A Dairy Australia/ National Centre for Dairy Education webinar

Developing Beverages with Dairy Proteins

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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

Composition	SMP	MPC56	MPC70	MPC80	MPI
Fat	0.8	1.2	1.2	1.5	1.5
Moisture	5.0	5.0	5.0	5.0	5.0
Protein	35.0	54.4	68.3	78.1	87.1
Lactose	51.0	31.7	18.2	8.4	0.5
Ash	8.2	7.6	7.3	7.0	5.9

Whey Protein Ingredients

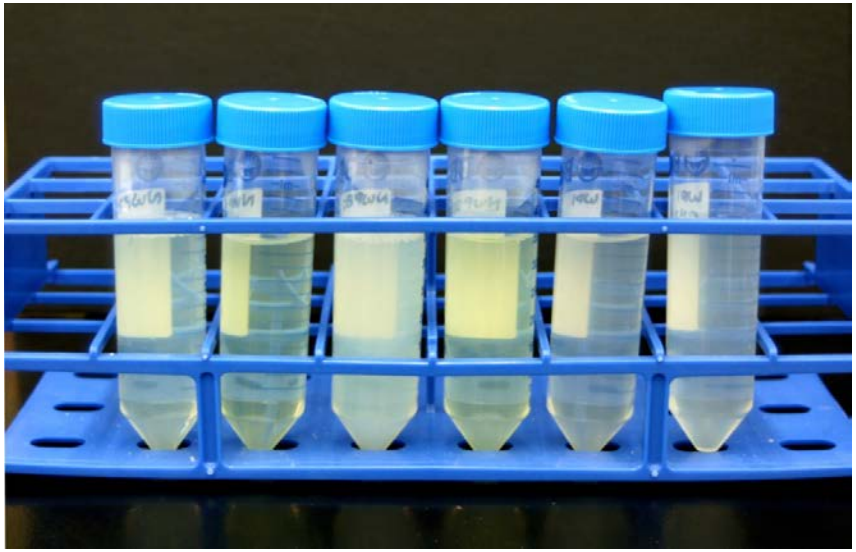
Composition (%)	WPC34	WPC80	WPI	*WPPC
Fat	3.0	5.0	1.0	10-20
Moisture	4.0	4.0	4.0	3-4
Protein	35.0	80.0	90.0	63-73
Ash	6.0	4.0	2.0	2.5-4.0
Lactose	51.0	4.0	1.0	5-11

