The Halo Effect: Dairy Ingredient Selection for Formulating High Protein Ice Cream

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UW-Madison, Wisconsin Center for Dairy Research

Center for Dairy Research *"Solution Based Research Backed by Experience, Passion and Tradition"*

Agenda

- Dairy Ingredient Composition
- Dairy Ingredient Functionality
- Optimizing Performance of Dairy Proteins
- Applications and Research

Milk and Whey Protein Ingredients

- Fluid Milk
- Ultra-filtered Milk
- Whole Milk Powder (WMP)
- Buttermilk Powder (BP)
- Nonfat Dry Milk (NFDM)
- Milk Protein Concentrate (MPC)
- Micellar Casein (MCC)

- Whey Protein Concentrate (WPC)
- Whey Protein Isolates (WPI)
- Milk-Derived Whey (Native Whey)
- Hydrolyzed Whey Proteins (WPH)

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

Whey Protein Phospholipid Concentrate (WPPC)

- Co-products of whey protein isolate
- No standard of identity

American Dairy Products Institute Standard

Component	%
Protein (dry basis)	Min 50
Fat	Min 12
Ash	Max 8
Total moisture	Max 6

UF Milk Composition

(Commercial Specs)

Component	UF 65	UF 85
Protein	11.20	13.57
Fat	0.20	0.24
Lactose	4.70	0.84
Ash	0.75	1.14
Moisture	83.15	84.21
Total	100.00	100.00

Milk Protein Ingredients

Product	Protein %	Fat %	Lactose %	Ash %	Moisture %
MPC 40	39.5 min	1.25 max	52.0 max	10.0 max	5.0 max
MPC 42	41.5 min	1.25 max	51.0 max	10.0 max	5.0 max
MPC 56	55.5 min	1.50 max	36.0 max	10.0 max	5.0 max
MPC 70	69.5 min	2.50 max	20.0 max	10.0 max	6.0 max
MPC 80	79.5 min	2.50 max	9.0 max	8.0 max	6.0 max
MPC 85	85.0 min*	2.50 max	8.0 max	8.0 max	6.0 max
MPI	89.5 min*	2.50 max	5.0 max	8.0 max	6.0 max

ADPI, 2016

(*) Protein content ≥ 85.0% is reported on a dry basis, all other parameters are reported “as is”

Micellar Casein Standard

Product	Protein %	Fat %	Lactose %	Ash %	Moisture %
42	41.5 min	1.25 max	51.0 max	6.0 max	5.0 max
70	69.5 min	2.50 max	16.0 max	8.0 max	6.0 max
80	79.5 min	3.00 max	10.0 max	8.0 max	6.0 max
85	85.0 min*	3.00 max	3.0 max	8.0 max	6.0 max
90	89.5 min*	3.00 max	1.0 max	8.0 max	7.0 max

ADPI, 2016

(*) Protein content over ≥ 85.0% is reported on a dry basis, all other parameters are reported "as is"

Milk Whey Protein Standard

Product definition: Obtained from bovine milk or skim milk by the removal of casein and non-protein constituents from milk so the finished dry product contains not less than 25% protein. It is obtained by microfiltration and/or chromatography of milk or skim milk and may be preceded by or followed by utrafiltration, nanofiltration….

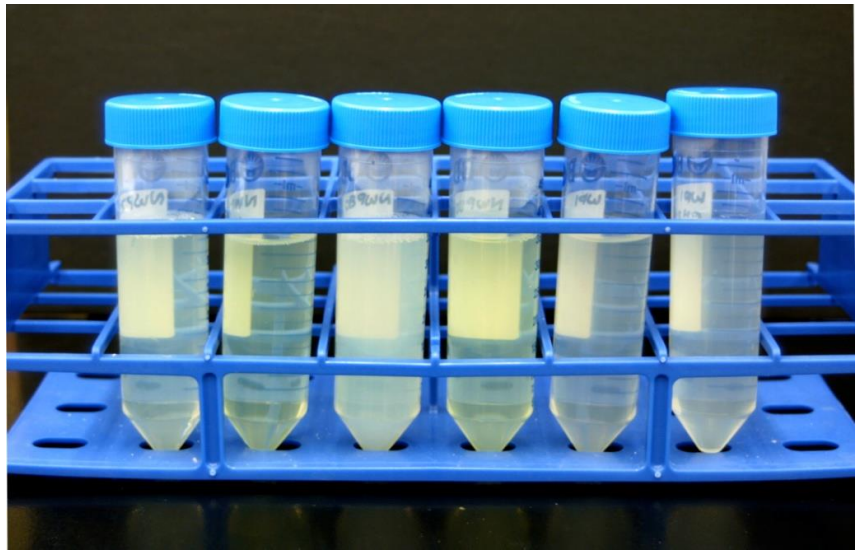
Product	Protein (%)	Fat (%)	Lactose (%)	Ash (%)	Moisture (%)
mWPC 34	33.5 min	2.0 max	55.0 max	7.5 max	6.0 max
mWPC 80	79.5* min	2.0 max	13.0 max	5.0 max	6.0 max
mWPC 90	89.5 min	1.5 max	4.0 max	4.5 max	6.0 max

