Utilization of dairy by-products in Ice-cream Manufacturing

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❖ Beta-serum & Phospholipids
❖ Objectives
❖ Materials and methods
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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
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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

<table>
<thead>
<tr>
<th>Composition of Individual PLs</th>
<th>Soy lecithin</th>
<th>Egg yolk</th>
<th>Dairy PLs</th>
<th>Functionality</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphingomyelin (SM)</td>
<td>0</td>
<td>1.5</td>
<td><strong>24%</strong></td>
<td>Inhibits colon tumors, immunological defense</td>
<td>Castro et al., 2015; Burling et al., 2012</td>
</tr>
<tr>
<td>Phosphatidylserine (PS)</td>
<td>0.5</td>
<td>1.0</td>
<td><strong>12%</strong></td>
<td>Cognitive function and releasing stress</td>
<td>Huang et al., 2020</td>
</tr>
</tbody>
</table>
Concentrates of PLs
**Concentration of PLs**

*Microfiltration + Super critical CO₂* (19% PL)

*Enzymatic hydrolysis + Microfiltration + Super critical CO₂* (56% PL)

*5 stage sequential extraction with ethanol, 70°C* (58% PL)

<table>
<thead>
<tr>
<th>Product</th>
<th>MPLs %</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphoric 500/600/700</td>
<td>34-75</td>
<td>Fonterra</td>
</tr>
<tr>
<td>Gangolac 600</td>
<td>15%</td>
<td>Fonterra</td>
</tr>
<tr>
<td>Lactoprodan®</td>
<td>20-75%</td>
<td>Arla Foods</td>
</tr>
<tr>
<td>Lipamine M20</td>
<td>20%</td>
<td>Lecico</td>
</tr>
</tbody>
</table>
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

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

Other

Cheese products
Instantizing process
Beverage mixes
• 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.

• Ice-cream is a potential vehicle for reusing the dairy by-products.
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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.
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Sequence of activities

Manufacturing of ice-cream

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

Centrifugation
- Upper phase
- Lower phase

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

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

- **Particle Size & Zeta Potential**
- **Fat destabilization**
- **Microstructure (CLSM)**
- **Steady shear measurements**
- **Oscillatory Analysis**

- Zeta Sizer; Dynamic Light Scattering; 1000 dilutions using DI
- \(\frac{\text{Turbidity of the ice - cream}}{\text{turbidity of the mix}} \times 100\)
- Single staining – Phospholipids (Rd dope)
- Flow sweep measurement using rheometer (Discovery Hybrid rheometer, HR 30, TA instruments)
- Temperature sweep using rotational rheometer, MCR92 225

**Non-fat dry milk**
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)

\[
\text{Recovered phospholipids (\%)} = \frac{\text{Weight of dried fraction}}{\text{Weight of lipids}} \cdot 100
\]
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Mapping of Phospholipids

Upper Phase
- Control
- Beta-serum

After mixing
After Pasteurization
After Freezing

Lower Phase
- Serum phase
- Control
- Beta-serum

After mixing
After Pasteurization
After Freezing

Bar graph showing total PLs % for different stages and phases:
- Control
- B-Serum
- Control
- B-Serum
- Control
- B-Serum

Stages:
- Stage - 1 (Mixing)
- Stage - 2 (Pasteurization)
- Stage - 3 (Freezing)
## Quality analysis of ice-cream

### Flow behavior of ice-cream mix

![Graph showing flow behavior of ice-cream mix](image)

### Table: Quality analysis of ice-cream samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Fat destabilization %</th>
<th>Particle Size (d.nm)</th>
<th>Zeta Potential (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC - NFDM</td>
<td>77.18±1.66</td>
<td>474.6±13.31</td>
<td>-24.3 ± 4.3</td>
</tr>
<tr>
<td>IC- B-serum</td>
<td>63.10±2.10</td>
<td>564.8±12.7</td>
<td>-27.1 ± 5.1</td>
</tr>
</tbody>
</table>
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 behavior

Time (min)

Meltdown %

IC Control

IC B-serum

Before meltdown

After meltdown

Control

Beta-serum
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!