*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



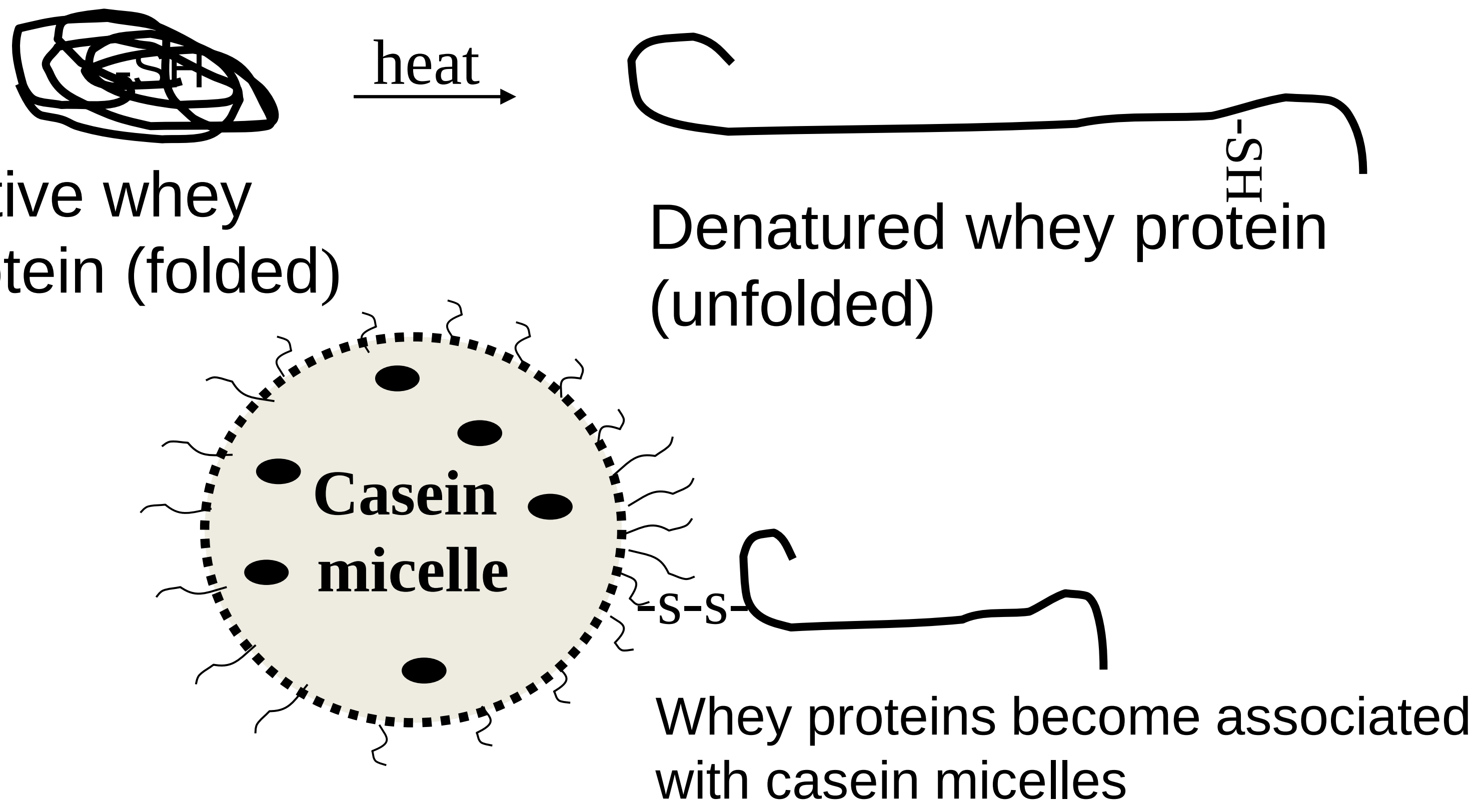
- Emulsification
- Whipping/foaming
- High solubility
- Gelation
- Viscosity and water binding
- Browning

Functional Properties of Milk Proteins

Caseins	Whey Proteins
Fat emulsification	Gelation
Foaming	Foaming
Soluble at pH >6	Soluble at any pH
Water binding	Heat sensitive
Precipitation by Ca^{++}	
Precipitation by chymosin	
Heat stable	

Early. 1992. The Technology of Dairy Products

Heat-Induced Changes in Milk Proteins



Disulfide bond -S-S-

Free sulphydryl group -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.

Time (min)	Before Heating NTU†	After Heating NTU
0	55	79
10	52	39
20	49	38
30	49	37
40	47	39
50	47	38
60	47	37
70	47	39
80	46	37
130	46	38

†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)