ADPI, 2017

*Protein content $\geq$ 79.5% is reported on a dry basis, all other parameters are reported “as is”

Names: milk whey protein, native whey protein, milk derived whey protein, milk soluble protein

Functional Properties



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

Characteristics of Caseins and Whey Proteins

Caseins	Whey Proteins
Random Coil	Ordered structures
Reasonable essential AA content	Good source of essential AA
Poor in sulfur AA	High in sulfur AA
Present as colloidal suspension	Soluble, globular
Very stable to heat (even boiling)	Readily denatured
Non-crystalline	Crystalline

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	

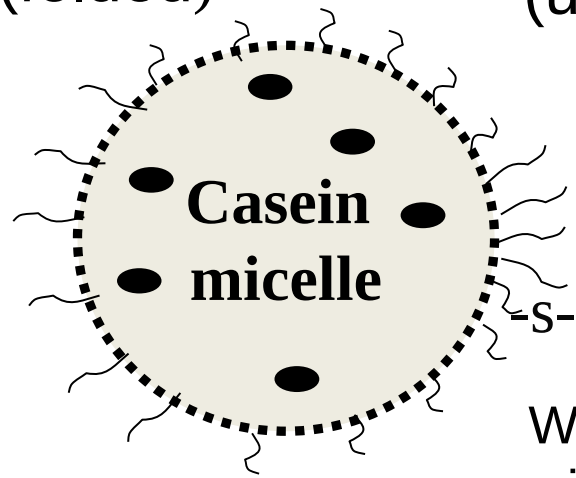
Early. 1992. The Technology of Dairy Products

Heat-Induced Changes in Milk Proteins

heat

Native whey
Protein (folded)

Denatured whey protein
(unfolded)



Whey proteins become associated
with casein micelles

Disulfide bond -s-s-

Free sulphydryl group -SH

Colloidal calcium phosphate (CCP)

