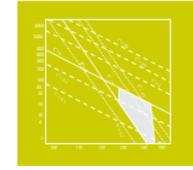
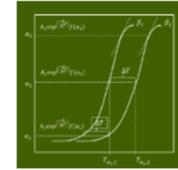
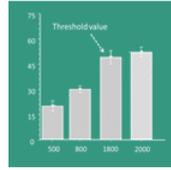


Kaavya Rathnakumar

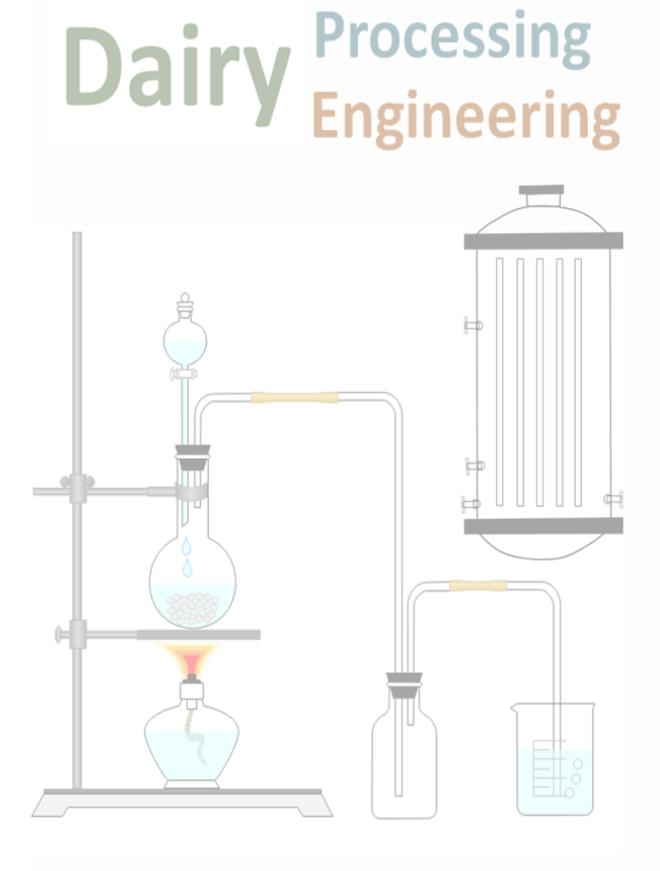
Sergio Martinez-Monteagudo



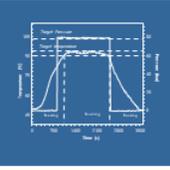
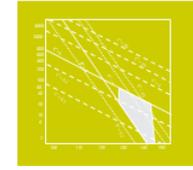
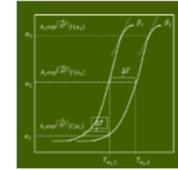
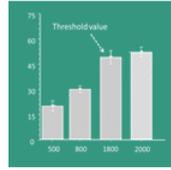
Content



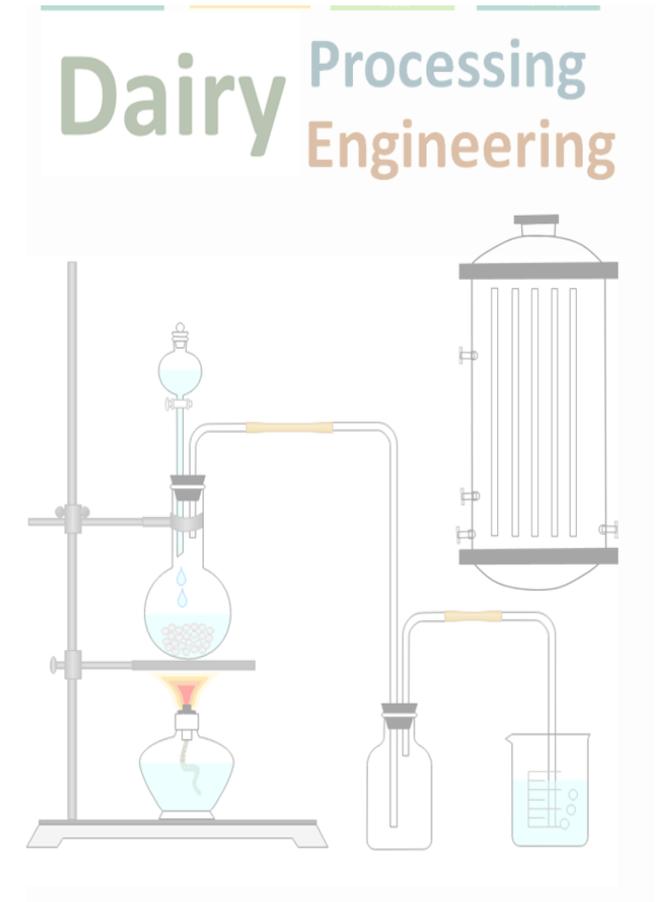
- ❖ Relevance – Dairy by-products
- ❖ Beta-serum & Phospholipids
- ❖ Objectives
- ❖ Materials and methods
- ❖ Results
- ❖ Outlook



Content



- ❖ Relevance – Dairy by-products
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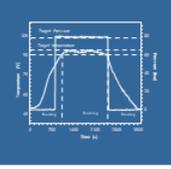
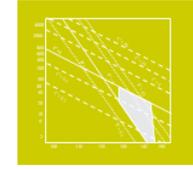
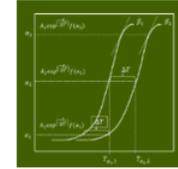
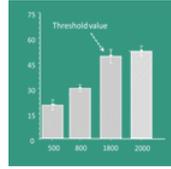


