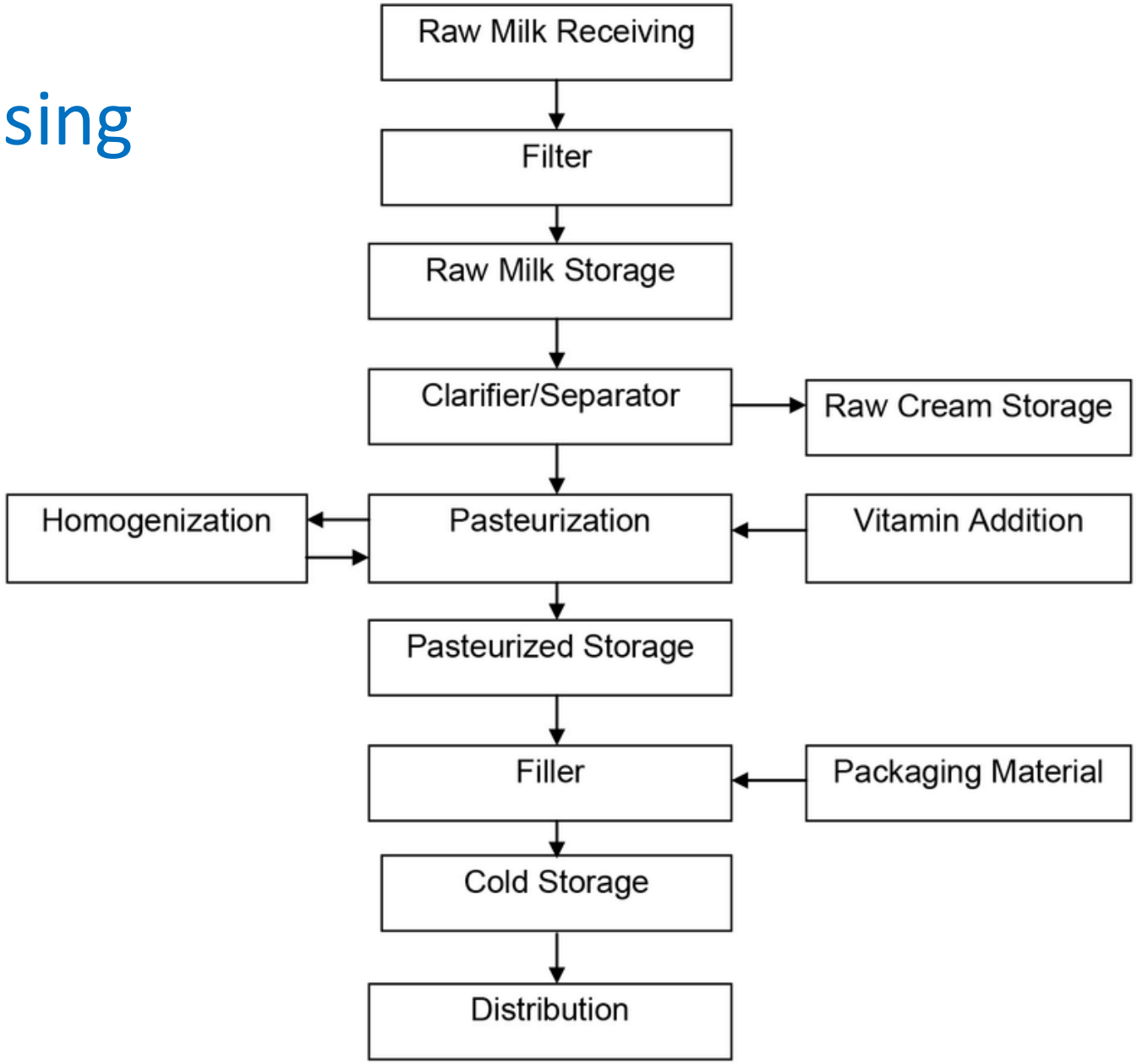
Fluid milk, cream and butter manufacturing

Learning Objectives

- Goals and steps in fluid milk processing
- Fluid milk composition and shelf life
- Issues and opportunities related to fluid milk
- Cream composition and properties
- Conversion of cream to butter and properties

Milk Processing Flow Chart



Goals in Fluid Milk Processing

- Milk Receiving and handling – safety and quality, negative antibiotics
- Standardization: Fat, TS and/or (SNF)
- Pasteurization: Kill all potential pathogens that could be found in milk thermal processing, extend shelf life
- Homogenization: Reduce creaming phenomena and modify texture/rheology of product
- Vitamin A&D Addition: meet regulations for fortification and replace what is lost as a result of fat removal
- Packaging and Filling – minimize (eliminate) post pasteurization contamination, (fluid milk shelf-life)

What is Extended Shelf Life (ESL) Milk?

Pasteurized, ESL (ultrapasteurized, Ultra Heat Treated)

Traditional

- Pasteurized
- ~10-21 days (refrigerated @ 40F)
- Raw milk quality and post-pasteurization contamination limit shelf life
- 161F, 15 sec

Extended Shelf Life

- Ultrapasteurized (UP)
- >30 day (60-90 days) refrigerated
- 280F, 2 seconds (PMO)
- Hygienic filling and packaging

Extended Shelf Life

- Ultra Heat Treated(UHT)
- - 1-2 years (ambient)
- - 280F, 2 seconds, hermetically sealed in sterilized package (FDA – LACF)

Pasteurized, Ultra-Pasteurized, Ultra-Heat-Treated Milks

Paramete	Pasteurized	Ultra-pasteurized	Ultra-Heat Treated
Heat Treatment	161°F, 15sec	280 °F, 2 sec	280 °F, 2 sec
Bacterial Kill	Some survival	Nearly “sterile”	Nearly “stable”
Recontamination	Possible/Likely	Prevent/minimized	Prevent/minimized
Fill Equipment	Limited protection	Protected	Sterile environment
Packaging Material	Paper, plastic	Paper, plastic	Hermetically sealed
Package Treatment	Untreated	Treated w/H_2O_2	Sterilzed
Product Storage	Refrigerated	Refrigerated	Ambient
Shelf-life	**10-21+ days**	**30-90 days**	**6+ months (1-2 years)**

Nicole Martin (nicole.martin@cornell.edu) in the Milk Quality Improvement Program
or visit website https://foodsafety.foodscience.cornell.edu/mqip

