Developing Beverages with Dairy Proteins

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Wisconsin Center for Dairy Research

Center for Dairy Research “Solution Based Research Backed by Experience, Passion and Tradition”
Beverage Opportunities

- Meal Replacements
- Sports Drinks
  - Recovery Drinks
  - Isotonics
  - Body Building/Muscle Building
- Energy Drinks
- Smoothies/Yogurt Drinks/Juice Drinks
- Waters
- Tea
- Coffee
- Carbonated drinks
# Milk Protein Ingredients

<table>
<thead>
<tr>
<th>Composition</th>
<th>SMP</th>
<th>MPC56</th>
<th>MPC70</th>
<th>MPC80</th>
<th>MPI</th>
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<tbody>
<tr>
<td>Fat</td>
<td>0.8</td>
<td>1.2</td>
<td>1.2</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Moisture</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
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<tr>
<td>Protein</td>
<td>35.0</td>
<td>54.4</td>
<td>68.3</td>
<td>78.1</td>
<td>87.1</td>
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<tr>
<td>Lactose</td>
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<td>31.7</td>
<td>18.2</td>
<td>8.4</td>
<td>0.5</td>
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<tr>
<td>Ash</td>
<td>8.2</td>
<td>7.6</td>
<td>7.3</td>
<td>7.0</td>
<td>5.9</td>
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# Whey Protein Ingredients

<table>
<thead>
<tr>
<th>Composition (%)</th>
<th>WPC34</th>
<th>WPC80</th>
<th>WPI</th>
<th>*WPPC</th>
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<tbody>
<tr>
<td>Fat</td>
<td>3.0</td>
<td>5.0</td>
<td>1.0</td>
<td>10-20</td>
</tr>
<tr>
<td>Moisture</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>3-4</td>
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<tr>
<td>Protein</td>
<td>35.0</td>
<td>80.0</td>
<td>90.0</td>
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<tr>
<td>Ash</td>
<td>6.0</td>
<td>4.0</td>
<td>2.0</td>
<td>2.5-4.0</td>
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<tr>
<td>Lactose</td>
<td>51.0</td>
<td>4.0</td>
<td>1.0</td>
<td>5-11</td>
</tr>
</tbody>
</table>

*Whey Protein Phospholipid Concentrate*
Which Dairy Ingredient?

- The choice of the protein ingredient should be based on the desired attributes of the beverage and pH of the drink.
- Whey protein isolates will provide high clarity.
- The functionality of caseins and whey proteins change with pH
Functional Properties

- Emulsification
- Whipping/foaming
- High solubility
- Gelation
- Viscosity and water binding
- Browning
## Functional Properties of Milk Proteins

<table>
<thead>
<tr>
<th>Caseins</th>
<th>Whey Proteins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat emulsification</td>
<td>Gelation</td>
</tr>
<tr>
<td>Foaming</td>
<td>Foaming</td>
</tr>
<tr>
<td>Soluble at pH &gt;6</td>
<td>Soluble at any pH</td>
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<tr>
<td>Water binding</td>
<td>Heat sensitive</td>
</tr>
<tr>
<td>Precipitation by Ca++</td>
<td></td>
</tr>
<tr>
<td>Precipitation by chymosin</td>
<td></td>
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<tr>
<td>Heat stable</td>
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</tbody>
</table>

Heat-Induced Changes in Milk Proteins

Native whey protein (folded) → Denatured whey protein (unfolded)

Whey proteins become associated with casein micelles

Disulfide bond \(-\text{s-s-}\)
Free sulphhydryl group \(-\text{SH}\)

Colloidal calcium phosphate (CCP)

J. Lucey
Factors that Influence the Functional Properties of Dairy Proteins in Beverages

• Hydration Conditions and Time
  – A well hydrated protein ingredient will have better heat stability and solubility

• pH
  – Caseins and whey proteins will behave differently at different pH

• Ionic strength
  – Generally the higher the ionic strength the greater the possibility for protein-protein interaction and loss of heat stability for whey proteins, divalent ions such as calcium and magnesium are more reactive (JL. Xiong J. Agric. Food Chem. 1992, 40, 380-384)

• Protein concentration
  – Higher concentrations of protein (>7%) are more challenging
Whey Protein Ingredient Processing Recommendations

- Good hydration is the key to good functionality
- In 2000, we began doing development with Ready to Drink (RTD) beverages
- We observed whey protein performance differences that seemed to be tied to hydration time
- Turbidity differences were observed
- Work was initiated to identify an optimum time/temp for hydration to achieve best clarity (low turbidity)
Adequate Hydration
Time=Increased Clarity