Dairy by-products

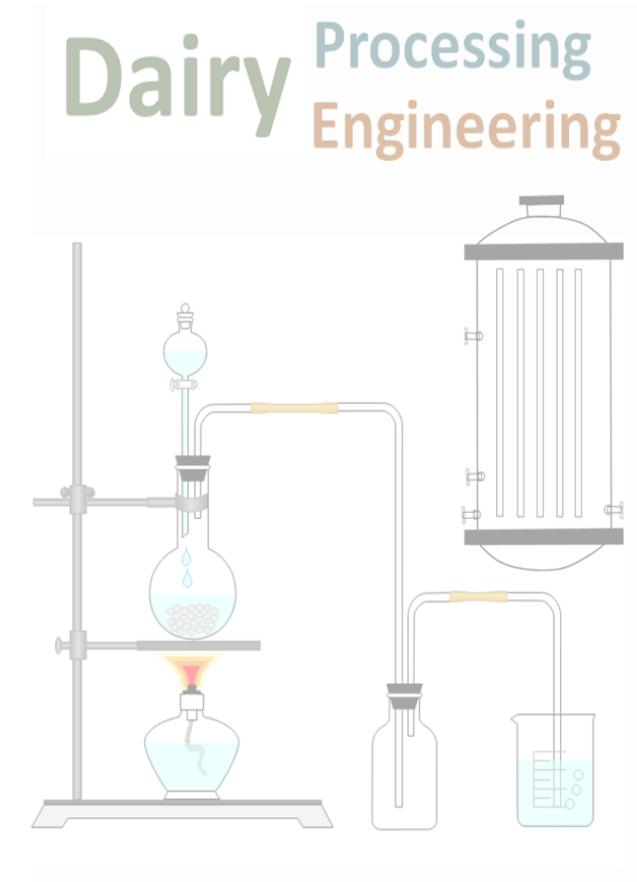
- represent 80% of the total milk manufactured
- generate high disposal costs by-products can cause a serious impact on the environment
- low in fat and have excellent technological and functional properties that benefit human health
- utilizing these valuable components, sustainable dairy product



Content

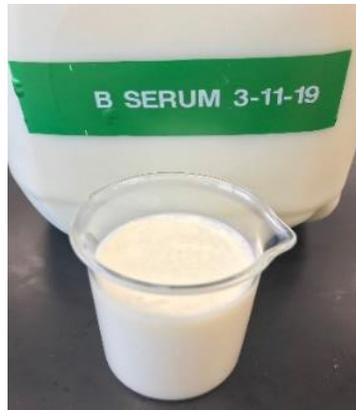


- ❖ Relevance – Dairy by-products
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Beta-serum(BS)

- Beta serum is a by-product obtained from the phase inversion during the manufacture of anhydrous milk fat (AMF)
- BS contains about 6-8% of phospholipids (PLs) on a dry basis

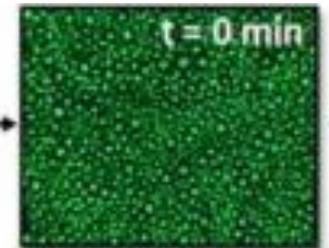


Phospholipids (PLs)

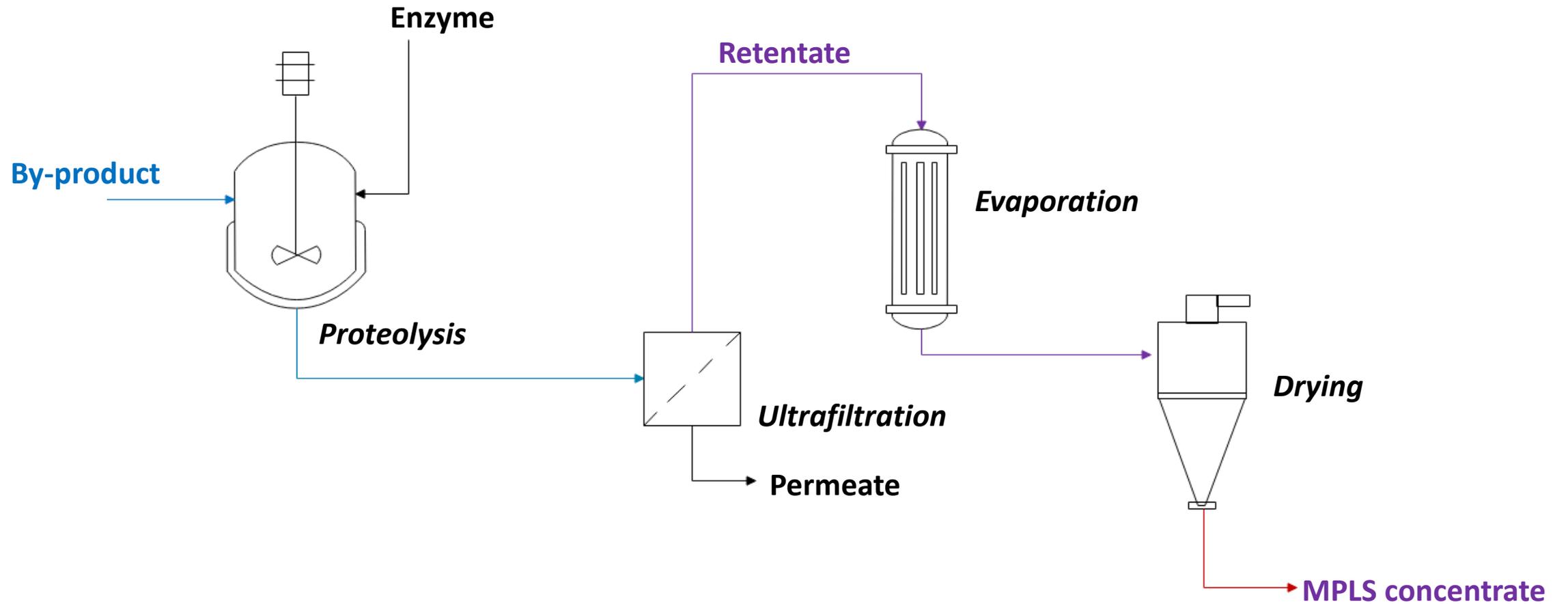
- PLs refers to a class of complex polar lipids
 - Arrangements with membrane proteins
 - milk fat emulsified and dispersed within the milk
- PLs account for 0.5-1% of the total milk fat
 - Season and lactation stage
- Functionality and health benefits
 - Power natural emulsifiers
 - Good stabilizer
 - Oxidation stability
 - Active health ingredient used in Infant formulas

Uniqueness of Dairy PLs

Composition of Individual PLs	Soy lecithin	Egg yolk	Dairy PLs	Functionality	Reference
Sphingomyelin (SM)	0	1.5	24%	Inhibits colon tumors, immunological defense	Castro et al., 2015; Burling et al., 2012
Phosphatidylserine (PS)	0.5	1.0	12%	Cognitive function and releasing stress	Huang et al., 2020



Concentrates of PLs



Concentration of PLs

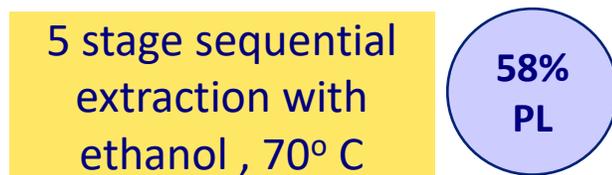
(Astaire et al., 2003)



(Barry et al., 2017)



(Price et al., 2018)



Product	MPLs %	Company
Phosphoric 500/600/700	34-75	Fonterra
Gangolac 600	15%	Fonterra
Lactoprodan [®]	20-75%	Arla Foods
Lipamine M20	20%	Lecico

Role of Lecithin/PLs

Chocolates

- reduces viscosity,
- replaces expensive ingredients such as cocoa butter
- improves the flow properties
- improve the shelf life for certain products.



