Microfiltered Milk Ingredients
Using advanced filtration technology to generate value for the dairy industry

Agenda

Using advanced filtration technology to generate value for the dairy industry

1. Profile of microfiltered milk processing and products

2. Potential for microfiltration technology to create high value streams and ingredients
Introduction – Comparing microfiltration and ultrafiltration of milk

**Ultrafiltration** concentrates all of the milk protein (casein and whey) → MPC and MPI Products

**Microfiltration** fractionates (separates) casein and whey protein → MIC MCC, MCI and NWP/MWP Products

**Membrane filtration technology**

Microfiltration membrane pore size: 0.1 – 0.2 µmeter

Water → Salts → Lactose → Whey proteins → Casein → Somatic Cells → Fat Globules → Bacteria

1. Microfiltration
2. Ultrafiltration
3. Nanofiltration
4. Reverse osmosis
Microfiltration – Protein fractionation technology separates casein and whey protein

Product streams obtained from milk microfiltration

1. Micellar Casein – used for cheese making and ingredient manufacture; fluid and dried products

2. Native Whey Protein – high quality “whey protein” with multiple applications (Aka Milk Whey Protein, ADPI Standard)

3. Milk Permeate – for milk powder standardization and lactose production
A profile of progressive commercial development in the use of microfiltration processing, primarily in Europe

Little adopted in Oceania
Adoption restricted by regulation in the USA (standards of identity for cheese)
Emerging use in other parts of the world

In Europe use of MF milk in cheese was the original investment driver. Demand for ingredients is now of growing importance as a factor for investment

Expanded production in the early 2000’s
By 2010 6 companies
By 2015 9 companies
By 2018 14 companies engaged in supplying MF milk products. Increase in investment activity spurred by removal of quotas; new operations and expansion of existing facilities.

Early adoption in the 1990’s focused on utilization of MF milk for cheese production, mostly inline

Supply structure for microfiltered milk – Current European Model
Similar model expected to evolve in the US, subject regulatory reform

1. MF Milk Users
Cheese plants that procure fluid microfiltered milk from external sources

2. Users/MF Processors
Microfiltered milk produced for internal use in cheese
Optional external sale for cheese making.
Ingredient processing of microfiltered milk and MWP in fluid and dry forms

3. MF Processors
MIC Protein produced exclusively for external sale
Production of fluid and dry ingredients
Sales to cheese producers and ingredient markets

≥50-60 cheese plants

14 + Companies – MF Processors
## Composition of microfiltered milk ingredients

### Some background on milk protein composition

<table>
<thead>
<tr>
<th>Ingredient Description</th>
<th>Casein/Whey Protein Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>For each 100 grams of milk protein</td>
<td></td>
</tr>
<tr>
<td>Milk: 80 grams casein, 20 grams whey protein</td>
<td>80/20</td>
</tr>
<tr>
<td>Milk Powders &amp; MPC: 80 grams casein, 20 grams whey protein</td>
<td>80/20</td>
</tr>
<tr>
<td>Casein/Caseinate: 98 grams casein, 2 grams whey protein</td>
<td>98/2 approx.</td>
</tr>
<tr>
<td>Micellar Casein: Varies</td>
<td>See later</td>
</tr>
<tr>
<td>Human Milk &amp; Infant Formula: 40 grams casein, 60 grams whey protein</td>
<td>40/60</td>
</tr>
</tbody>
</table>

### Standard casein ratio Products

### Adjusted casein ratio Products

### Composition of microfiltered milk ingredients A – Micellar Casein Products

**Micellar Casein Composition Spectrum**

![Micellar Casein Composition Spectrum](image-url)
### Composition of microfiltered milk ingredients A – Micellar Casein Products

#### Commercial Product Variants by Protein Content and CAS/WP Ratio

<table>
<thead>
<tr>
<th>Casein to Whey Protein Ratio</th>
<th>80/20</th>
<th>85/15</th>
<th>88/12</th>
<th>90/10</th>
<th>92/8</th>
<th>95/5</th>
<th>&gt;98/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>87%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wide spectrum of commercial (micellar) casein ingredients

#### Micellar Casein Ingredients

<table>
<thead>
<tr>
<th>Fluid Products</th>
<th>Dried Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-16% Total Solids</td>
<td>5% Moisture</td>
</tr>
</tbody>
</table>