J. Lucey

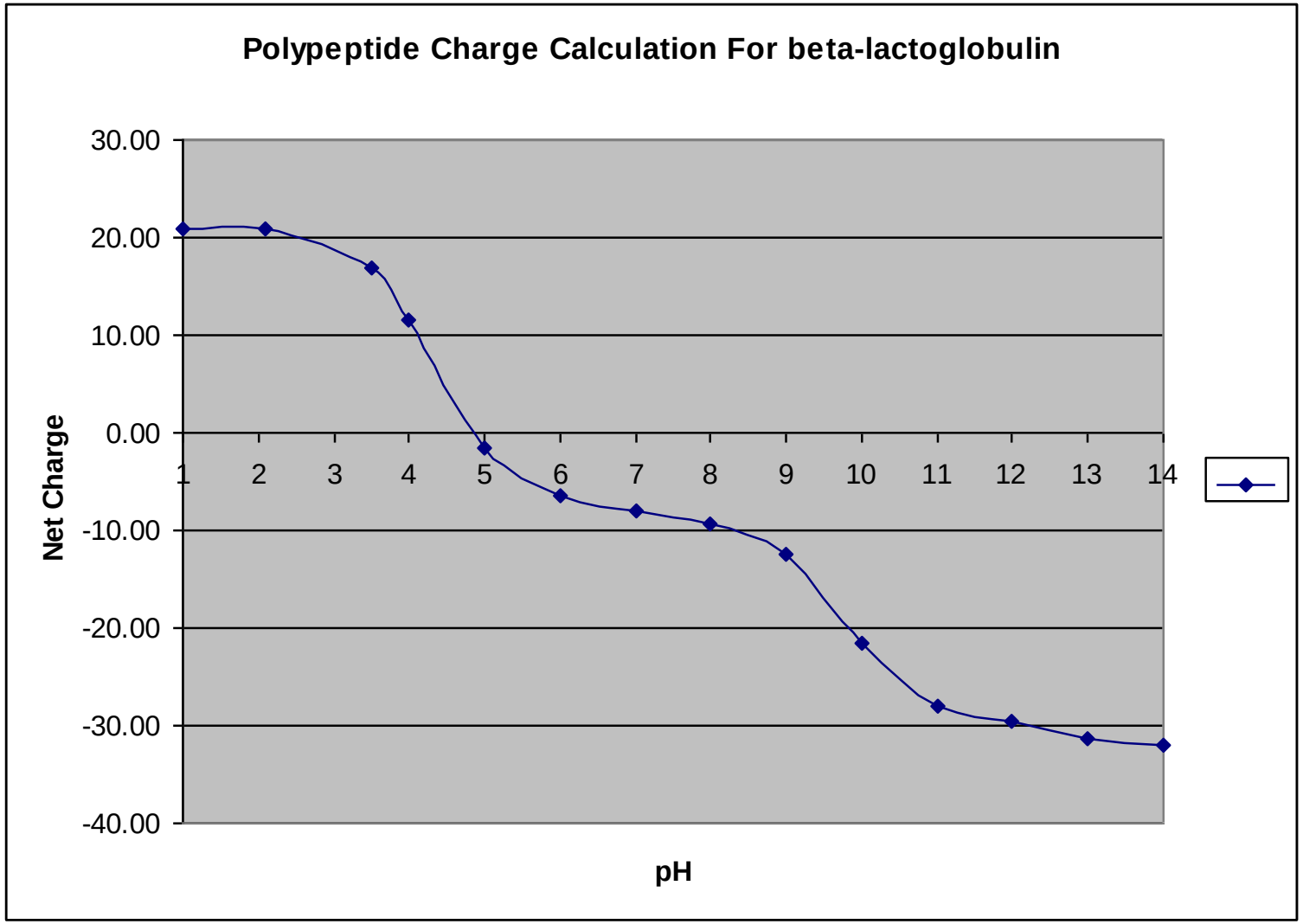
Testing Hydration Using WPI Turbidity Over Time

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