Changes Caused by Processing

Heat-induced changes

- Proteins
  - Liberation of sulfhydryl groups (SH-groups)
  - Increases antioxidative properties of milk
  - Leads to cooked taste
- Maillard Browning reactions (darkening)

Culprits to Shelf-life extension

Post processing contamination

- Psychrotrophic bacteria (Pseudomonas)

Heat resistant bacteria and enzymes

- Psychrotrophic sporeformers (Bacillus)
- Somatic cell proteases and lipases

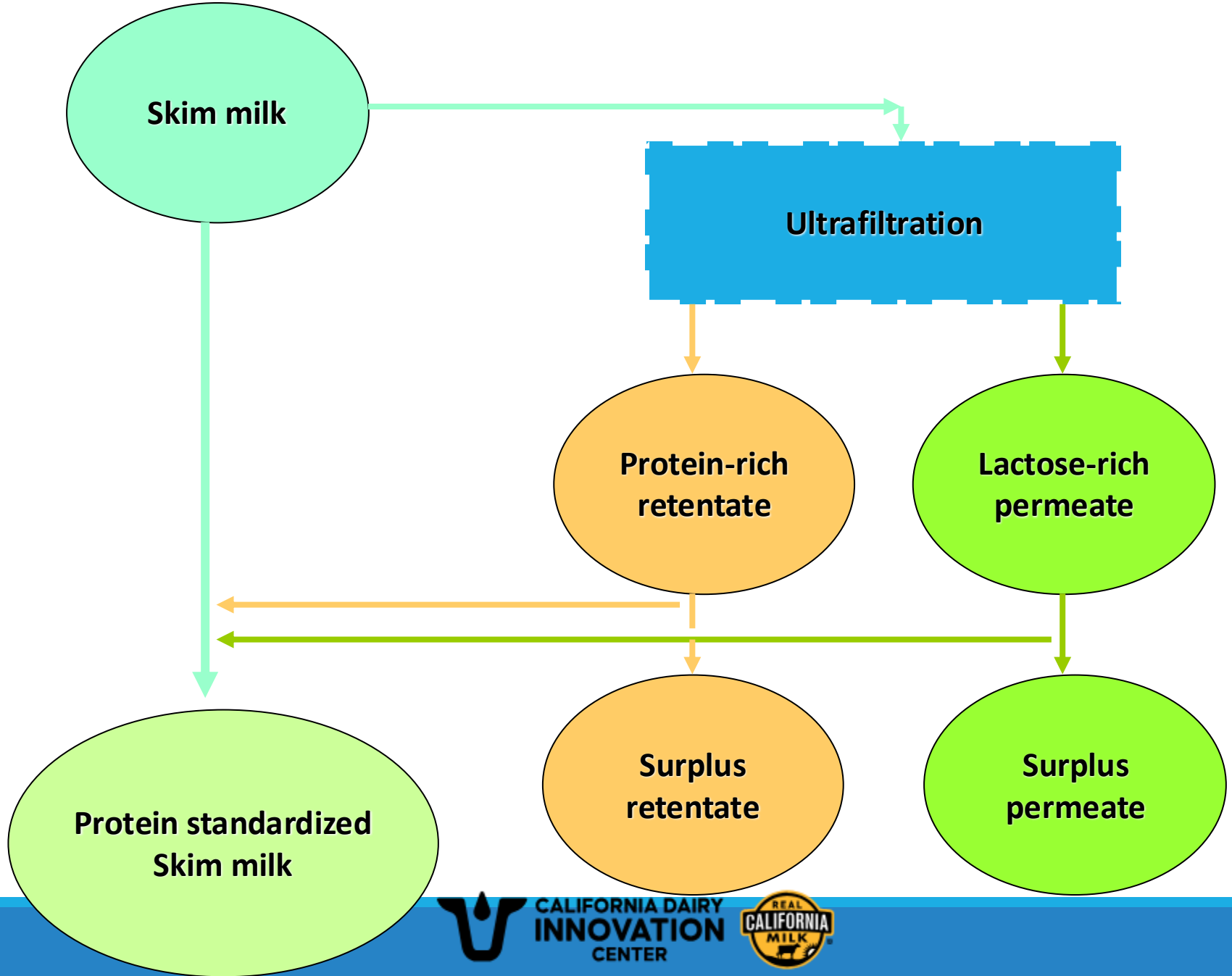
Packaging

- Mechanical strength
- Light transmission

Solids NonFat Standardization & Treatment

- Standardization (2/10, 1/11)
  - Addition of condensed skim or reverse osmosis skim retentate
  - Addition of nonfat dry milk
- Standardization (Australia 3.0% protein)
  - by addition of ultrafiltered milk permeate
- Reduction of lactose
  - Hydrolysis of lactose (lactose free)
  - by ultrafiltration and concentration of protein (Fairlife milk)

MILK PROTEIN STANDARDIZATION



Producing low lactose or lactose free milk

Figure 5: Hydrolysis process using lactase

Process Temperature and time for hydrolysis	Lactase
5°C, 24h	2.2g/L for in-batch process
8°C, 24h	1.3g/L for in-batch process
20°C, 48h	1.0g/L for continuous process
20°C, 72h	0.65g/L for continuous process
43°C, 1 h (Yoghurt production)	0.5g/L for in-batch fermentation