Casein/Whey Protein Ratio 85/15 - 95/5

#### Dry Matter Basis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>55 - 88%</td>
</tr>
<tr>
<td>Lactose</td>
<td>1.5 - 28%</td>
</tr>
<tr>
<td>Minerals</td>
<td>5.5 – 9.0</td>
</tr>
<tr>
<td>Fat</td>
<td>1.0-2.5</td>
</tr>
</tbody>
</table>
Composition of microfiltered milk ingredients B – Milk Whey Protein

- Retentate (Casein)
- Permeate (Whey Protein)
- Native Whey Protein
- Milk Whey Protein (MWP)

Depending on the type of MF membrane and process conditions, some casein may pass into the permeate (Beta Casein)

**Compositional Profile for Milk Whey Protein Ingredients**

<table>
<thead>
<tr>
<th>Casein/Whey Protein Ratio</th>
<th>0/100 - 30/70 approx.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry Matter Basis</strong></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>35 - 90%</td>
</tr>
<tr>
<td>Lactose</td>
<td>1.5 - 60%</td>
</tr>
<tr>
<td>Minerals</td>
<td>5.5 – 7.0</td>
</tr>
<tr>
<td>Fat</td>
<td>trace</td>
</tr>
</tbody>
</table>

**Summary**

- Commercial microfiltered milk ingredients exhibit a wide range of protein profiles
- Differences in the type of membrane filtration systems employed for primary microfiltration along with varying process conditions play a significant role in determining compositional outcomes

30/70 is close to requirement for infant formula
Why develop microfiltered milk business?

Micellar Casein (MIC) Fluid and Powders

Milk Whey Protein (MWP) Fluid and Powders

Wide ranging opportunities for business development

Cheese Industry
- Cheese Milk Pretreatment

Nutritional Markets
- Infant Formula
- Sports Nutrition Powders
- Clinical Nutrition
- Nutrition Bars
- Ready to Drink Beverages

Food Ingredient Markets
- Cultured Dairy Products
- Dairy Based Desserts
  - Cheese
  - Confectionery
  - Coffee Creamers

Dairy Advance Business Consulting LLC
2019 ADPI Dairy 360

Productivity and efficiency benefits for cheese making with microfiltered milk

<table>
<thead>
<tr>
<th></th>
<th>Output per Million Pounds of Vat Milk (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regular Milk 2.5% Casein</td>
</tr>
<tr>
<td>American Cheese</td>
<td>105,000</td>
</tr>
<tr>
<td>Mozzarella</td>
<td>110,000</td>
</tr>
<tr>
<td>Hard Cheese</td>
<td>80,000</td>
</tr>
</tbody>
</table>

Substantial increase in cheese vat capacity (+35-48%) in this example

Higher levels possible

Plus substantial quality benefits

Dairy Advance Business Consulting LLC
2019 ADPI Dairy 360
Milk Whey Protein compared to Whey Protein

**Differences**
- Direct from milk
- No color
- No enzyme/rennet
- No starter cultures
- No GMP
- No fat
- Limited heat exposure
- Limited protein damage
- Low enzyme content

**Benefits**
- Enhanced nutritional value and protein quality
- Cleaner flavor
- Consistent Composition
- Better protein functionality
- More traceable

**Commercial Value and Market Opportunities**
- Infant formula
- Cheese
- Nutritional products
- Food ingredients

Milk Whey Protein Potential – High value opportunities

1. Multiple applications for MWP as an ingredient in its own right
2. MWP as raw material for derivative products
   - Beta casein for infant formula
   - Production of alpha lactalbumin (higher yield than from conventional whey)
   - Lactoferrin from “milk”
   - High quality feed stock for hydrolysate

*Milk Whey Protein*
A transformative product which will reshape the whey industry over time
Summary benefits from microfiltered milk technology

- Diversification in use of Skim Milk – strategic benefit for dairy industry
- Strengthen the cheese industry via increased productivity and other benefits
- Innovative new ingredient products with transformative potential
- Benefits for consumers from product quality and enhanced nutritional profile. Opportunities for vertical integration in consumer products
- Upside for milk producers from expanded market opportunities

Thank you

Questions?

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APPENDIX

PRODUCT STANDARDS

Milk Whey Protein Standard

Product Definition
Milk Whey Protein is obtained from bovine milk or skim milk by the removal of casein and non-protein constituents from milk so that the finished dry product contains not less than 27% protein. It is obtained by microfiltration, ultrafiltration, or chromatographic methods or other similar means that may be prescribed followed by dehydration, nanofiltration, evaporation, dehydrating, or other suitable methods, or in which all or part of the lactose, minerals, and water may be removed. Products cannot be produced through any process or combination of processes that include enzymatic coagulation of protein and or acid precipitation of protein in bovine milk or skim milk.