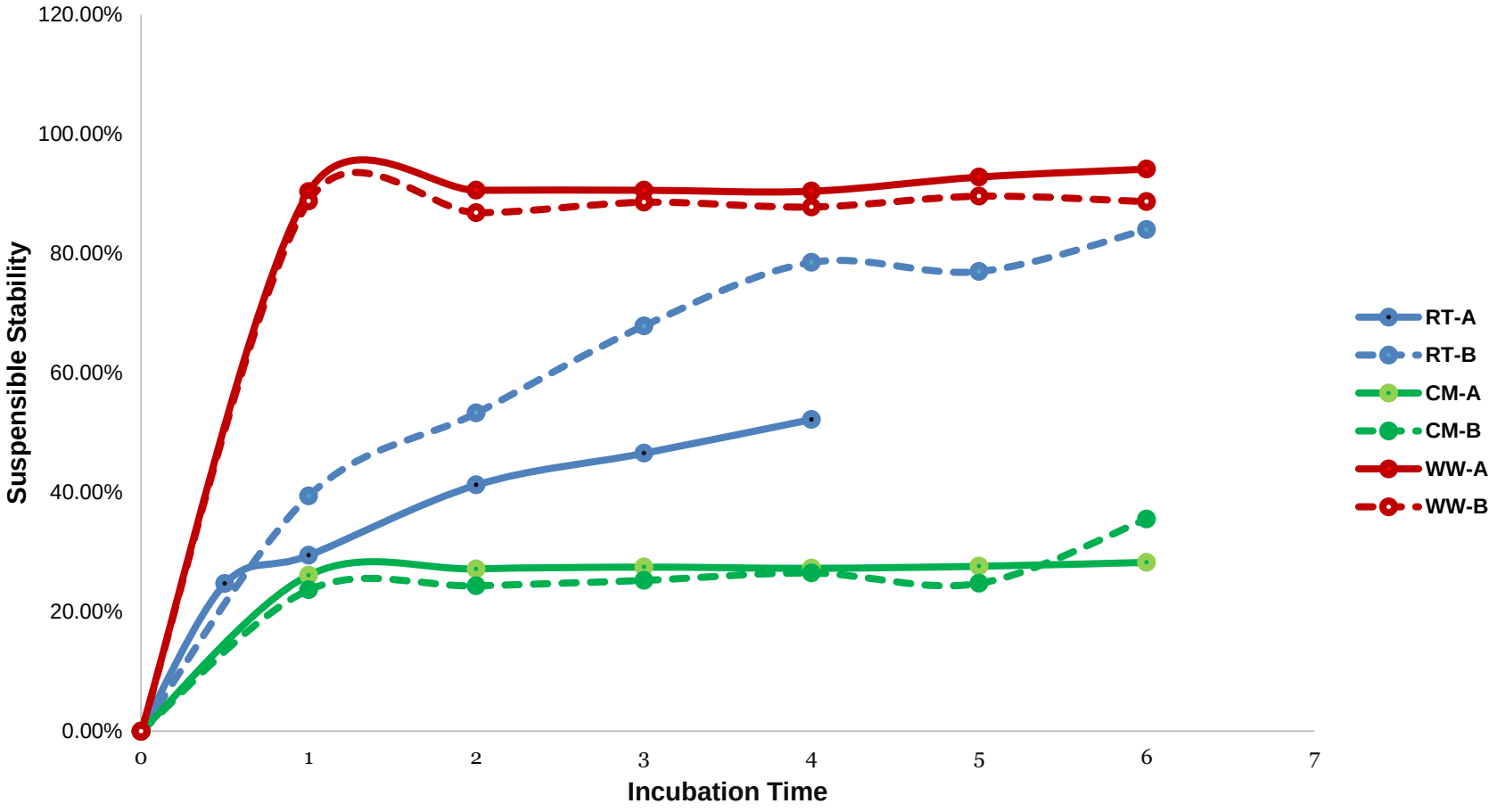
†NTU = Nephelos Turbidity Units
Data courtesy of UW-Madison, Dr. Mark Etzel and Caitlin LaClair