• A challenge of incorporating WPI into clear beverages is that heating often causes cloudiness of the beverage.
• A simple and inexpensive way to increase clarity is to allow adequate hydration time of the WPI in solution before heat treatment.
• Turbidity less than about 40 NTU is considered clear to the consumer.
Maximizing Heat Stability and Clarity

• Procedure
  – Blend dry ingredients
  – Mix with water
  – Allow mixture to hydrate 20-30 minutes
  – Heat solution to 88°C for up to 2 minutes, fill bottle and cool.

• Benefit
  – By using an adequate hydration time, turbidity of the solution after heat treatment is reduced by about 50%.
# WPI Turbidity Over Time

Solution of 25 g/L protein, pH 3.2.
Heat treatment of 190°F for 2 minutes.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Before Heating NTU†</th>
<th>After Heating NTU</th>
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<tbody>
<tr>
<td>0</td>
<td>55</td>
<td>79</td>
</tr>
<tr>
<td>10</td>
<td>52</td>
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<td>20</td>
<td>49</td>
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<td>40</td>
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<td>50</td>
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<td>60</td>
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<td>70</td>
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<td>80</td>
<td>46</td>
<td>37</td>
</tr>
<tr>
<td>130</td>
<td>46</td>
<td>38</td>
</tr>
</tbody>
</table>

†NTU = Nephelos Turbidity Units
Data courtesy of UW-Madison, Dr. Mark Etzel and Caitlin LaClair
Hydration of WPC/WPI

- Use high speed mixer like a tri-blender or liquifier to get whey protein into solution
- Use water that is less than 60°C to avoid any potential denaturation of whey proteins
- Once in solution do not agitate at high speed for 30 minutes, use slow agitation or intermittent agitation-foaming can be a big issue (use of anti-foaming agents)
- Can add other ingredients in with the whey protein during hydration time (except for pH adjusting ingredients)
Hydration of MPC/MPI

- Hydration is much slower than whey protein ingredients
- High shear mixer still important to disperse the powder and dissolve the lumps
- Allow >4 hrs of hydration time at cold temperatures (1-2 hrs at 50C)
- Inadequate hydration will lead to loss of heat stability and ultimately loss of solubility
- Chalky mouthfeel is often a sign of inadequate hydration
Solubility
(10% solutions)

Whey Protein Isolate

Milk Protein Isolate

pH 6.2  pH 4.6  pH 3.0

pH 7.0  pH 4.6  pH 3.0
Protein Net Charge vs pH

Polypeptide Charge Calculation For beta-lactoglobulin

Dr. Allen Foegeding, NCSU
pH Categories

• pH 2.8-3.4
  – Isotonics, sports drinks, clear juice drinks, flavored waters

• pH 3.5-4.5
  – Yogurt drinks/smoothies-Cloudy, creamy appearance

• pH 6.8-7.0
  – Shakes, meal replacements-cloudy, viscous
pH 2.8-3.5

- High acid, mostly hot/ambient fill or UHT
- Definitely use whey proteins
- More fat or denatured whey protein will increase cloudiness
- Best clarity with WPI in this pH range
- As pH decreases, astringency increases.
- Maximum 7% protein at pH 3.0 under hot fill conditions
- If maximizing amounts of protein-need for some hydrolyzed whey proteins to avoid gelling
Typical Processing Steps for pH 2.8-3.5

- Mix whey protein in water at ambient temperature (25°C) with a high speed mixer.
- Add other ingredients such as sweeteners, colors, and flavors and allow mix to hydrate 30 minutes with slow agitation.
- Add pH adjusting ingredients such as acids to desired pH.
- Heat to 82°C for 2 minutes and cool to 25°C.
pH 3.5-4.5

- High acid, mostly hot fill or UHT
- Whey proteins will work but will need some protection and added processing steps.
- Smoothies usually in this pH range-some contain yogurt as an ingredient
- At higher levels of protein (4%+) will need the help of stabilizers (ie. high methoxy pectin) plus homogenization, possibly buffers
- Stabilizer choice depends on level of protein, pH, heating conditions, and desired viscosity
Typical Processing Steps for pH 3.5-4.5