Baked goods

- Wetting agent
- Pan release agent
- Cake batter stabilizer
- Fat replacer
- Finer crumb grain
- Greater loaf volume
- Better gluten stability
- Better emulsification of fats
- Longer shelf-life
- Increased water absorption



Frozen desserts

- Replacement of stabilizer
- creamy texture



Other

Cheese products

Instantizing process

Beverage mixes



Role of emulsifier

- It allows the oil-water emulsion to stabilize by forming a micelle, or a cluster of molecules that lower surface tension.
- non-polar tail of lecithin is attracted to the nonpolar **fat**, and so the **fat** globule can be dissolved in the lecithin



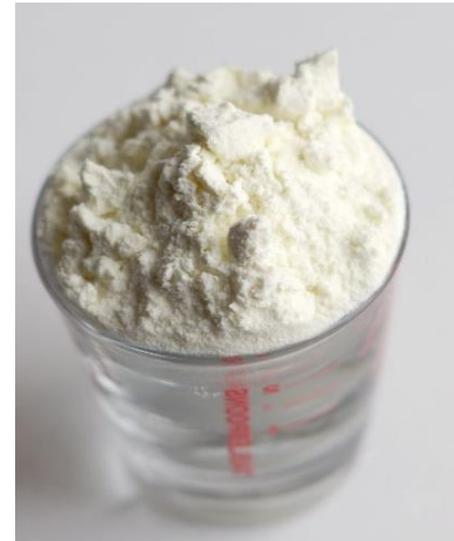
Ice-cream

- According to IDFA, consumption per person each year in the US alone is around 2L.
- Ice cream global sales represent over USD 73.8 Billion per year, with annual growth of close to 5 % and are projected to increase around USD 97 billion by 2023.

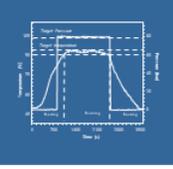
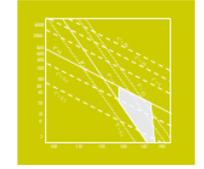
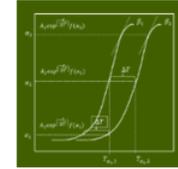
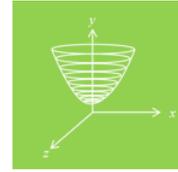
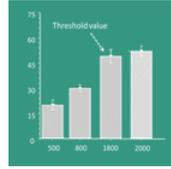


Dairy by-products

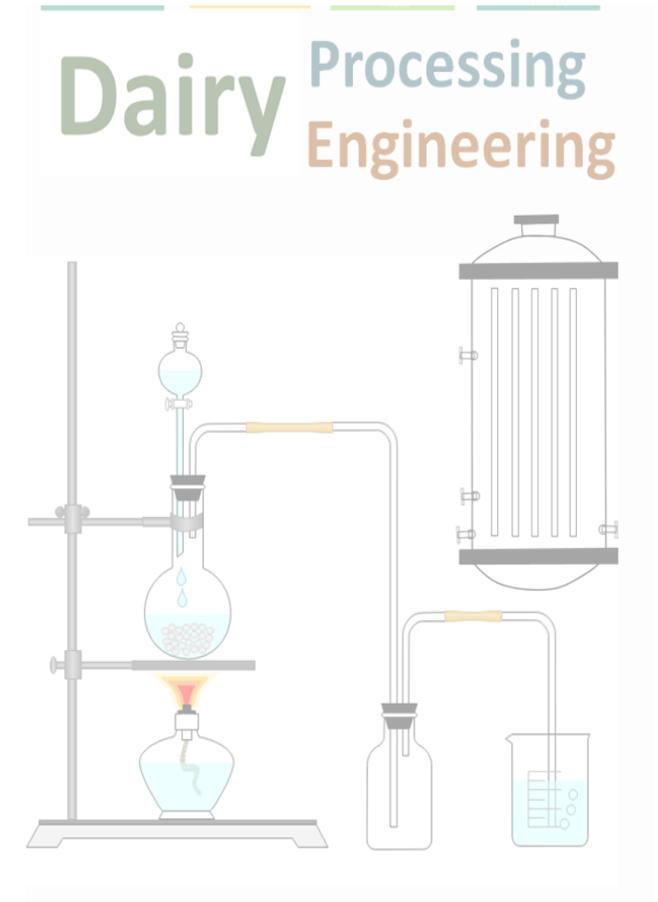
- ice-cream is a potential vehicle for reusing the dairy byproducts.