Table 3: Time/temperature/dosage correlations

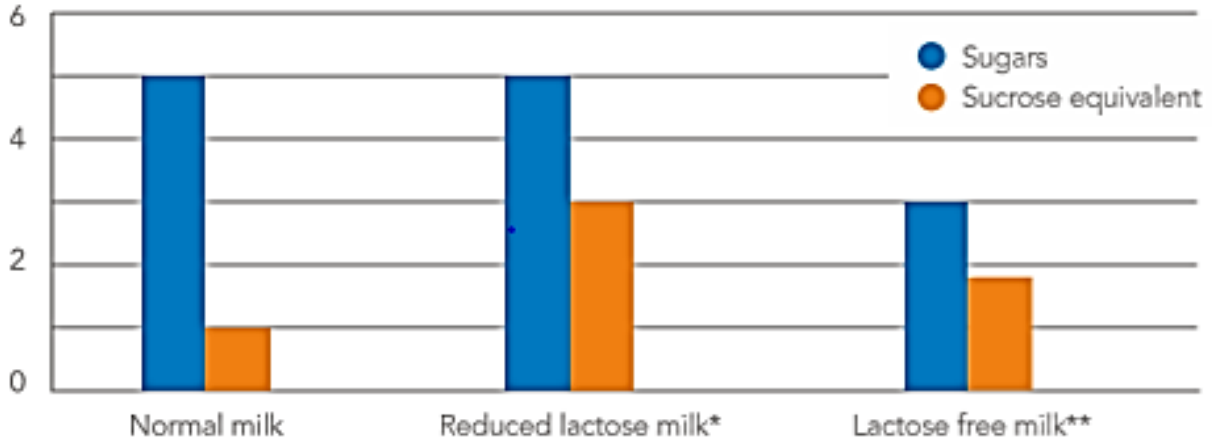


Figure 7: Sweetness perception threshold related to sucrose equivalent.
* Low lactose milk (1% lactose) with 80% of lactose enzymatically hydrolysed
** Lactose free milk (0.01% lactose) with 40% of initial lactose content removed by filtration and the remaining lactose is enzymatically hydrolysed.

Lower Carbohydrate, Lactose free milk

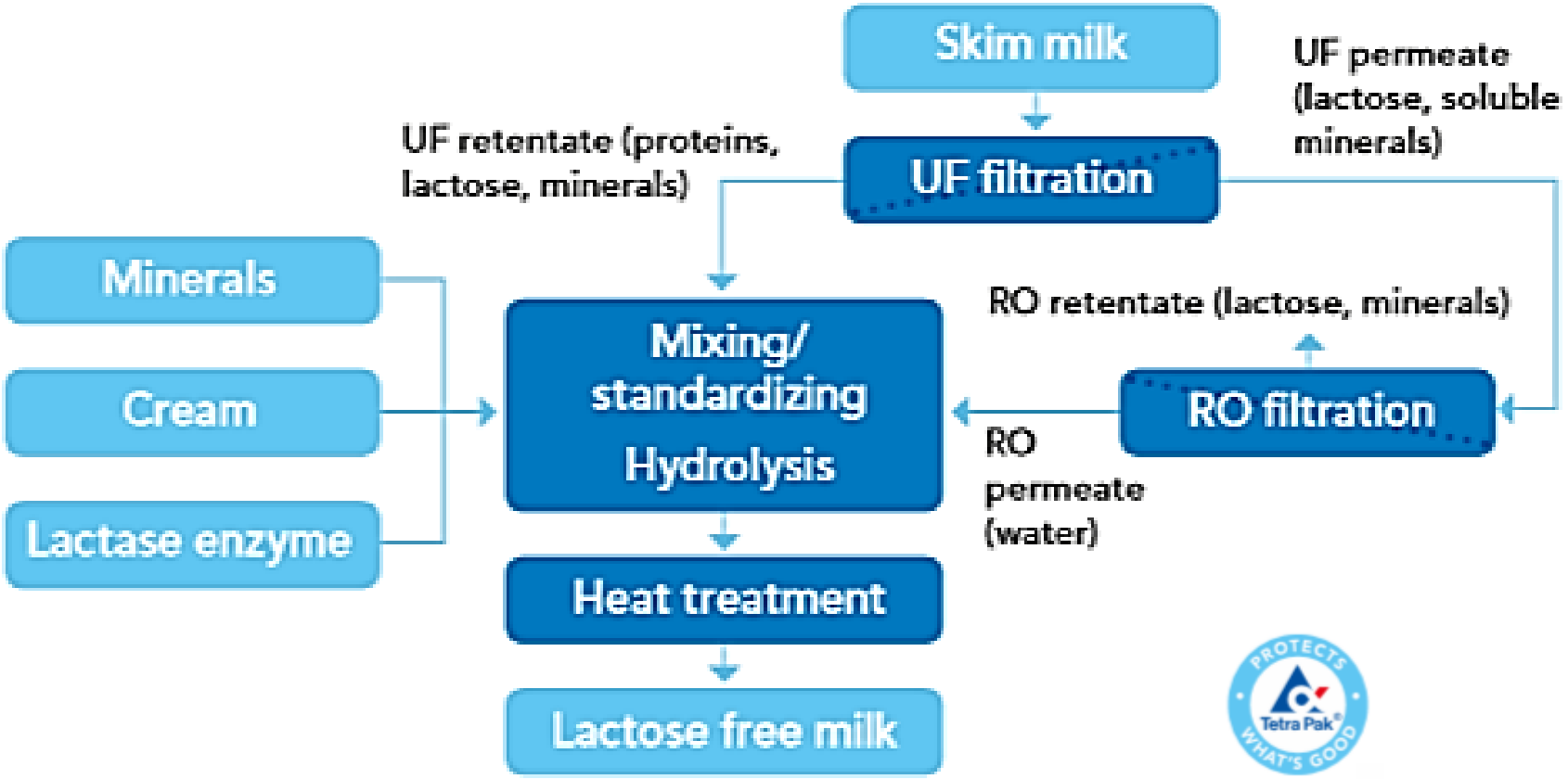
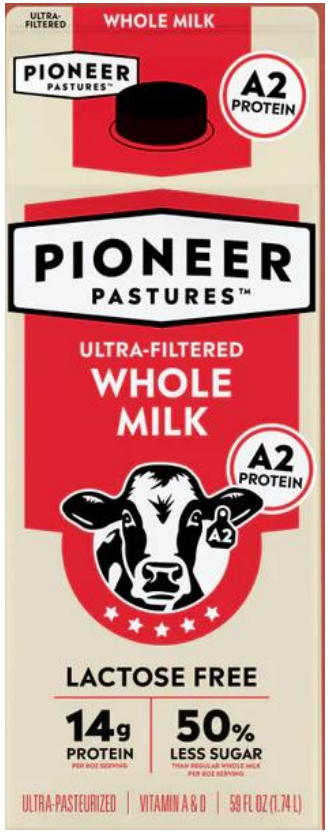


Figure 8: Lactose separation by means of UF, including recovery of water in RO



Higher Protein Milk

- Ultrafiltration of Skim Milk
- Diafiltration to remove lactose and lactose hydrolysis to breakdown lactose
- Golden Guernsey milk (higher fat, higher protein)

Compositional Standards

	Standard	Federal	California
Grade A Pasteurized Milk	Milkfat Minimum	3.25%	3.5% *
	Milk Solids-Not-Fat (SNF), minimum	8.25%	8.7% *
	Total Milk Solids	No Standard	12.2% Minimum
Grade A Reduced Fat Milk	Milkfat	Maximum 2.1% No Minimum	Maximum 2.1% Minimum 1.9%
	SNF, minimum	8.25%	10.0%
Grade A Lowfat Milk	Milkfat	Maximum 1.2% No Minimum	Maximum 1.1% Minimum 0.9%
	SNF, minimum	8.25%	11.0%
Grade A Nonfat Milk	Milkfat	0.20%	0.20%
	SNF, minimum	8.25%	9.0%

What's in Your Glass?