Whey Protein Net Charge vs pH



Dr. Allen Foegeding, NCSU

Hydration Profile of two MPC85



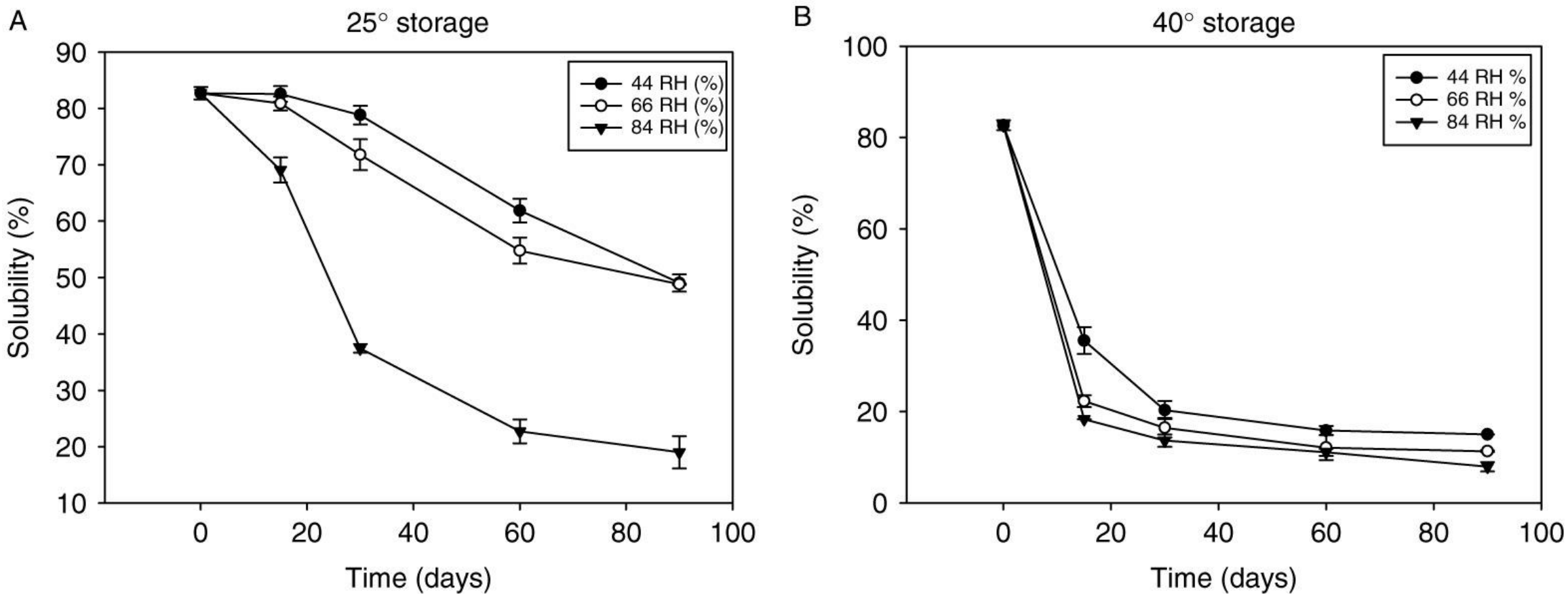
RT – Room temperature water (21C)
CM – Cold milk (4C)
WW – Warm water (50C)