Content



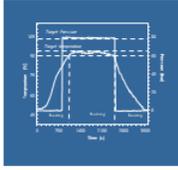
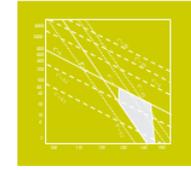
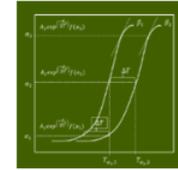
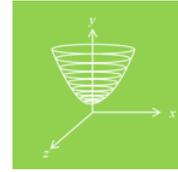
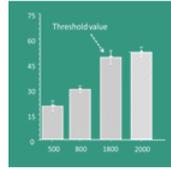
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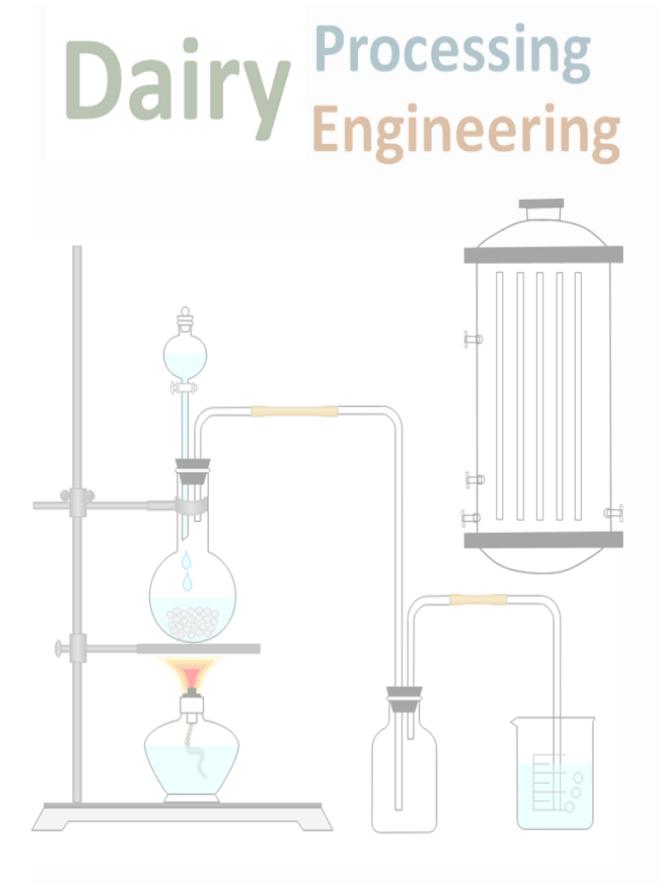
Objectives

- **The primary objective of the research aimed to evaluate the effect of Beta-serum on selected quality parameters of ice-cream.**
- **Secondary objective to monitor the presence of phospholipids at different processing steps of the ice-cream manufactured.**

Content



- ❖ Relevance – Dairy by-products
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Sequence of activities

Manufacturing of ice-cream

B-serum powder Non-fat dry milk (control)

Centrifugation
- Upper phase
- Lower phase

1 Mapping of PLs
i. Mixing
ii. Pasteurization
iii. Freezing

- CLSM
- Total Lipids
- Total Phospholipids

Ice-cream mix

Hardened Ice-cream

Quality analysis of ICM & IC
- Compositional analysis
- Particle size
- Zeta Potential
- Fat destabilization
- Desorption index
- Overrun
- SDS-Page
- Flow behavior of ICM

- Meltdown behavior
- Oscillatory analysis
- Total lipids
- Total PLs
- CLSM

2

3

**Dairy byproduct-
Concentrated Beta-serum
(BS)**

The BS was
obtained from
a local plant
(Valley Queen),
Milbank, SD



Non-fat dry milk



Particle Size & Zeta
Potential



Zeta Sizer ;Dynamic Light
Scattering; 1000 dilutions using
DI

Fat destabilization



*(Turbidity of the ice -
cream)/(turbidity of the
mix) × 100*

Microstructure
(CLSM)



Single staining – Phospholipids
(Rd dope)

Steady shear
measurements



Flow sweep measurement using
rheometer(Discovery Hybrid
rheometer, HR 30, TA
instruments)

Oscillatory Analysis



Temperature sweep using
rotational rheometer, MCR92
225

Quantification of total lipids

Folch Extraction (FE)

- 1g sample
- Chloroform:methanol (2:1)
- Vortexed & centrifuged
- Evaporation of solvent at 40°C

$$\text{Total lipids (\%)} = \frac{\text{Weight of recovered lipids}}{\text{Weight of sample}} \cdot 100$$

Fractionation of extracted lipids

SPE silica column



Elution of neutral lipids (CHCL3:MeOH)



Recovery of PL

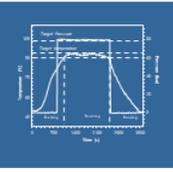
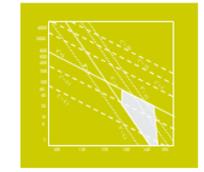
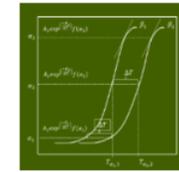
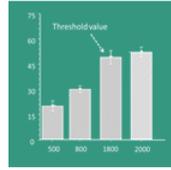


Evaporation at vacuum (40 C)

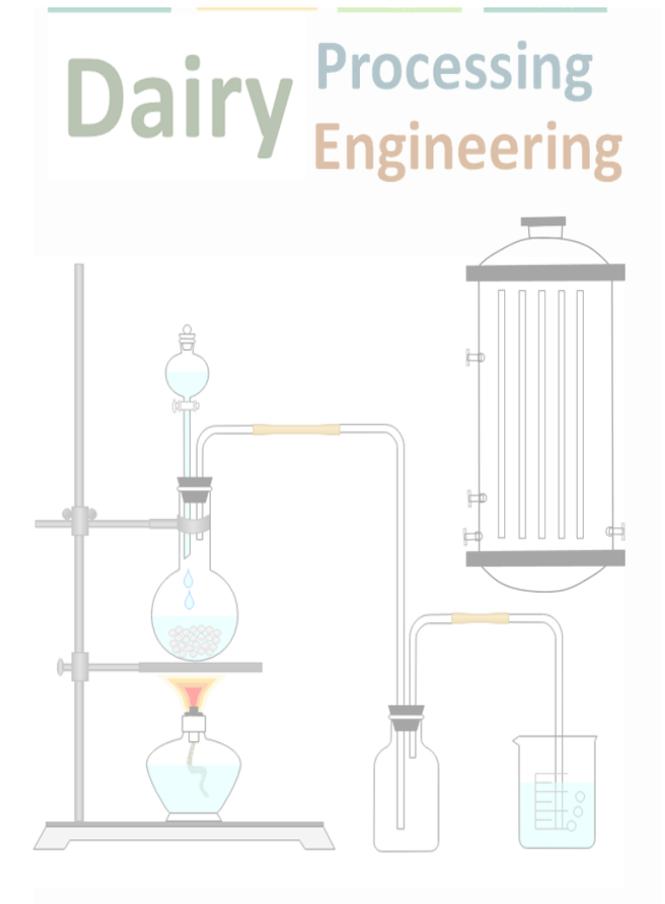
$$\text{Recovered phospholipids (\%)} = \frac{\text{Weight of dried fraction}}{\text{Weight of lipids}} \cdot 100$$