Milk Whey Protein products with a protein content less than 80.5% protein are referred to as Milk Whey Protein Concentrates (mWPC).

Milk Whey Protein products with a protein content ≥80.5% protein on a dry matter basis are referred to as Milk Whey Protein Isolates (mWPI).

Composition
Several different mWPC or mWPI products are commercially available. These may include:

<table>
<thead>
<tr>
<th>Product</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Lactose %</th>
<th>Ash %</th>
<th>Moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>mWPC 34</td>
<td>Min. 35.5%</td>
<td>Max. 2.0%</td>
<td>Min. 55.0%</td>
<td>Max. 7.0%</td>
<td>Min. 6.0%</td>
</tr>
<tr>
<td>mWPC 80</td>
<td>Min. 70.5%*</td>
<td>Max. 2.0%</td>
<td>Min. 13.0%</td>
<td>Max. 5.0%</td>
<td>Min. 6.0%</td>
</tr>
<tr>
<td>mWPI 90</td>
<td>Min. 80.0%*</td>
<td>Max. 1.5%</td>
<td>Max. 4.0%</td>
<td>Max. 4.0%</td>
<td>Min. 4.0%</td>
</tr>
</tbody>
</table>

*Protein content ≥ 80.5% is reported on a dry basis, all other parameters are reported as is.

Microbiological Standards and Methods of Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Plate Count</td>
<td>M009-000</td>
<td>ASTM 969.23</td>
</tr>
<tr>
<td>Coliform Bacteria</td>
<td>Milk + w/</td>
<td>AFAC 309.01 (bentonite)</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Not App.</td>
<td>FDA/BAM</td>
</tr>
<tr>
<td>Listeria</td>
<td>Not App.</td>
<td>FDA/BAM</td>
</tr>
</tbody>
</table>
### Concentrated Milk Proteins Standard

**Product Definition**

Concentrated Milk Proteins products are obtained by concentrating bovine skim milk through ultrafiltration processes to obtain a final dry product containing 40% or more protein by weight. Concentrated Milk Proteins products may be produced by the unfractionated or fractionated process. Concentrated Milk Proteins products may be produced by combining separately produced casein (nonfat) and whey proteins.

**Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI) are produced by ultrafiltration methods:**

- **Milk Protein Concentrate (MPC):** milk proteins are concentrated to a final product containing milk proteins and whey proteins.
- **Milk Protein Isolate (MPI):** milk proteins are concentrated to a final product containing milk proteins.

Concentrated Milk Protein products may also be produced using Microfiltration, which will allow the casein-to-whey ratio to be compared to that found in milk. The casein-to-whey protein ratio typically ranges between 5:1 and 8:1 for commercially available products. When Microfiltration is used, the resulting product is called Microfiltered Milk Protein (MMP) or Microfiltered Casein (MC).

**Comparison: MPC and MPI**

Several different MPC and MPI products are commercially available, each of which is identified by a number which represents its protein content. These include:

<table>
<thead>
<tr>
<th>Product</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Lactose (%)</th>
<th>Ash (%)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPC 50</td>
<td>50.0</td>
<td>3.00</td>
<td>10.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>MPC 60</td>
<td>60.0</td>
<td>3.00</td>
<td>5.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>MPC 70</td>
<td>70.0</td>
<td>3.00</td>
<td>0.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>MPC 80</td>
<td>80.0</td>
<td>2.00</td>
<td>0.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>MIPS</td>
<td>30.0</td>
<td>1.00</td>
<td>0.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

(*) Protein content is reported on a dry basis; all other parameters are reported as-is.
Product Labeling

Milk Protein Concentrate (MPC) is labeled to reflect the protein content of the finished product. Product labeled as Milk Protein Isolate (MPI) must contain a minimum of 89.5% protein. Microfiltered Milk Protein (MMP) and Micellar Casein (MC) are labeled to reflect their protein content.

Product Applications and Functionality

MPC, MPI, MMP and/or MC can be used as food ingredients in a variety of food categories. Depending on the food category in which the concentrated milk proteins are used, they can serve as: emulsifiers, flavor enhancers, flavoring agents, formulation aids, humectants, stabilizers and thickeners, texturizers, and sources of high-quality protein.

Storage & Shipping

Product should be stored and shipped in a cool, dry environment with temperatures below 80°F and relative humidity below 65%. Stocks should be rotated and utilized within 1 – 2 years.

Packaging

Multiwall kraft bags with polyethylene inner liner or other suitable closed container – i.e., “tote bins”, etc.