MPC Hydration Test

- 10ml solution – 10min centrifugation at 700 × g
- Supernatant – overnight in 100C oven
- $\% \, Suspension \, Stability \, = \frac{Solid \, content \, in \, supernatant}{Solid \, content \, in \, solution} \times 100\%$

Sikand et al. (2011)

Storage Induced Changes to MPC80

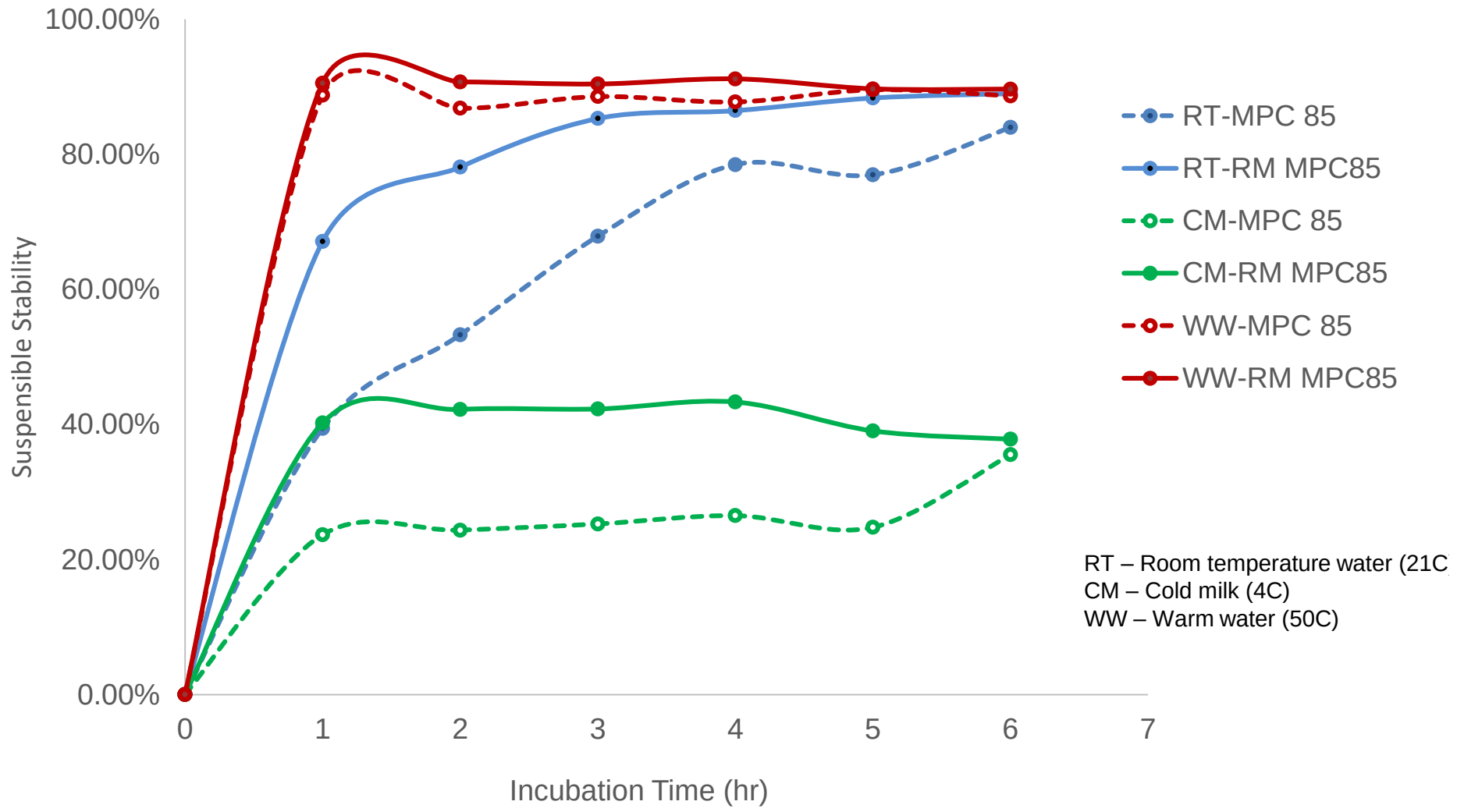


Fyfe et al, 2010
https://onlinelibrary.wiley.com/doi/epdf/10.1002/jsfa.4461

Ways to Optimize Dairy Protein Performance

- Make sure dairy protein ingredients are well dissolved and hydrated under conditions to insure optimum functionality
- Utilize dairy protein ingredients with improved solubility and heat stability-modify their typical functionality, ie heat stable whey protein ingredients or hydrolyzed whey proteins
- For MPC ingredients, reducing the calcium content can provide faster hydration and improved heat stability