Choices are great, but they can be overwhelming.

This at-a-glance chart can help you understand what's in your glass.

$0.30 per 8 oz.*

$0.22 8 oz. per gallon[1]

Dairy Milk, 1%

(8 oz., unsweetened)

106 Calories

8g Protein

2g Fat

13g Carbohydrates

$0.55 per 8 oz.*

Lactose-Free Dairy Milk, 1%

(8 oz., unsweetened)

105 Calories

8g Protein

2g Fat

13g Carbohydrates

$0.51 per 8 oz.*

Soy Beverage

(8 oz., unsweetened)

94 Calories

9g Protein

5g Fat

3g Carbohydrates

$0.46 per 8 oz.*

Almond Beverage

(8 oz., unsweetened)

37 Calories

1g Protein

3g Fat

1g Carbohydrates

$0.69 per 8 oz.*

Oat Beverage

(8 oz., unsweetened)

118 Calories

2g Protein

7g Fat

13g Carbohydrates

*Cost per 8 ounces based on ½ gallon sized container

See Cornell Dairy Foods Science Notes: Milk Quality Improvement

https://foodsafety.foodscience.cornell.edu/mqip/information-sheets/

Cream

131.155 Light **cream**.
Title 21 Chapter I Part 131
(a) Description. Light **cream** is **cream** which contains not less than 18 percent but less…food is “Light **cream**”, or alternatively “Coffee **cream**” or “Table **cream**

131.150 Heavy **cream**.
Title 21 Chapter I Part 131
(a) Description. Heavy **cream** is **cream** which contains not less than 36 percent milkfat…of the food is “Heavy **cream**” or alternatively “Heavy whipping **cream**”.

131.180 Half-and-half.
Title 21 Chapter I Part 131
food consisting of a mixture of milk and **cream** which contains not less than 10.5 percent

Cream

Constituents	% Composition			
Fat	25	30	42	50
Protein	2.54	2.40	2.05	1.69
Lactose	3.70	3.50	2.99	2.47
Ash	0.56	0.40	0.39	0.37
Solids Non Fat (SNF)	6.80	6.00	5.28	4.55
Total Solids	31.80	42.30	47.42	59.08
Water	68.20	57.70	52.59	40.92

The solids-not fat (SNF) content of cream can be calculated by the formula given below:

Percent SNF = (100 - % fat in cream)/(100 - % fat in milk) x (% SNF in Milk)

Heavy Cream (36% fat) Functionality

- Foam formation and stability
  - Whipped cream topping
- Heat stability (e.g. cream sauce)
- Coffee cream
- Sensory (flavor, texture, appearance)

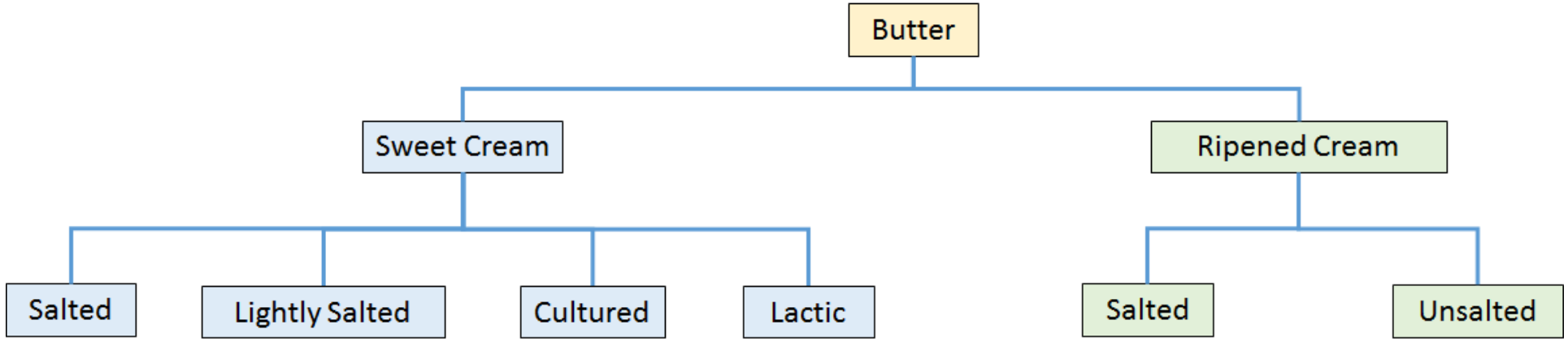
Optional ingredients. The following safe and suitable optional ingredients may be used:
(1) Emulsifiers.
(2) Stabilizers.
(3) Nutritive sweeteners.
(4) Characterizing flavoring ingredients (with or without coloring) as follows:
(i) Fruit and fruit juice (including concentrated fruit and fruit juice).
(ii) Natural and artificial food flavoring.

