Challenges and Opportunities with Making Cheese Using UF Milk

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NYS Cheese Manufacturers' Association Meeting

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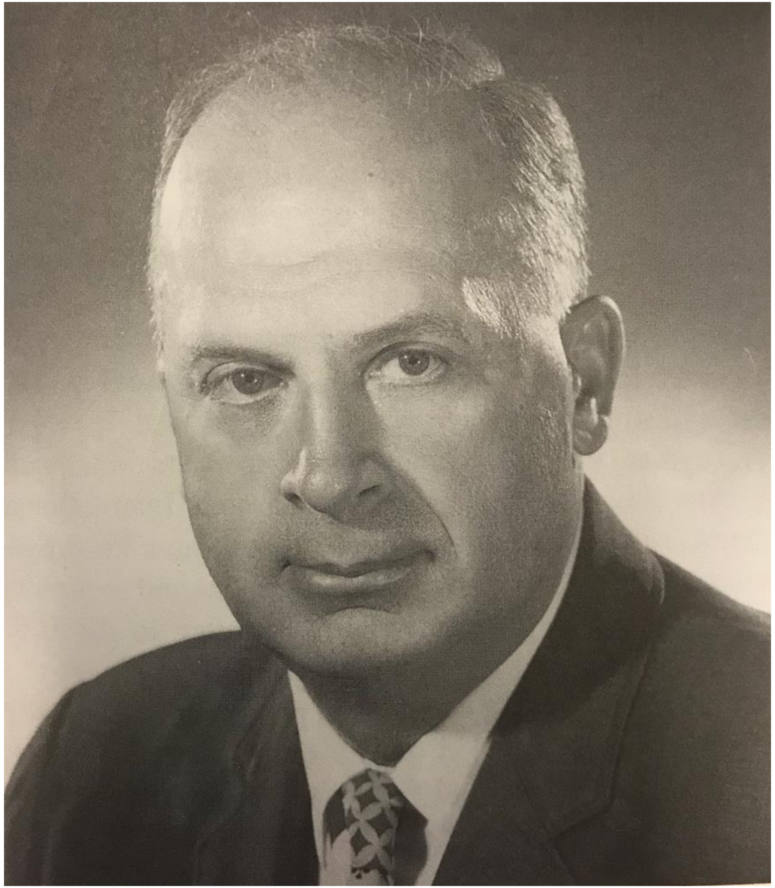
Dedication

Frank Vincent Kosikowski



Outline

- History: UF for Cheese Making
- Basics of Milk Filtration Processes
  - Milk Filtration Processes: Different Types
  - Definition of Common Filtration Terms
- Ultra Filtration of Milk Prior to Cheese Making
  - Challenges
  - Opportunities
- Future

History of UF for Cheese Making

OUR INDUSTRY TODAY

Cheesemaking by Ultrafiltration

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Cornell University, Ithaca, New York 14850

Journal of Dairy Science. April **1974**
Volume 57, Issue 4, Pages 488–491

54 years ago:

I can hear Frank asking (OMG), what took you so long?

History of UF for Cheese Making

Mozzarella and Cheddar Cheese Manufacture by Ultrafiltration Principles

H. R. COVACEVICH and F. V. KOSIKOWSKI
Department of Food Science
Cornell University
Ithaca, New York 14853

Journal of Dairy Science. June **1978** Volume 61, Issue 6, Pages 701–709

History of UF for Cheese Making

Cheddar Cheese from Ultrafiltered Whole Milk Retentates in Industrial Cheese Making

K. S. KEALEY and F. V. KOSIKOWSKI
Department of Food Science
Cornell University
Ithaca, NY 14853

Journal of Dairy Science. December **1985**
Volume 68, Issue 12, Pages 3148–3154

Outline

- Basics of Milk Filtration Processes
  - Definition of Key Terms

Definition Key Terms

- **Membrane Filtration – a process where a solvent (i.e., water) containing solutes or suspended solids (i.e., fat, protein, lactose, minerals) is filtered allowing some materials to pass through the filter and others to be fully or partially retained.**

Definition Key Terms

- **Retentate - the material that does not pass through the filter.**
- **Permeate - the material that passes through the filter.**

Definition Key Terms

- Concentration Factor – the ratio between initial feed and the resulting retentate (can be calculated on either based on mass or volume).
- Feed 100 lbs
- Retentate 50 lbs
- Concentration Factor = (100/50) = 2X