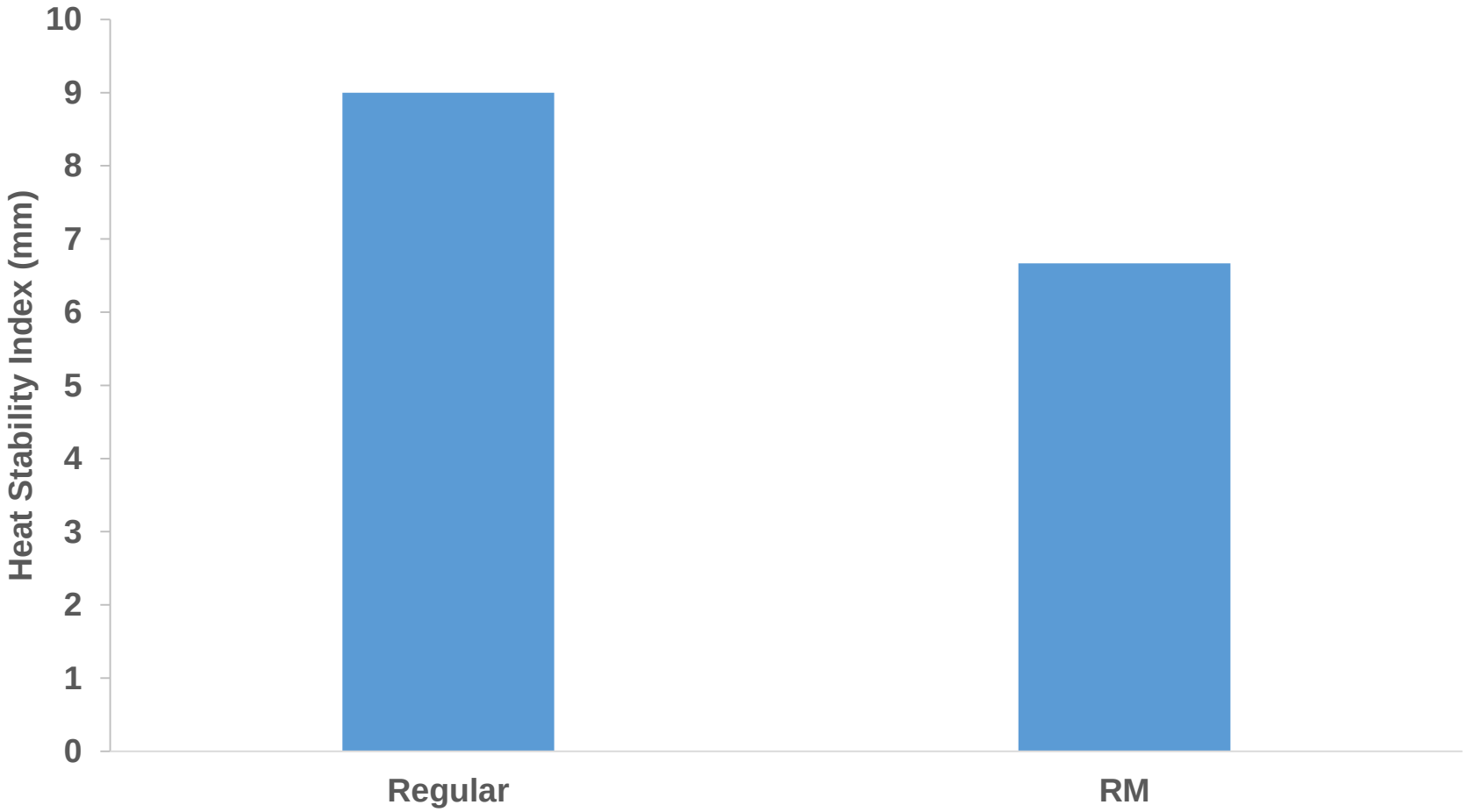
Regular vs Reduced Mineral MPC85



RT – Room temperature water (21C
CM – Cold milk (4C)
WW – Warm water (50C)

Heat Stability of MPC85

Regular and Reduced Mineral (25% reduced)



5% protein solutions at 85C for 15 minutes

Tips for Using Dairy Proteins

- Hydration of Dairy Protein Ingredients Prior to Mix Pasteurization is Key
  - Should mix in WPC with a high speed mixer and allow 30 minutes of hydration time with slow agitation to provide protection during heating process (temp of water or milk <60C (140F)
  - Mix in MPC with a high speed mixer and hydrate for at least 12 hours in cold temperatures or 1 hour at 50C (122F) for MPC80 and higher
  - Inadequate hydration will lead to loss of heat stability and ultimately loss of solubility
  - Chalky mouthfeel and possible shrinkage during frozen storage is often a sign of inadequate hydration of MPC

Tips for High Protein Ice Creams

- MPC/MPI/Micellar casein will provide the best heat stability at high concentrations
  - They also have very high water binding ability and can thicken a mix too much
  - Hydration of MPC/MPI/Micellar casein ingredients is critical
- Remember that whey protein is not very heat stable
  - It is always better to have more casein than whey protein
- Keep your eye on the freezing point
  - Hardness and no melt defect are common

Using Whey Protein

5% protein

12.3% protein

Using MPC or MPI

6.3% protein

7.8% protein

8.6% protein

9.2% protein

Product Using UF Milk

7.5% protein

Research and Application Work

- Use of WPC80 or WPPC in ice cream
- Use of whey permeate in soft serve
- Use of WPPC and DLP (delactose permeate) in ice cream
- Use of UF milk in ice cream

Research

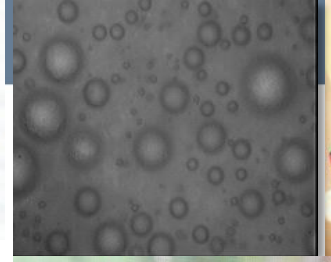
- Bund RK, Hartel, RW. Blends of delactosed permeate and pro-cream in ice cream: effects on physical, textural and sensory properties. Int Dairy J. 2013;31(2):132-138.
- Levin, M, Burrington, K., Hartel, R. Whey protein phospholipid concentrate and delactosed permeate composition and functionality. 2016. J Dairy Sci. JDS-16-10974.R2.
- Levin, M. Burrington, K. Hartel, R. Whey protein phospholipid concentrate and delactosed permeate: Applications in caramel, ice cream, and cake. 2016. J. Dairy Sci. JDS-16-10975.R1.

Dairy Protein Ingredients in Frozen Dessert Research

- **Physical Properties of Ice Cream Containing Milk Protein Concentrates V. B. Alvarez, C. L. Wolters, Y. Vodovotz, and T. Ji, 2005, J. Dairy Sci 88:862-871**
  - 20 and 50% substitution of the protein in the mix using MPC6 and 85- formulations had higher mix viscosity, larger amount of fat destabilization, narrower ice melting curves, and greater shape retention compared with the control.
- **Increasing the Protein Content of Ice Cream, M. R. Patel, R. J. Baer, and M. R. Acharya, 2006, J. Dairy Sci. 89:1400–1406**
  - Control- 3.78% protein. Treatments 2 and 5 -4.9% protein, Treatments 3 and 6-protein 6.05% protein, and Treatments 4 and 7 -7.18% by addition of whey protein concentrate or milk protein concentrate. In all treatments, levels of milk fat, milk SNF, beet sugar, and corn syrup solids were kept constant at 37% total solids. T2-4 WPC80, T5-7 MPC70
  - Mixed in MPC or WPC in fluid ingredients at 44C and mixed for 10-15 minutes.
  - With increased protein, the ice crystal size was favorably reduced in treatments 2, 4, and 5 and was similar in treatments 3, 6, and 7 compared with treatment 1.
  - T7-7.18% protein using MPC70 showed shrinkage