Butter

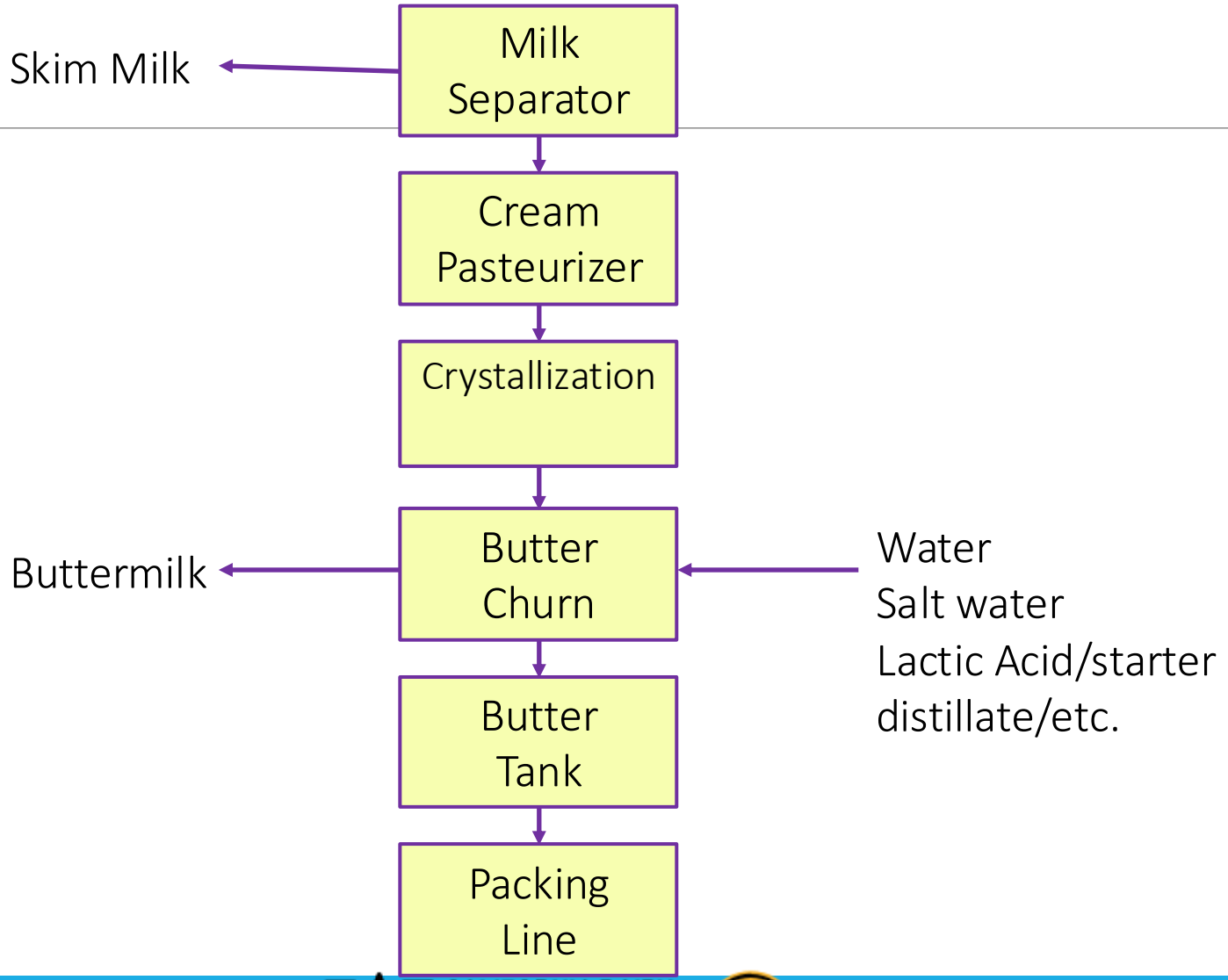
BUTTER
NET WT. 4 OZ. (113.4g)
BUTTER
NET WT. 4 OZ. (113.4g)
BUTTER
NET WT. 4 OZ. (113.4g)

What is Butter?

- Butter is a water-in-oil emulsion, with ~80% milk fat, 16% moisture, and ~ 2% milk solids-not-fat either with or without salt
- European butter may have ~82% fat)
- Butter consists of milk fat, non-fat-constituents (from skim milk and added salt and/or flavor/color and water).



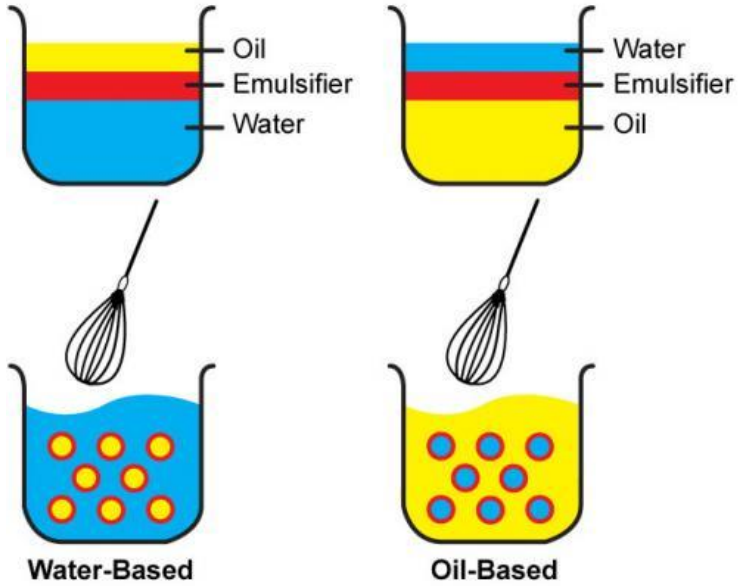
Butter Manufacturing Process Steps



Introduction (Churning)

Phase-reversal (inversion) process

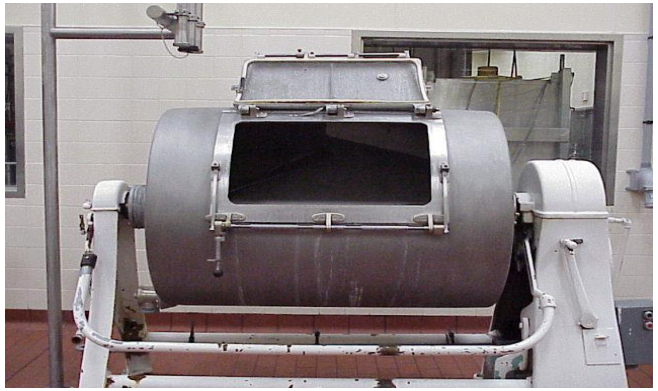
- Oil-in-water emulsion (cream) to water-in-oil emulsion (butter)



Introduction (Churning)

Conventional batch churn

- used in smaller-scale production
- equipped with axial strips and dashers inside the churn
- churning and working are separated