Content



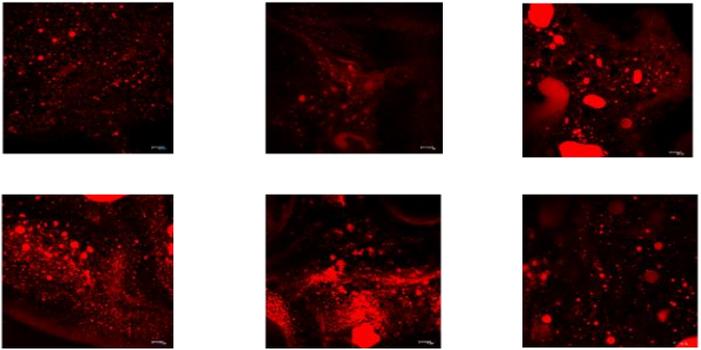
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Mapping of Phospholipids

Upper Phase

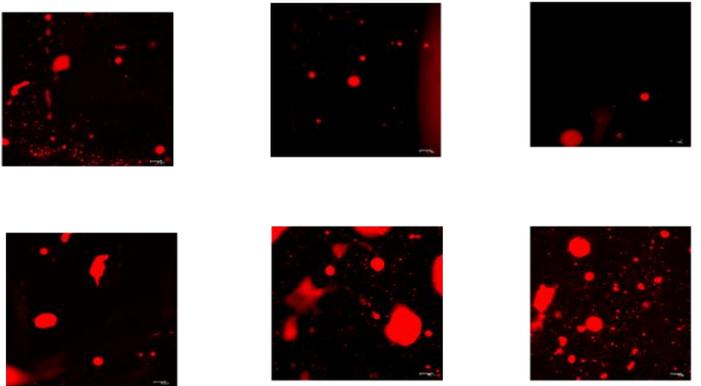
Control
Beta-serum



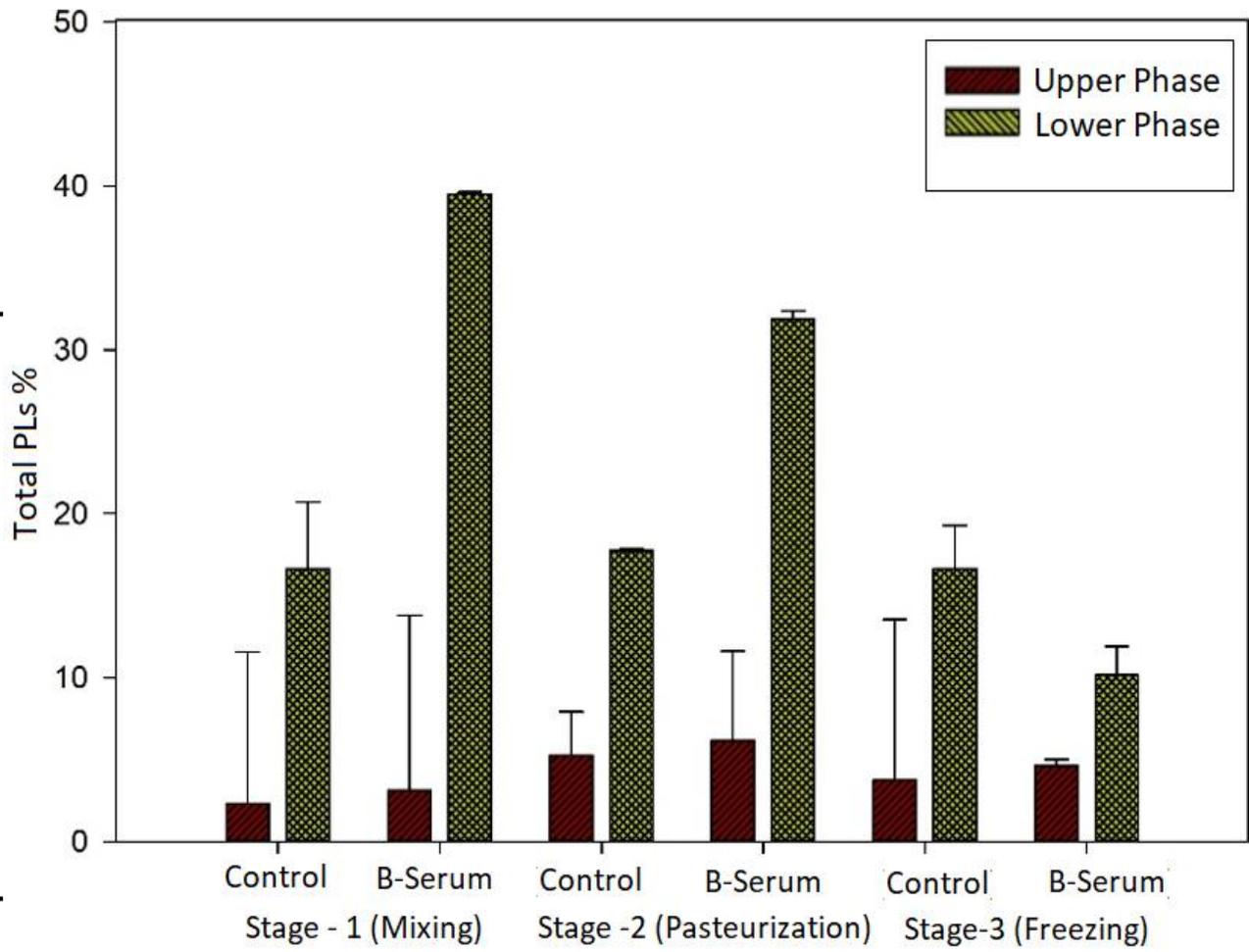
Lower Phase

Control
Beta-serum

Serum phase

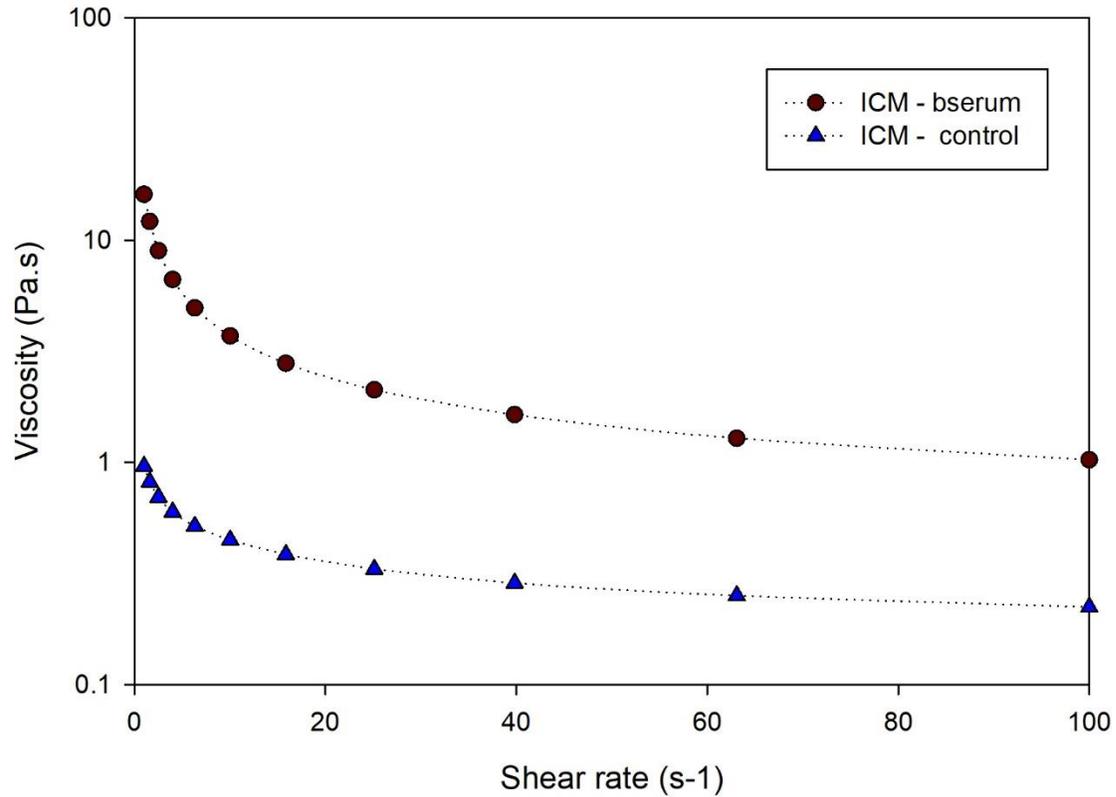