Definition Key Terms

- **Concentration Factor**

Feed	100	100	100
Retentate	50	33.4	25
Permeate	50	66.6	75
CF =	2x	3x	4x

Definition Key Terms

- **Diafiltration – a process that can be done in conjunction with nano-, ultra-, and micro-filtration.**
- **Additional solvent (e.g., water) is added to the feed solution during the filtration process to achieve more complete removal of membrane permeable solutes from the feed stream. For example, to flush lactose out of the retentate to make a lactose reduced milk.**

Definition Key Terms

- Diafiltration
  - Water diafiltration
  - Permeate diafiltration
  - Serial elution diafiltration

Definition Key Terms

- **Membrane Filtration** – examples of membrane filtration are:
  - Reverse osmosis
  - Nanofiltration
  - Ultrafiltration
  - Microfiltration

Milk Filtration Processes

Types of Membrane Filtration

- Reverse Osmosis
- Nanofiltration
- Ultrafiltration
- Microfiltration

- smallest pore size

- largest pore size

Milk Filtration Processes

Types of Membrane Filtration

- Reverse Osmosis - highest pressure
- Nanofiltration
- Ultrafiltration
- Microfiltration - lowest pressure

Milk Filtration Processes

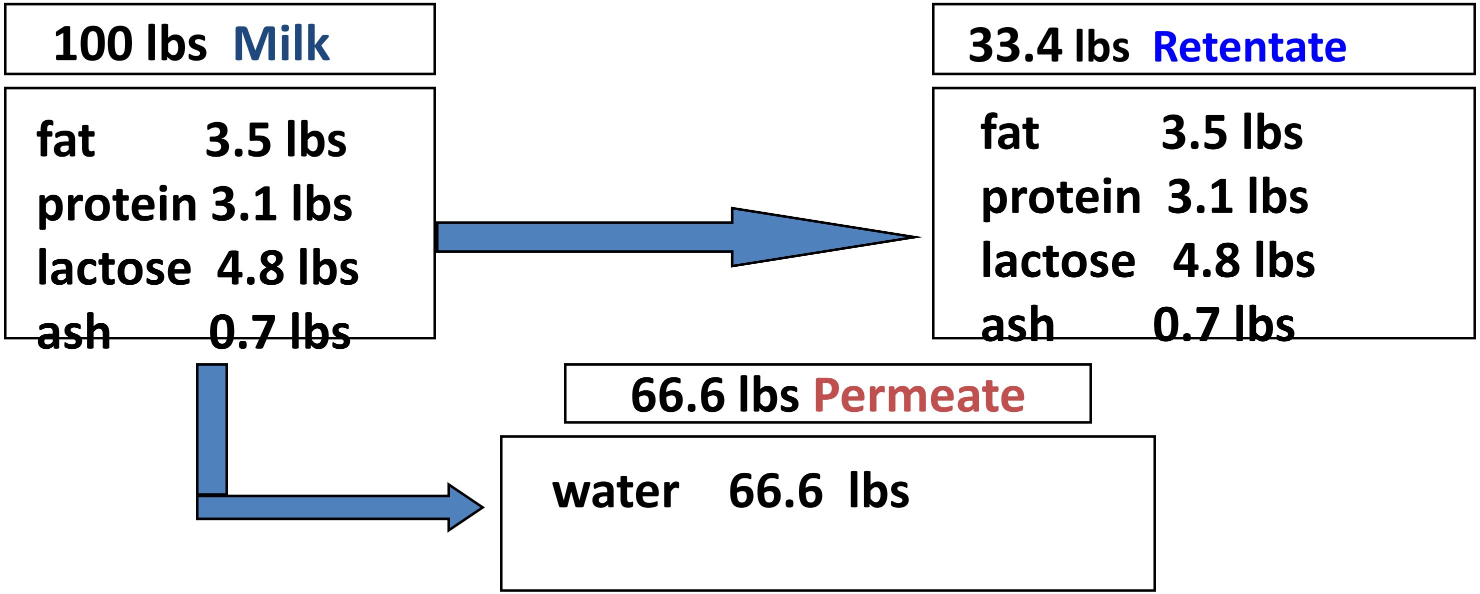
- Concentration Process
  - Reverse Osmosis
- Fractionation Processes
  - Nanofiltration
  - Ultrafiltration
  - Microfiltration

Reverse Osmosis

- Retentate - all milk solids, including salts retained
- Permeate - water
- Application - concentration of whey or milk

Basics of Separation Processes

3X Reverse Osmosis – water removal



Nanofiltration

- <u>Retentate</u> - all fat, protein, and lactose, calcium, part of the water and sodium chloride
- <u>Permeate</u> – water, sodium chloride