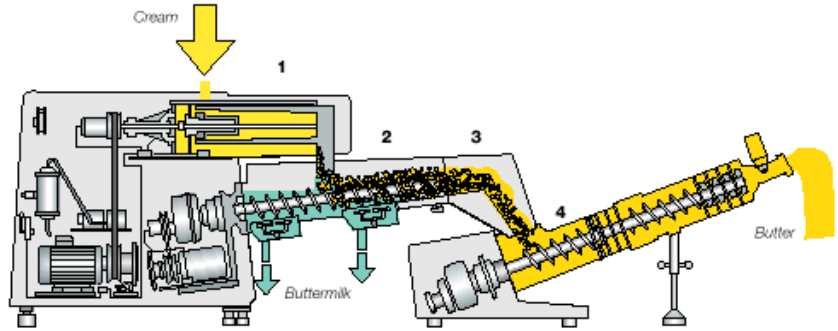


How Butter is Made (batch churning and packaging)
https://www.youtube.com/watch?v=qwb2uZLSLhw

How It's Made-Butter

Introduction (Churning)

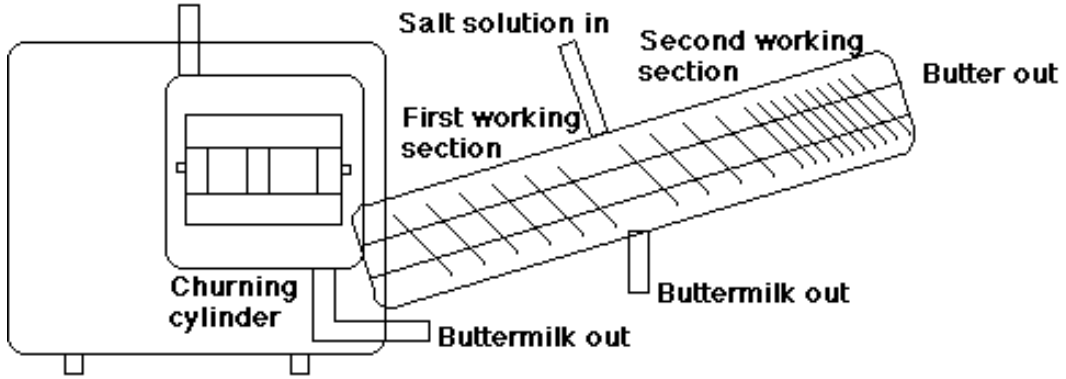
Churning breaks the oil in water emulsion and fat begins to form popcorn sized clumps



Cream in

Continuous churn (Fritz process)

- used in modern butter industry
- “continuous”
- uniform and fine water dispersion



Continuous Butter Churn

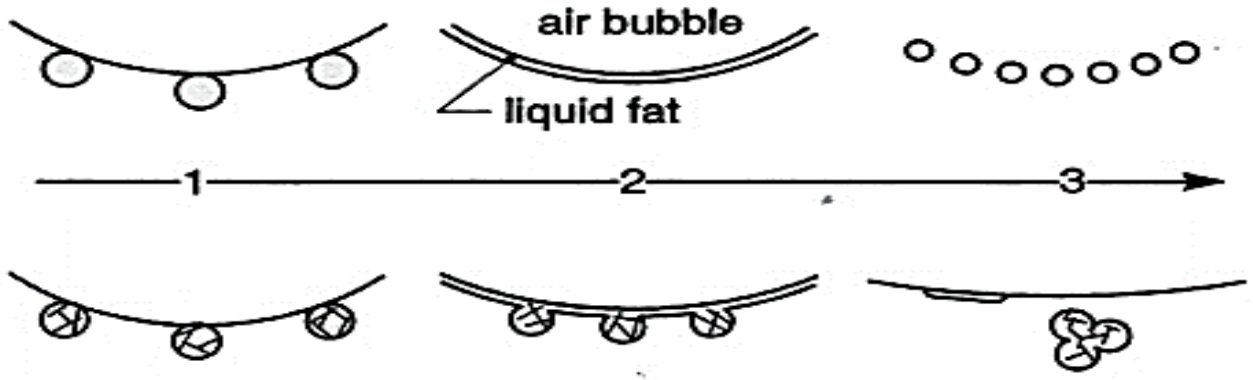


FIGURE 19.4 Schematic representation of the interactions between fat globules and air bubbles during churning. The fat is liquid and it is disrupted by beating in of air (top). The fat globules contain solid fat and form fat clumps (bottom).

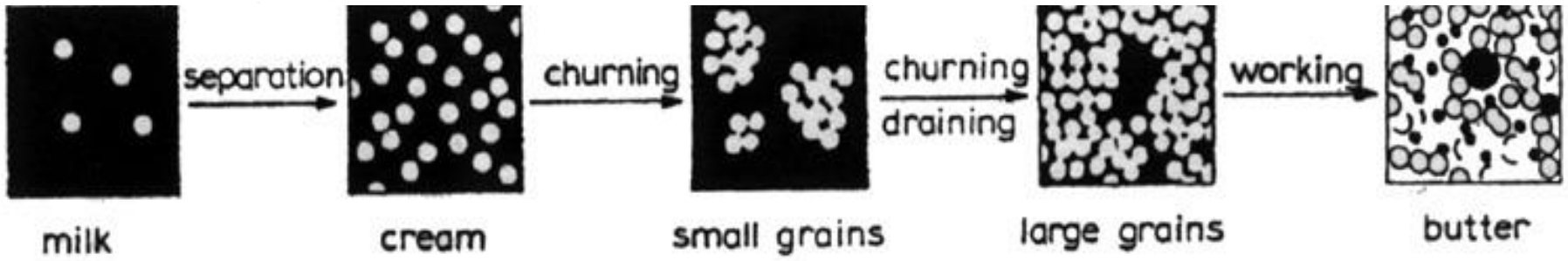


FIGURE 19.2 Stages in the formation of butter. Greatly simplified, not to scale. Black is the aqueous phase; white is fat. From H. Mulder and P. Walstra, *The Milk Fat Globule* (Wageningen: Pudoc, 1974).