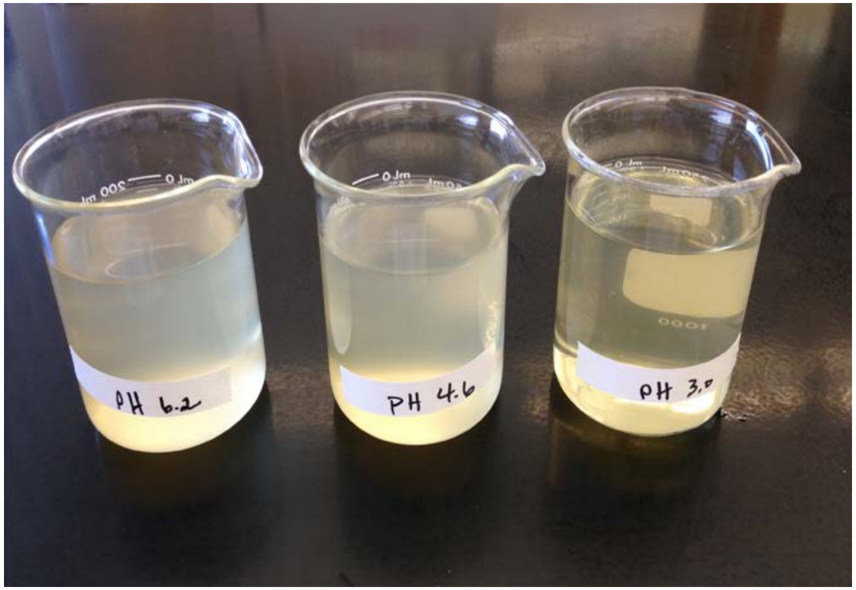
Hydration of MPC/MPI

- 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

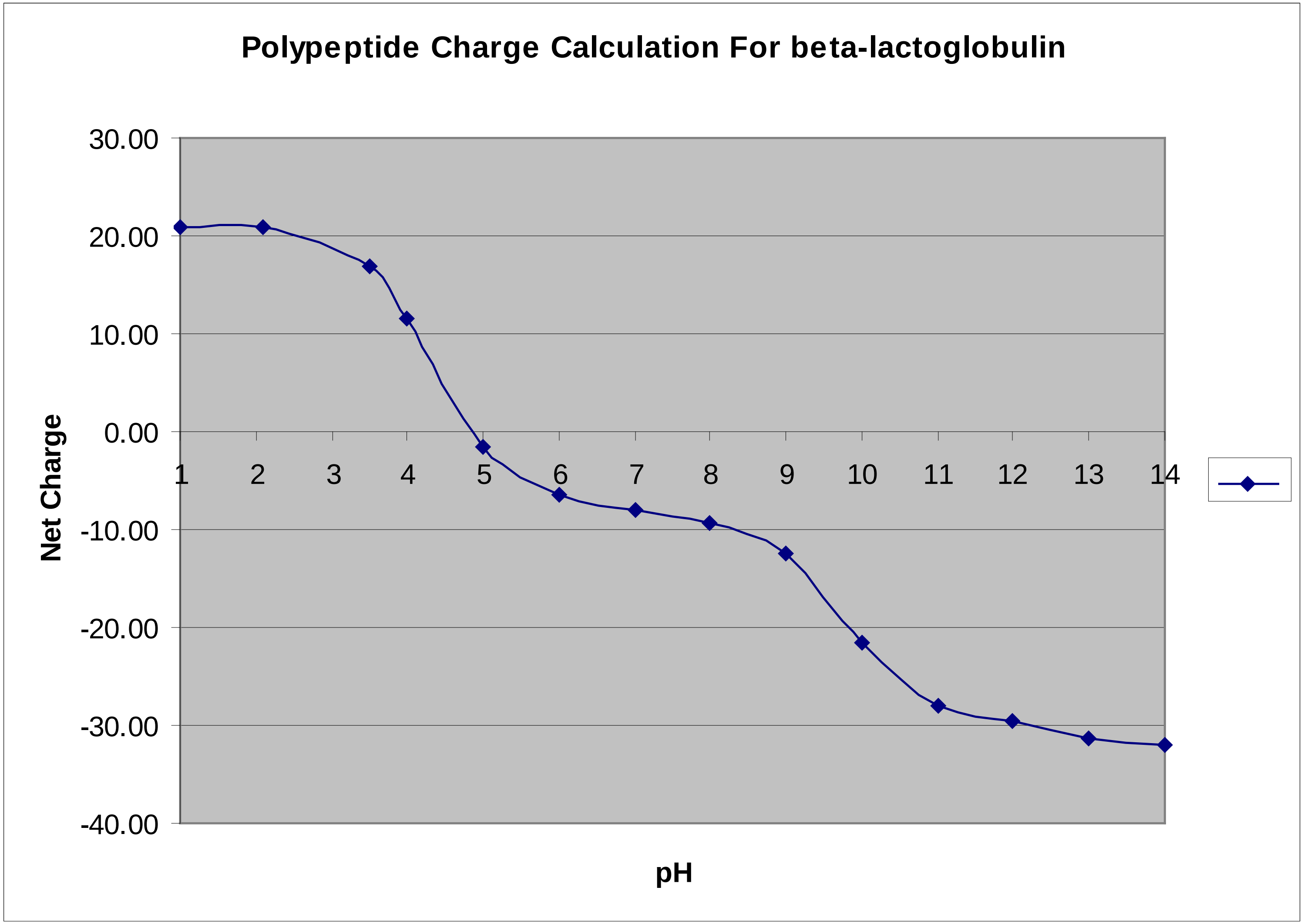


Milk Protein Isolate

pH 6.2 pH 4.6 pH 3.0

pH 7.0 pH 4.6 pH 3.0

Protein Net Charge vs pH



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/astingency 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

Type	Buffering Capacity	Calcium Binding
Citrate	Very good	Poor
Monophosphate	Excellent	Poor
Diphosphate	Very good	Good
Triphosphate	Good	Very good
Polyphosphate	Poor	Excellent

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 137C for 6 seconds
- Homogenize at 2500 psi/700 psi
- Cool product to 25C