After mixing After Pasteurization After Freezing



Quality analysis of ice-cream

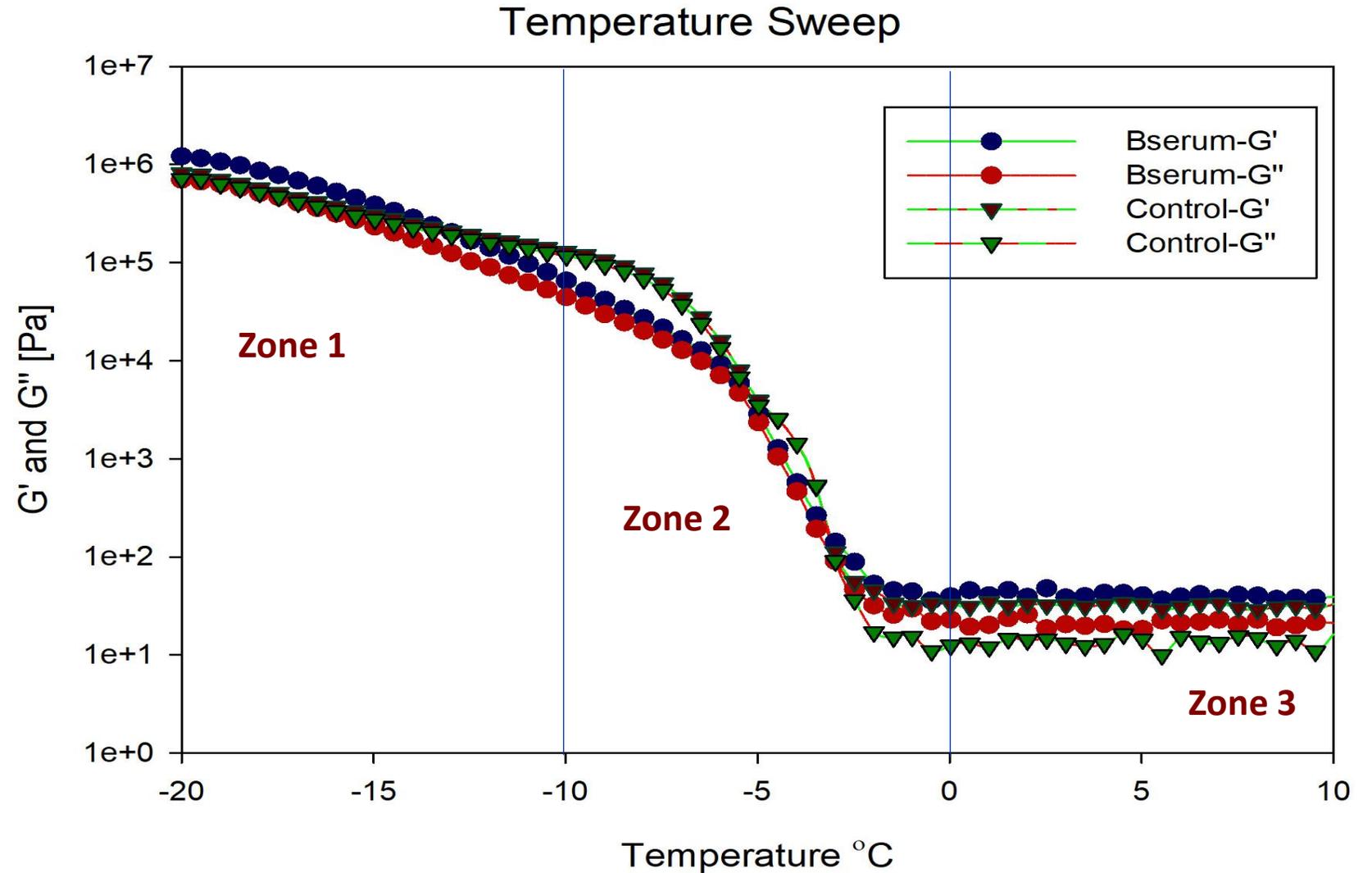
Flow behavior of ice-cream mix



Samples	Fat destabilization %	Particle Size (d.nm)	Zeta Potential (mV)
IC - NFDM	77.18±1.66	474.6±13.31	-24.3 ± 4.3
IC- B-serum	63.10±2.10	564.8±12.7	-27.1 ± 5.1