Working Section converts the popcorn sized milkfat clumps to form a water in oil emulsion

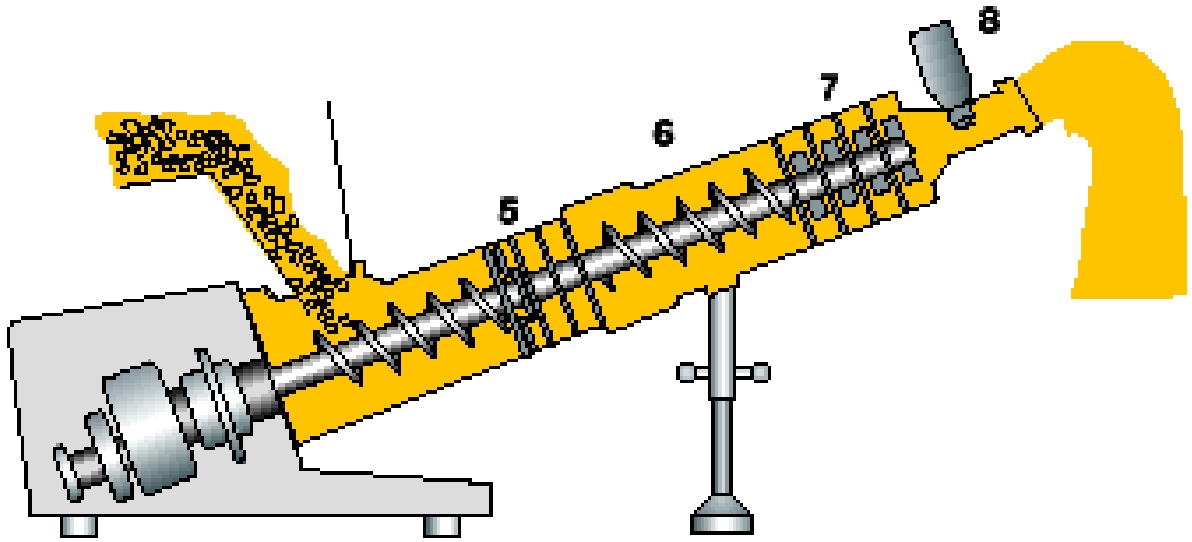
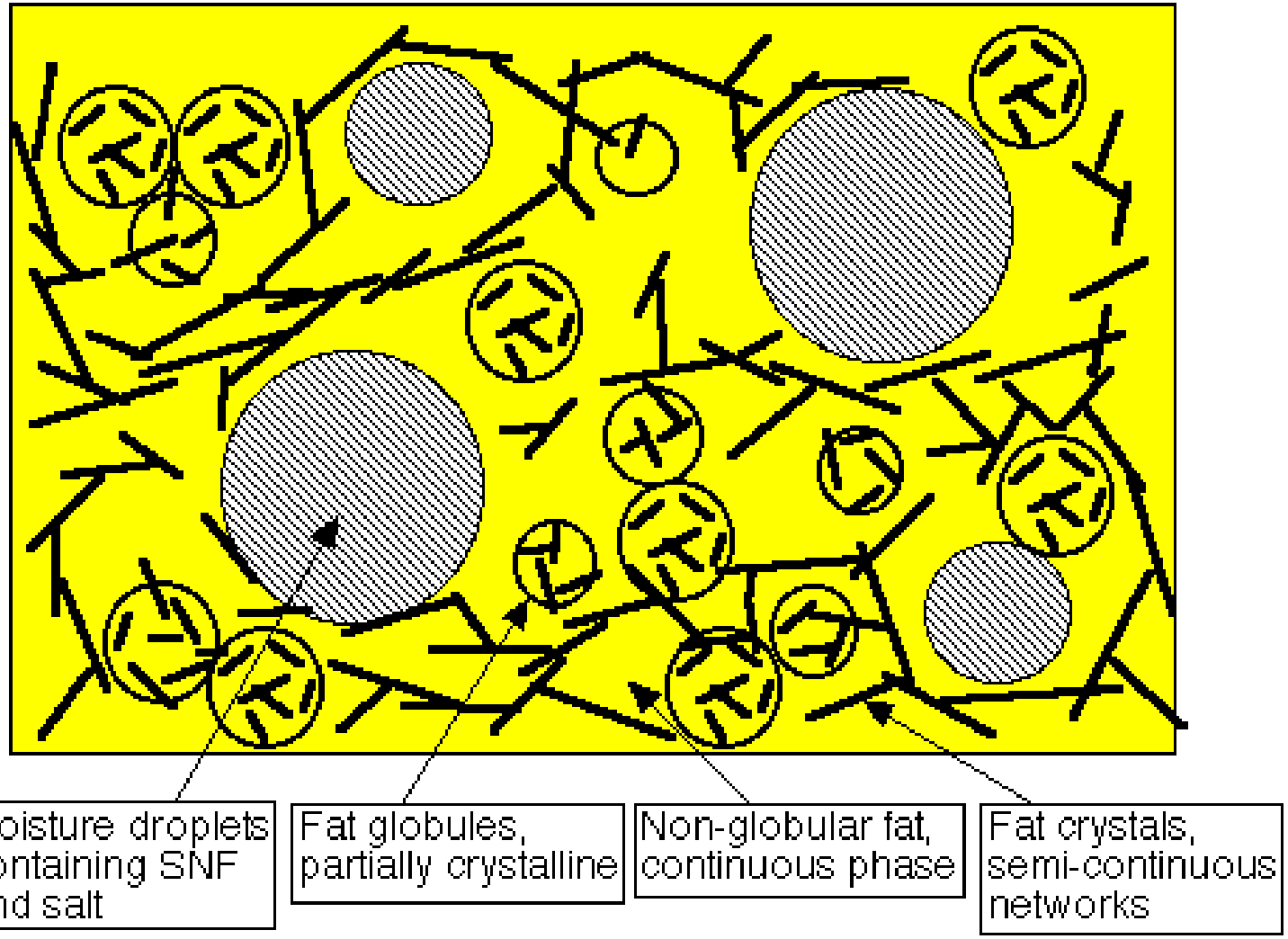


Fig. 12.7 *The vacuum working section*
5 Injection section
6 Vacuum working section
7 Final working stage
8 Moisture control unit