- <u>Application</u> - removal of natural milk monovalent salts from UF permeate

Basics of Separation Processes

3X Nanofiltration – remove some sodium chloride

100 lbs UF Permeate

lactose	4.8 lbs
ash	0.7 lbs
Soluble Ca	0.3 lbs
NaCl	0.2 lbs

33.4 lbs Retentate

lactose	4.8 lbs
ash	0.5 lbs
Soluble Ca	0.3 lbs
NaCl	0.075 lbs

66.6 lbs Permeate

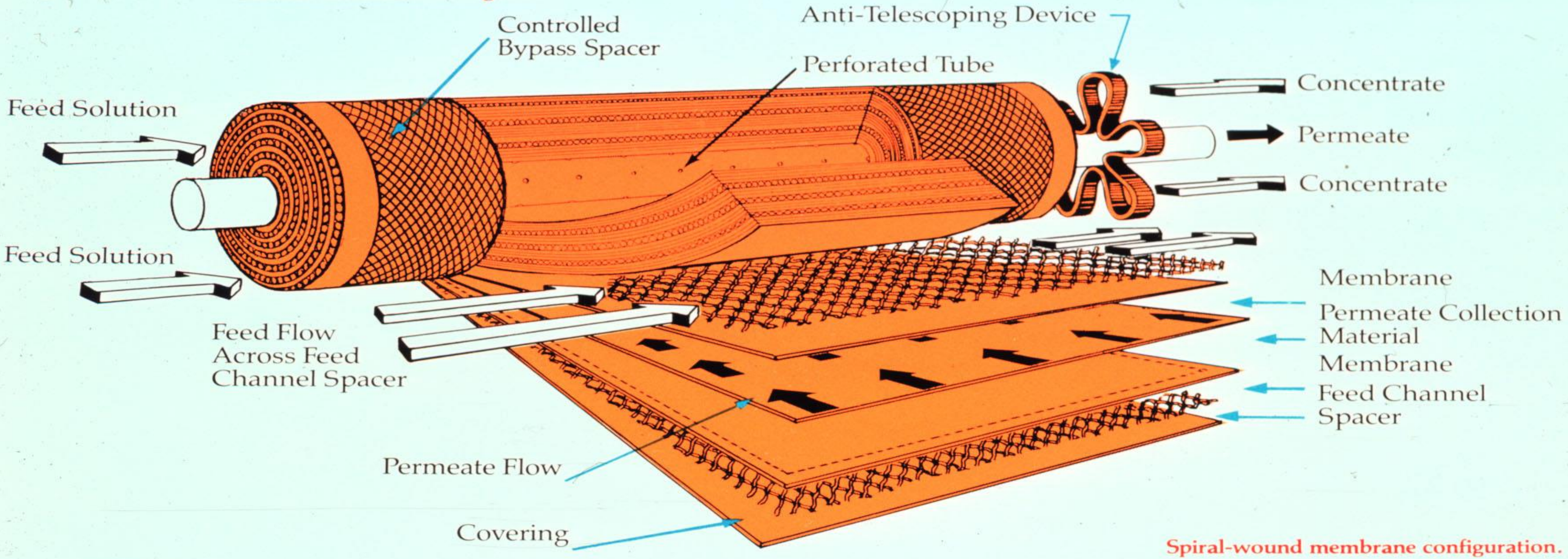
water	66.4 lbs
NaCl	0.125 lbs

Nanofiltration

- **Applications**
  - Concentration of lactose from UF permeate for purified lactose production
  - Permeate from Nanofiltration contains milk soluble salts (primarily sodium).
  - Calcium can be concentrated (retentate) and used in food product formulations as a dairy source of calcium.
  - Milk sodium and chloride can be removed from milk UF permeate and added as natural milk salts.

Ultrafiltration

- Retentate - fat, protein, bound minerals, bound minerals and part of lactose, NPN, and soluble minerals
- Permeate – water, part of lactose, NPN, and unbound minerals



Spiral-wound membrane configuration.