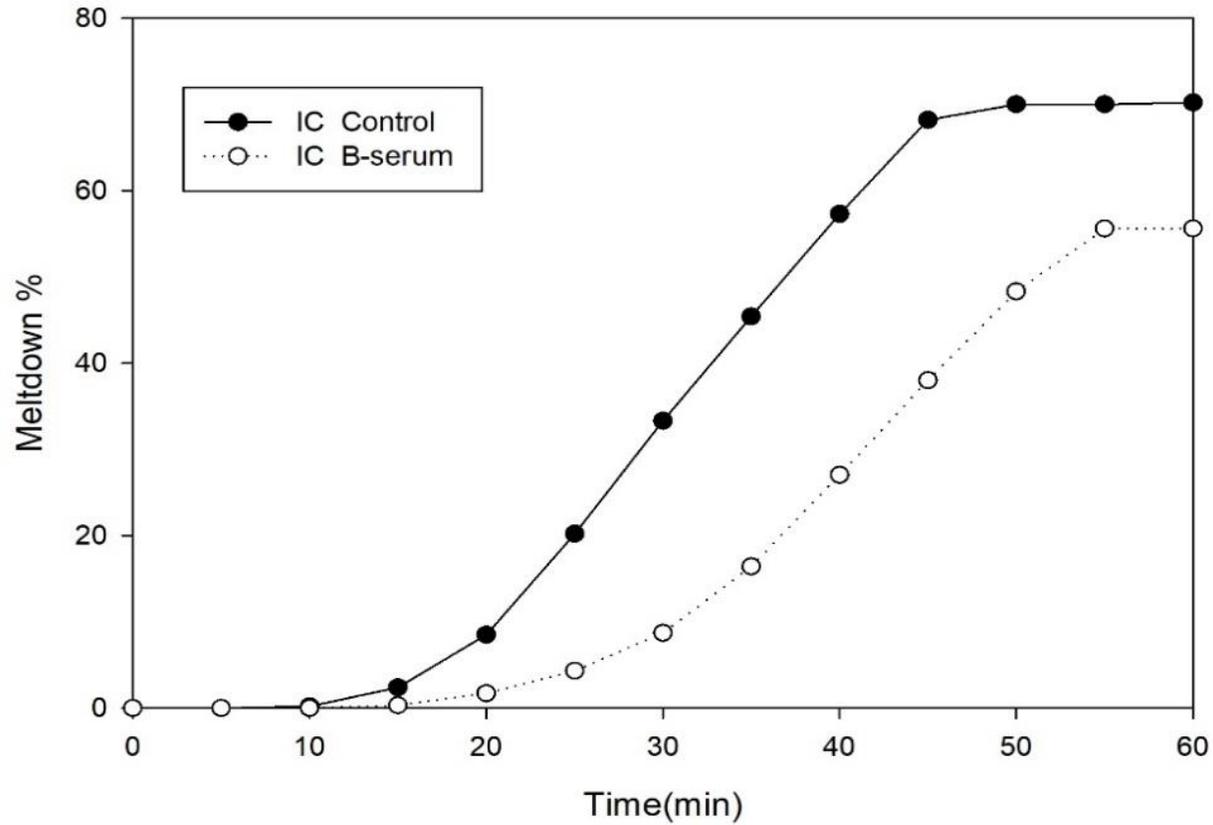
Melting behavior of Ice-cream

- **Zone 1 - Scoopability and rigidity (IC-BS , higher G' and G'')**
- **Zone 2 – sensorial impression of coldness (IC-BS showed more steeper slopes – dominating icy structure)**
- **Zone 3 - dispersed air and fat phase (Higher G' than G'' – IC BS higher creaminess)**



Meltdown

Meltdown behavior

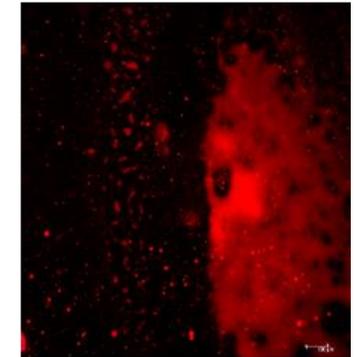
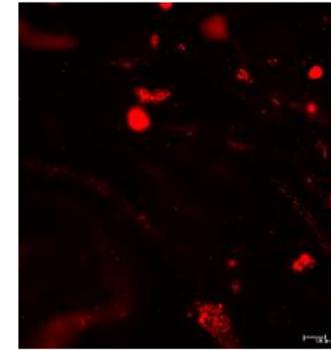


Microstructure

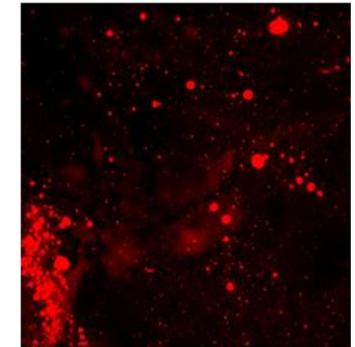
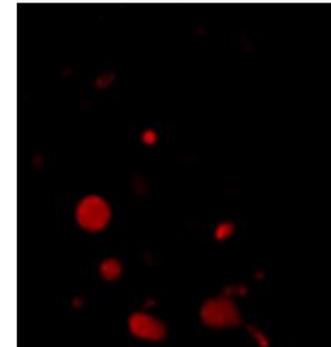
Control