Butter Structure



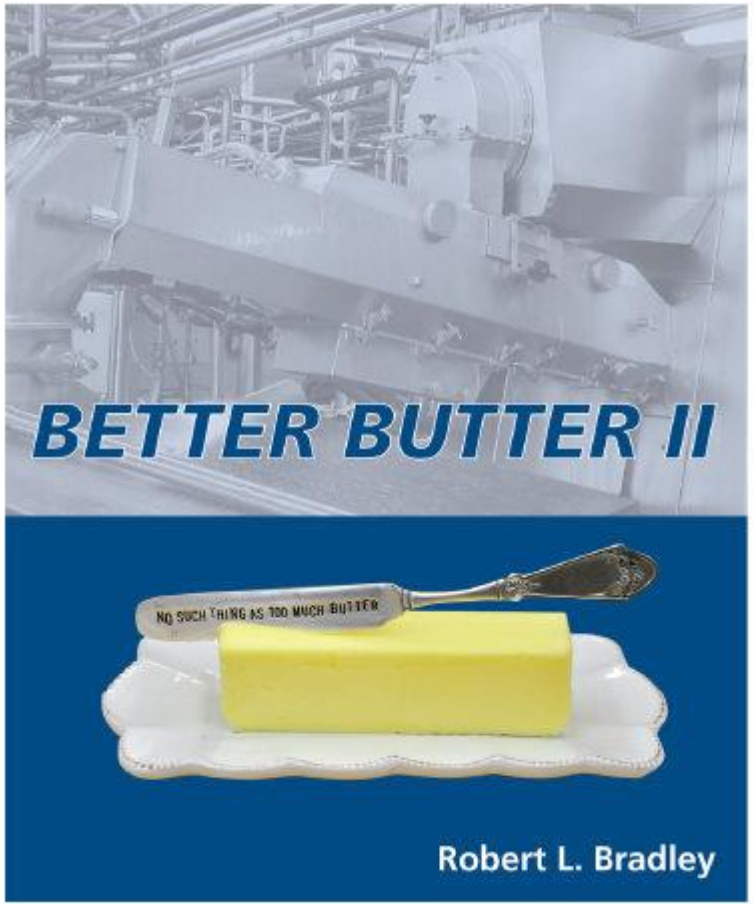
Butter Blends (spreadable butters)

Ingredients: Pasteurized Cream (derived from milk), Canola Oil, Salt, Vitamin A Palmitate, Beta Carotene.

Clarified Butter (Ghee/AMF/butteroil)

Ingredients： Milkfat

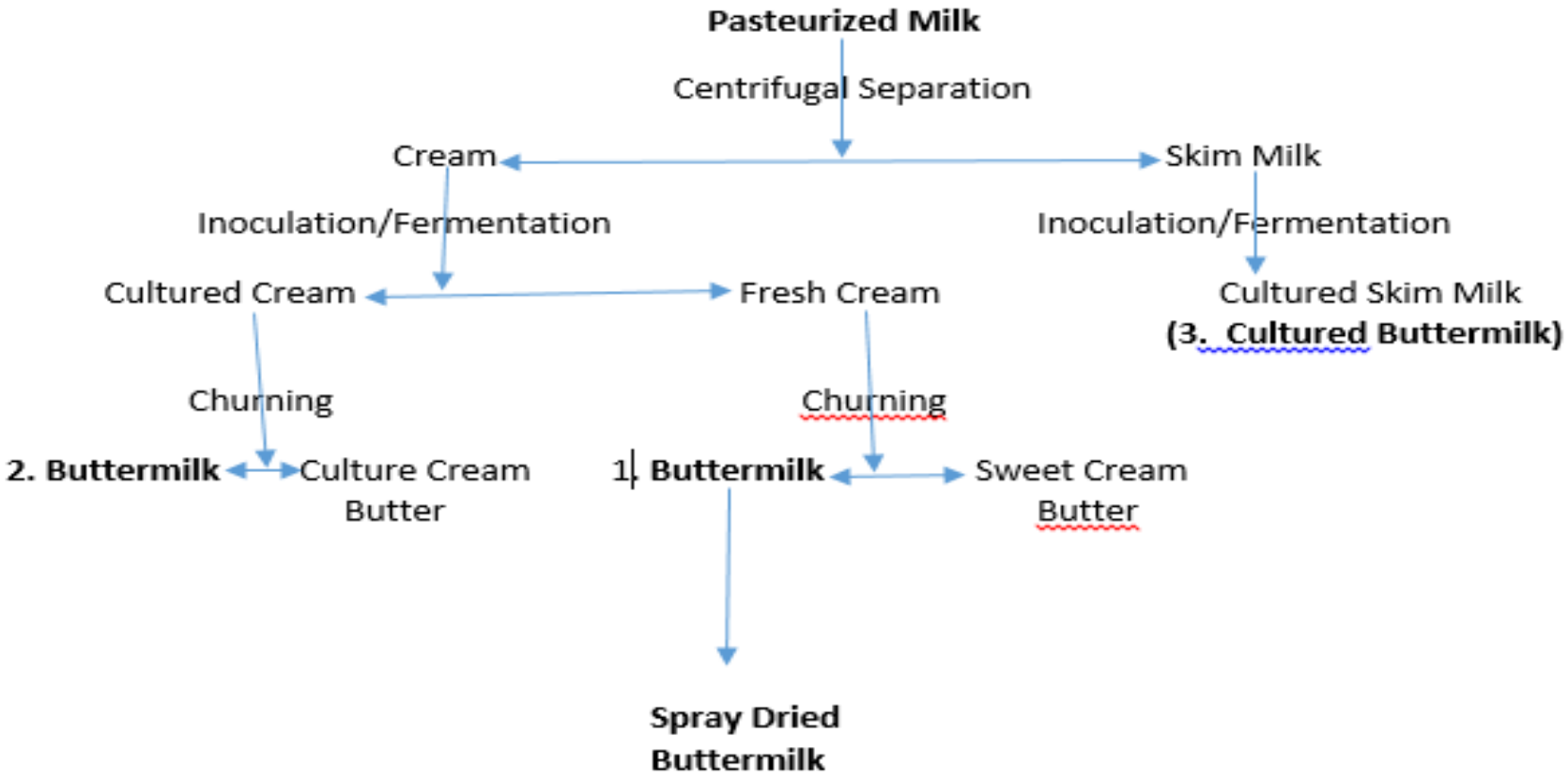
Brown Butter



https://cdr.wisc.edu/butter

Processes to obtain “Buttermilk”

1. **Buttermilk from churning of fresh cream**
2. **Buttermilk from churning of cultured cream**
3. **“Cultured Buttermilk” from fermentation of skim milk**



What have we learned?

- Goals and steps in fluid milk processing
  - *Raw milk to pasteurized, homogenized, standardized milk with good shelf-life*
- Fluid milk composition and shelf life
  - *Bacteria and bacterial spores that can grow at refrigerated temperatures that come from poor sanitation or post pasteurization contamination*
- Issues and opportunities related to fluid milk
  - *Lactose intolerance, raw vs. pasteurized milk*
- Cream composition and properties
  - *(heat stability, whipping, whitening)*
- Conversion of cream to butter and properties
  - *Phase inversion during churning and working*