pH 2.8-3.5 Drinks

40g protein/600 ml

9 g protein/300 ml

20 g protein/500 ml

12 g protein/355 ml

Cherry juice and
whey protein

12 g protein/240 ml

pH 3.5-4.5 Drinks

16 g protein/240 ml

8 g protein/300 ml

15 g protein/325 ml

12 g hydrolyzed
whey protein/ 325 ml

16 g hydrolyzed whey protein/475 ml
Only non-juice drink

Neutral pH Drinks

7 g protein/240 ml

30 g protein/500 ml

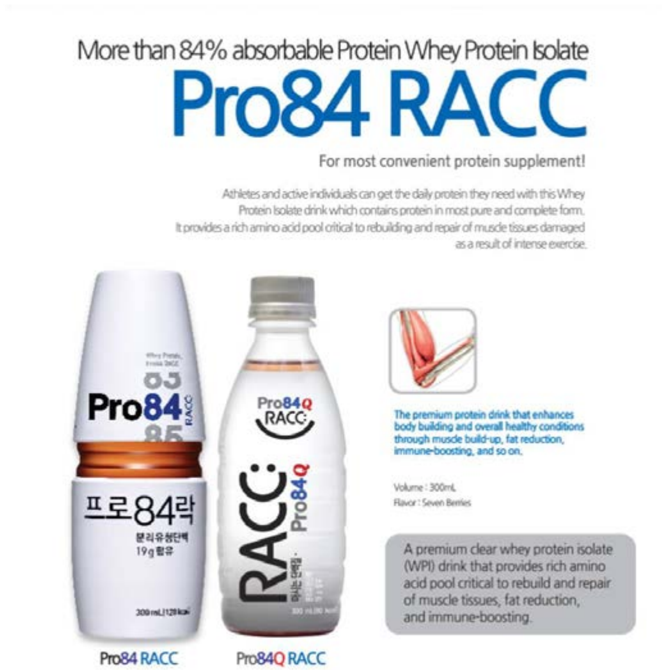
20 g protein/300 ml

20g protein/355 ml

10 g protein/300 ml

16g protein/240 ml

International Beverages



South Korea

Thailand-whey protein enhanced milk
25 g protein

Thank You

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