• Mix whey protein in water at ambient temperature (25°C) with a high speed mixer.
• Add other ingredients such as sweeteners, colors, and flavors and allow mix to hydrate 30 minutes with slow agitation.
• Hydrate high methoxy pectin in 85°C water until solution is clear and add to rest of mix.
• Add pH adjusting ingredients such as acids to desired pH.
• Homogenize mix at 3500 psi/700 psi.
• Heat to 82°C for 2 minutes and cool to 25°C.
Acid Choice

- Phosphoric acid most common acid and has lowest level of sourness/astingingency at pH 3.0, works best for whey protein drinks
- Citric acid has a bright refreshing sourness that dissipates quickly
- Malic acid—more lingering sourness than citric, works well with artificial sweeteners, enhances fruit flavors
- Tartaric and fumaric acid—more astringent
- Lactic acid—enhances dairy flavors
Flavor Choice

- In our work at CDR the tropical fruits have worked the best with whey protein ingredients.
- Examples are mango, pineapple, lychee, coconut, banana, orange, grapefruit, tangerine, etc.
- Peach, apple, and cranberry also work well.
- The berry flavors have more difficulty masking the whey flavors and aromas.
- It is not unusual to use higher levels of flavors as protein will bind flavors over time.
Other Ingredients

- There are no interactions of concern with nutritive or non-nutritive sweeteners with whey proteins.
- Use sweeteners to balance the astringency of whey proteins at low pH.
- The addition of soluble fiber complements whey protein by reducing the astringency of low pH drinks.
- The addition of fats will also help reduce astringency at low pH, ie using a WPC80 which contains fat will have less astringency than a drink made with WPI.
pH 6.5-7.0

- Low acid, UHT or Retort
- Often a combination of milk proteins and whey proteins are used.
- More difficult to reach 2 g protein/oz, hydrolyzed whey proteins can help here too.
- Stabilizer choice depending on types of proteins and level, homogenization needed for higher levels of protein.
- Buffers definitely needed for UHT and retort conditions.
Typical Stabilizers in Neutral pH Dairy Protein Drinks

- κ-carrageenan-use especially if casein present to aid in protein stability
- Gellan gum-provides gel network to help suspend protein in solution, used more if casein not present
- Cellulose gum-adds viscosity/mouthfeel
# Properties of Emulsifying Salts/Buffers

<table>
<thead>
<tr>
<th>Type</th>
<th>Buffering Capacity</th>
<th>Calcium Binding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrate</td>
<td>Very good</td>
<td>Poor</td>
</tr>
<tr>
<td>Monophosphate</td>
<td>Excellent</td>
<td>Poor</td>
</tr>
<tr>
<td>Diphosphate</td>
<td>Very good</td>
<td>Good</td>
</tr>
<tr>
<td>Triphosphate</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Polyphosphate</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
Processing Steps for Neutral pH Beverages

- Mix whey protein in water at ambient temperature (25°C) with a high speed mixer.
- Add other ingredients such as sweeteners, colors, stabilizers and flavors and allow mix to hydrate 30 minutes with slow agitation.
- Add pH adjusting ingredients such as buffers to reach pH 7.0.
- Heat to 137°C for 6 seconds
- Homogenize at 2500 psi/700 psi
- Cool product to 25°C
pH 2.8-3.5 Drinks

- **40g protein/600 ml**
- **9 g protein/300 ml**
- **12 g protein/240 ml**
- **12 g protein/355 ml**
- **20 g protein/500 ml**

- Cherry juice and whey protein
pH 3.5-4.5 Drinks

- mix 1 peach
  - 15 g protein/325 ml
- Bolthouse Farms Mango Protein Plus
  - 16 g protein/240 ml
- BeneVia
  - 8 g protein/300 ml
- G Series Fit
  - 12 g hydrolyzed whey protein/325 ml
- Only non-juice drink

16 g hydrolyzed whey protein/475 ml
Neutral pH Drinks

- **SideKicks**: Vanilla Shake, 7 g protein/240 ml
- **Muscle Milk Light**: Chocolate, 30 g protein/500 ml
- **SlimFast**: Creamy Chocolate, 20 g protein/300 ml
- **Rockin’ Refuel**: Chocolate, 20 g protein/300 ml
- **Bolthouse Farms Protein Plus**: Chocolate, 16 g protein/240 ml
- **Shamrock Farms**: 20 g protein/355 ml
International Beverages

South Korea

Thailand-whey protein enhanced milk
25 g protein
Thank You

- Dairy Australia
- WI Milk Marketing Board
- National Dairy Council