Beta-serum

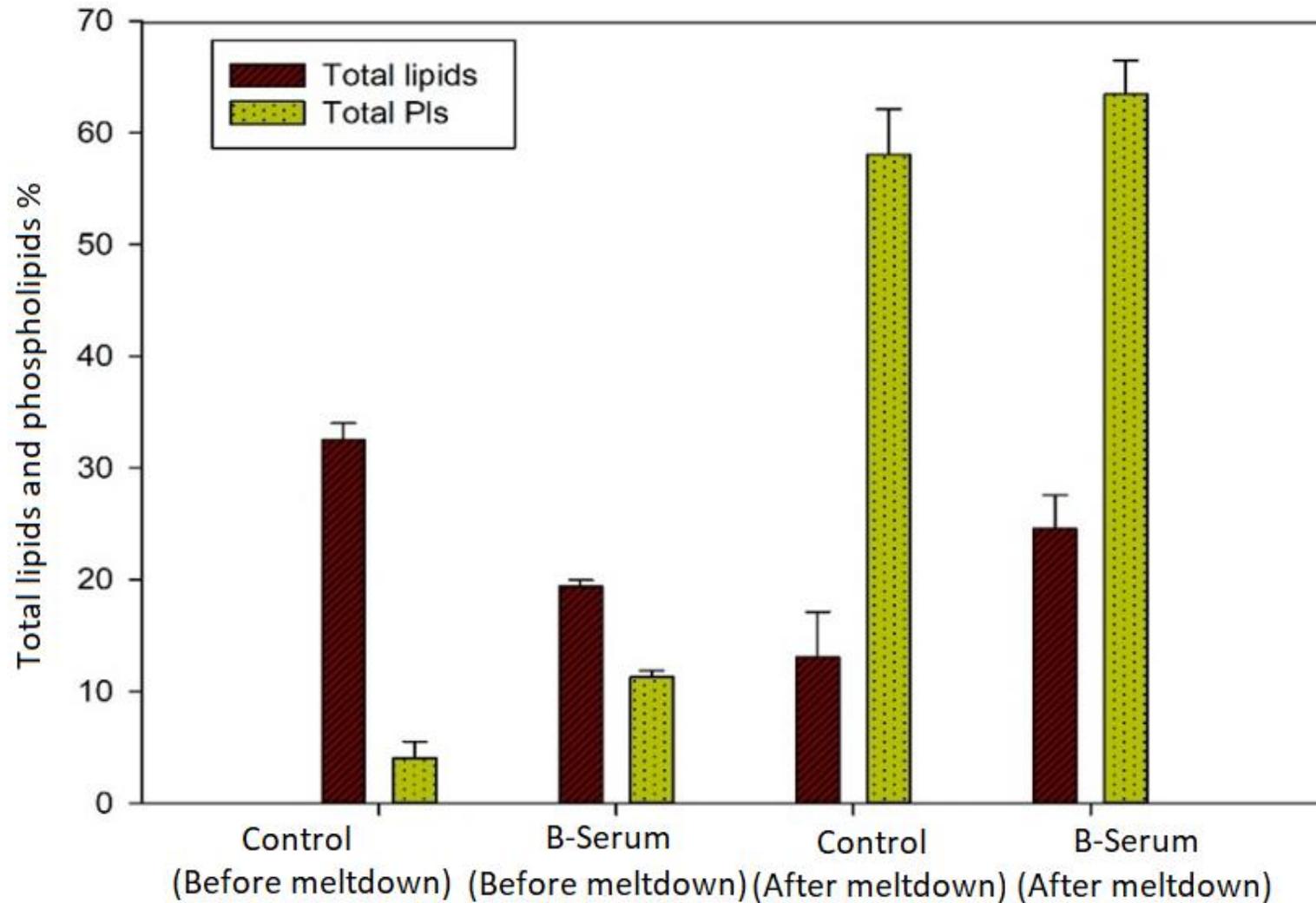
Before
meltdown



After
meltdown



Quantification of PLs before and after meltdown



Total PLs

- Before Meltdown

Control – 4 %

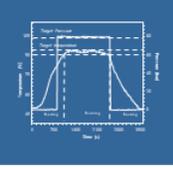
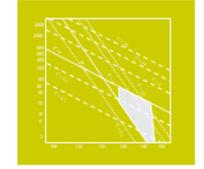
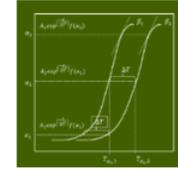
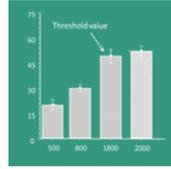
B-serum -11 %

- After Meltdown

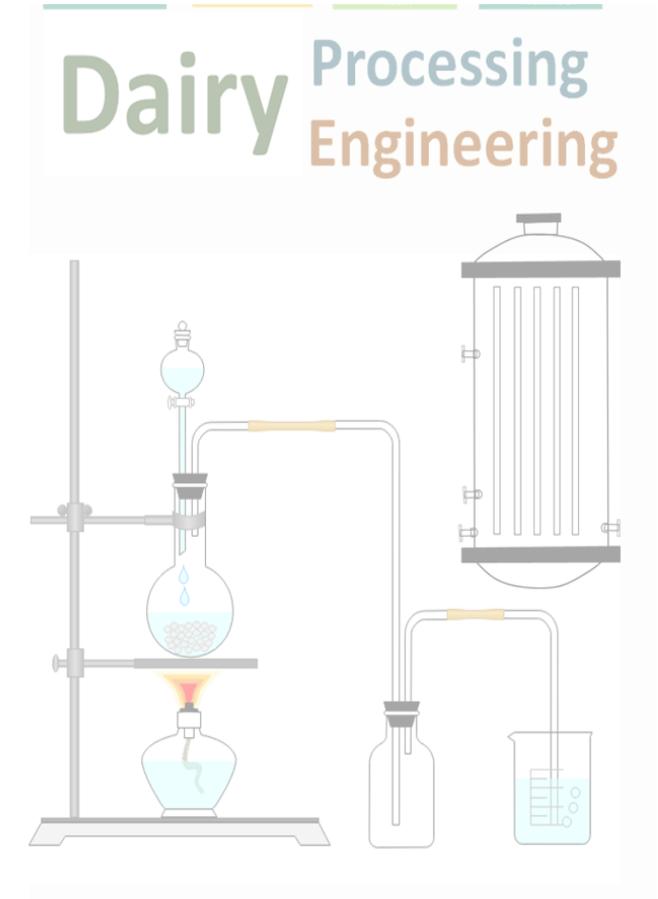
Control - 58 %

B serum - 64%

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Outlook

- Ice-cream with NFDM and Beta serum provided similar quality attributes
- The beta-serum application in ice cream manufacturing provides insights that dairy by-product beta-serum can be used as replacers of non-fat dry milk in ice creams for sustainable and healthy markets
- This mapping can provide insights into where the PLs is during the ice-cream manufacturing process
- Further quantification of individual PLs and scale-up will require to study of the sensorial description of the product as well as consumer acceptance



THANK YOU!



**SOUTH DAKOTA
STATE UNIVERSITY**
Department of Dairy
and Food Science



United States Department of Agriculture
National Institute of Food and Agriculture