More Research

- **Fat destabilization and melt-down of ice creams with increased protein content, E. Daw, R.W. Hartel, 2015, Int. Dairy J. 43:33-41.**
  - Ice creams were formulated with NFDM, MPC, WPI, and WPPC to contain 4, 6, 8 and 10% protein content.
  - Viscosity and shear thinning increased with increasing protein content
  - Extent of partially coalesced fat decreased and melt rate increased as protein content increased.
  - Whey proteins (from WPPC or WPI) were most effective at reducing partial coalescence
  - Melt rate was inversely proportional to the extent of fat destabilization


UW FOOD SCIENCE CLUB
BUCKY PUCK
ICE CREAM SANDWICH





Babcock Hall
Chocolate Turtle
Super Premium
Ice Cream




STRACEMAN


FDC
FROZEN
DESSERT CENTER
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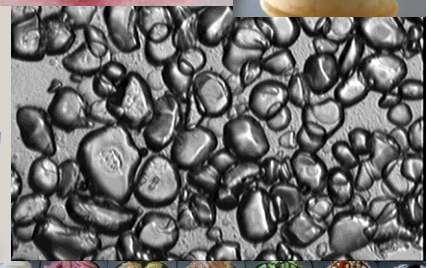




Babcock Hall
W
Dairy Store


Our Mission

The mission of the Frozen Dessert Center is to:

Advance and communicate the science of frozen desserts.

We accomplish this mission through a coherent program that includes:

- **Research** – use basic and applied means to understand the scientific underpinnings of frozen desserts.
- **Product Development** – support the needs of individuals and organizations seeking to improve the performance of frozen desserts.
- **Education** – transfer accurate and timely information regarding frozen desserts.

About Us

- Founded in fall of 2012
- Combines the frozen dessert expertise and resources housed within the University of Wisconsin – Madison Food Science Department.
  - **Advisory Staff:**
    - Dr. Richard Hartel – Microstructure analysis
    - Dr. Scott Rankin - Sensory, flavor, batch production
    - Bill Klein – Dairy Plant – large scale production

- We are designed to assist variety of industries with various services:
  - **Development** - Work with companies to design trials
  - **Trials** - Small and large-scale mix and frozen product trials
  - **Reports/Data** - Microstructure and sensory analyses and reports
  - **Overall** – Helping companies carryout projects from ideas to actual legal products

- The Center also provides learning platforms for undergraduate and graduate students at the University of Wisconsin - Madison.

Services

- **Ingredients & Flavors** – Analyzing new ingredients and flavors in frozen desserts, sensory, microstructure analyses, stability testing, and quality control
- **Mix and frozen dessert production** – small and large scale test runs on new ingredients or processing conditions
- **Equipment** – Testing the use of equipment or process for frozen dessert manufacturing
- **Shipping** – Ship products overnight to a specified location

Available Equipment

- Analytical
  - Melt-down test, Ice and air cell size and distribution, microscopy imaging, stability testing
- Freezers
  - Batch
  - Continuous - small and large scale
- Pasteurizers & homogenizers
  - Batch (LTST) and Large (HTST)
- Dairy plant scale-up equipment
- Sensory software

Future of the FDC

- Industry Advising Group
- Annual Conference
  - October 22-23, 2018
  - New global trends
  - Non-dairy desserts
  - Ice cream freezing and storage

Contact Information

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CDR Turbo Technology

- Development of a High Protein Ice Cream
  - Concentrated High Protein Milk approach
  - Up to 10% protein
  - Avoids hydration issues such as chalkiness and shrinkage
  - Clean label
- Applications
  - Sports nutrition
  - Weight management
  - Healthy ageing
  - Medical foods

A comprehensive **business accelerator** focused on increasing the speed of new **product commercialization** in dairy related industries

Eligibility – any U.S. based business or entrepreneur

Additional Network State and National Resources

- UW-Extension marketing data
- WI Tech. Council
- WI Dept. of Workforce Development
- WI Housing & Economic Development (WHEDA)

To Learn How TURBO can Help Your Company

Please contact:

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or

Check out: www.turbo.cdr.wisc.edu

Thank You

- IDFA
- WI Milk Marketing Board
- National Dairy Council/Dairy Management, Inc.