Ultrafiltration

- **Applications**
  - concentration of whey proteins in separated whey (e.g., 34% and 80% WPC)
  - concentration of milk fat and protein
    - skim milk protein concentrate (MPC)
    - whole milk fat and protein concentrate
  - protein standardization of fluid milk

Basics of Separation Processes

3X Ultrafiltration – remove some lactose, soluble mineral, NPN

100 lbs Milk	
fat	3.5 lbs
protein	3.1 lbs
lactose	4.8 lbs
ash	0.7 lbs

33.4 lbs Retentate	
fat	3.5 lbs
protein	3.1 lbs
lactose	1.63 lbs
ash	0.546 lbs

66.6 lbs Permeate	
lactose	3.17 lbs
ash	0.154 lbs

Microfiltration - Small Pore

- Retentate - all fat, casein, and casein bound minerals and part of the lactose, serum protein, and soluble minerals
- Permeate - water, milk serum proteins, lactose, unbound milk minerals

Microfiltration - Small Pore

- Applications
  - separation of casein from milk serum (i.e., whey) proteins
  - production of dairy beverages with altered casein to milk serum protein ratios, production of protein fortified clear non-dairy beverages, and isolation of native casein micelles for ingredient use in foods and for retorted shelf-stable beverages.

Basics of Separation Processes

3X Small Pore Microfiltration

Remove lactose, soluble mineral, NPN, and serum proteins

100 lbs Skim Milk

casein	2.5 lbs
serum prot.	0.6 lbs
lactose	4.8 lbs
ash	0.7 lbs

33.4 lbs Retentate

casein	2.5 lbs
s.p.	0.2 lbs
lactose	1.63 lbs
ash	0.546 lbs

66.6 lbs Permeate

s.p.	0.4 lbs
lactose	3.17 lbs
ash	0.154 lbs

Basics of Separation Processes

Large Pore Microfiltration

- In this application the feed material (e.g., skim milk or separated whey) is filtered with the objective of keeping the bacteria in the retentate and producing very little retentate.
- The goal is to have as much of the feed material as possible end up as permeate (current state of the art is 0.5% of the original milk volume is the concentrate of removed bacteria and about 0.5% of the original milk solids).

Microfiltration - Large Pore

- Retentate – bacteria plus a small amount of milk protein, lactose, and minerals.
- Permeate - milk protein, lactose, milk minerals
- Application - extended shelf-life fluid milk by removal of bacteria from skim milk (currently we can achieve 60 to 90 days of shelf life on skim and 2% fat milks).

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Challenges

Reaction to possible use of UF of milk for cheese making by a cheese maker that produces aged Cheddar.

You are going to do "*what*" to my milk for cheese making?
I have a hard enough time making consistent, high quality aged cheese given the normal seasonal variation milk composition.

Challenges

1. The ratio of protein and fat to water and lactose in the concentrated milk for cheese making is different.
2. Concentration of fat and protein are higher, so there will be more curd and less whey going into the Cheddaring step and more curd per vat to handle in downstream equipment.

Challenges

3. The ratio of soluble mineral to bound mineral has changed. There is more bound mineral and less soluble mineral. This will impact coagulation firmness and rate.
4. Set seems to be faster and firmer. Do I reduce the amount of rennet?
5. How much starter culture do I use?

Challenges

6. Need to rely more on measuring pH and less on titratable acidity.
7. Less whey per unit weight of curd needs to be expelled during cooking and Cheddaring, so temperatures, time, and mechanics of cheese making need to be adjusted to achieve the correct final moisture.

Challenges

8. **A better understanding of milk chemistry and how to control the chemistry of the cheese through manipulation of the blend of milk ingredients going into the cheese vat and how to modify the make procedure to achieve the proper partitioning of water and mineral between curd and whey.**

Opportunities

1. Increase pounds of cheese produced per man hour and per turn of equipment by 10 to 40%.
2. If UF retentate is purchased from another processing plant or farm and you make WPC in your factory, then the amount of UF permeate from whey will be decreased per pound of cheese and WPC produced.

Opportunities

3. For high moisture current varieties of Cheddar style (Jack, Colby, Washed curd cheddar, etc.) cheeses, there is an opportunity to control residual lactose and soluble mineral in the cheese to avoid acid production and decrease of pH during refrigerated storage of cheese.

Opportunities

4. For Cheddar style cheeses for slicing, there is an opportunity to control residual mineral, and bound versus soluble mineral balance, to achieve better sliceability for natural cheese slices.

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- **Future**

https://www.youtube.com/watch?v=-b5aW08ivHU

Challenges and Opportunities with Making Cheese Using MF Milk

Sam Alcaine (??)
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NYS Cheese Manufacturers' Association Meeting

March 3, 2059

History of MF for Cheese Making

A Microfiltration Process to Maximize Removal of Serum Proteins from Skim Milk Before Cheese Making*
B. K. Nelson and D. M. Barbano

Northeast Dairy Foods Research Center, Department of Food Science, Cornell University, Ithaca, NY 14853

Journal of Dairy Science. **2005**. Volume **88:1891–1900**

54 years into the future: 2059

I will be asking (OMG), what took you so long?