



NADRO 2025 Annual Meeting
National Association of Dairy Regulatory Officials

Pathogen mitigation in raw milk cheese production

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Case studies: Raw milk cheese outbreaks

Cheese type	Cheddar
Year	2024
Company	Raw Farm LLC
Company location	California
Aged for over 60 days?	Yes
Pathogen	<i>E. coli</i> O157:H7
# people affected	11
Source of contamination	

(FDA, 2024)

Case studies: Raw milk cheese outbreaks

Cheese type	Cheddar	Gouda
Year	2024	2018
Company	Raw Farm LLC	
Company location	California	British Columbia
Aged for over 60 days?	Yes	Yes
Pathogen	<i>E. coli</i> O157:H7	<i>E. coli</i> O121 Shiga-toxin
# people affected	11	7
Source of contamination		Raw milk

(FDA, 2024)

(Boyd et al., 2021)

Case studies: Raw milk cheese outbreaks

Cheese type	Cheddar	Gouda	Ouleout
Year	2024	2018	2017
Company	Raw Farm LLC		Vulto Creamery
Company location	California	British Columbia	New York
Aged for over 60 days?	Yes	Yes	Yes
Pathogen	<i>E. coli</i> O157:H7	<i>E. coli</i> O121 Shiga-toxin	<i>Listeria monocytogenes</i>
# people affected	11	7	8
Source of contamination		Raw milk	Lack of Sanitation Environmental

(FDA, 2024)

(Boyd et al., 2021)

(CDC, 2017)

Raw milk cheeses

- In the US, raw milk cheeses are legal for cheese types that require aging for 60 days or longer
 - The idea is that aging for this long and exposure to low pH and other antimicrobial factors reduce pathogen counts sufficiently for cheese to be “safe”
 - Clear evidence that this is not true for all cheeses and/or pathogens
 - Surface and mold ripened cheeses (e.g., camembert, brie, blue cheese) are a particular concern due to pH increase that occurs during aging

FDA Draft Risk Assessment on Listeriosis from Soft-Ripened Cheese

- Released on February 11, 2013 (189 pages)
 - Covers Brie and Camembert
 - Focus on farmstead cheeses
- Joint effort by FDA and Health Canada
- **Key finding: the risk of listeriosis from soft-ripened cheeses made with raw milk was estimated to be 112 times higher** than that from soft-ripened cheese made with pasteurized milk.

Key pathogens of concern in raw milk cheeses

- *Salmonella*
- Shiga-toxin *E. coli* (STEC), including *E. coli* O157:H7
- *Listeria monocytogenes*
- *Staphylococcus aureus*
- Potentially *Brucella*, *Mycobacterium tuberculosis*, and *Coxiella burnetti* (Q fever)
 - These pathogens are still a concern and/or re-emerging in some parts of the US

***Salmonella enterica* and *E. coli* control in raw milk cheeses**

- **Salmonella will always be a risk**
- Control *Salmonella* in raw milk (e.g., raw milk testing)
 - Impossible to assure raw milk that is 100% *Salmonella* free, but **use of raw milk from farms that routinely test negative for *Salmonella* may reduce the overall risk**
- Avoid high risk raw milk cheeses (surface ripened etc.)
- GMPs that prevent introduction from farms and live animals:
 - Particularly important for facilities that are on or close to farms

***Salmonella enterica* and *E. coli* control in cheese plants**

- Processing plant environment as a potential source (particularly for *Salmonella*, less so for *E. coli*)
 - In addition to *Listeria*, a *Salmonella* environmental sampling plan should be implemented in most cheese plants; typically fewer *Salmonella* samples are collected
 - As a rule of thumb *Listeria* is the main concern in wet environments, while *Salmonella* is the main concern in dry environments
- Ingredients added to cheese a major concern (e.g., spices, herbs)
 - *Salmonella* in low water activity environments (spices, nuts, dry powders) is significantly more resistant to heat compared to *Salmonella* in high water activity environments (e.g., fluid milk)

Pasteurization review



- 5-log reduction

If initial raw milk CFU/ml

Raw milk SPC	Remaining count after pasteurization
100,000	1
300,000	3
1,000,000	• 10

Raw milk cheese

- Raw milk → highest quality
- Farm practices:
 - Prevalence of *Listeria* and *Salmonella* in the farm
- Sanitation practices – Processing plant
 - Environmental Monitoring

Who makes raw milk cheese?

- Very small producers
- Farmsteads
- Artisans
- Some big plants

60-day aging for raw milk cheese

- Is the cheese safe for the consumer?

Journal of Food Protection, Vol. 69, No. 5, 2006, Pages 990–998

Survival of a Five-Strain Cocktail of *Escherichia coli* O157:H7 during the 60-Day Aging Period of Cheddar Cheese Made from Unpasteurized Milk[†]

J. E. SCHLESSER,^{1*} R. GERDES,² S. RAVISHANKAR,² K. MADSEN,² J. MOWBRAY,^{3‡} AND A. Y.-L. TEO^{2§}

increased during the cheese-making operations. Population of *E. coli* O157:H7 in cheese aged for 60 and 120 days at 7°C decreased less than 1 and 2 log, respectively. These studies confirm previous reports that show 60-day aging is inadequate to eliminate *E. coli* O157:H7 during cheese ripening. Subpasteurization heat-treatment runs were conducted at 148°F (64.4°C)

Intrinsic and extrinsic factors affecting cheese safety

Intrinsic factors

Team Safe Cheese

Competitive inhibition from cheese cultures

Low A_w

Low pH

Salt

Team Pathogens

Hurdle technology in food preservation

Multiple methods to inhibit or eliminate microbial growth



Extrinsic factors

- Plant practices:
 - Prerequisite programs
 - SSOPs
 - GMPs
 - Food Safety plan
 - Process Preventive Control
 - Supply-chain Preventive Control
 - Sanitation Preventive Control
 - Environmental Monitoring Program

Some cheese types are more “at risk”

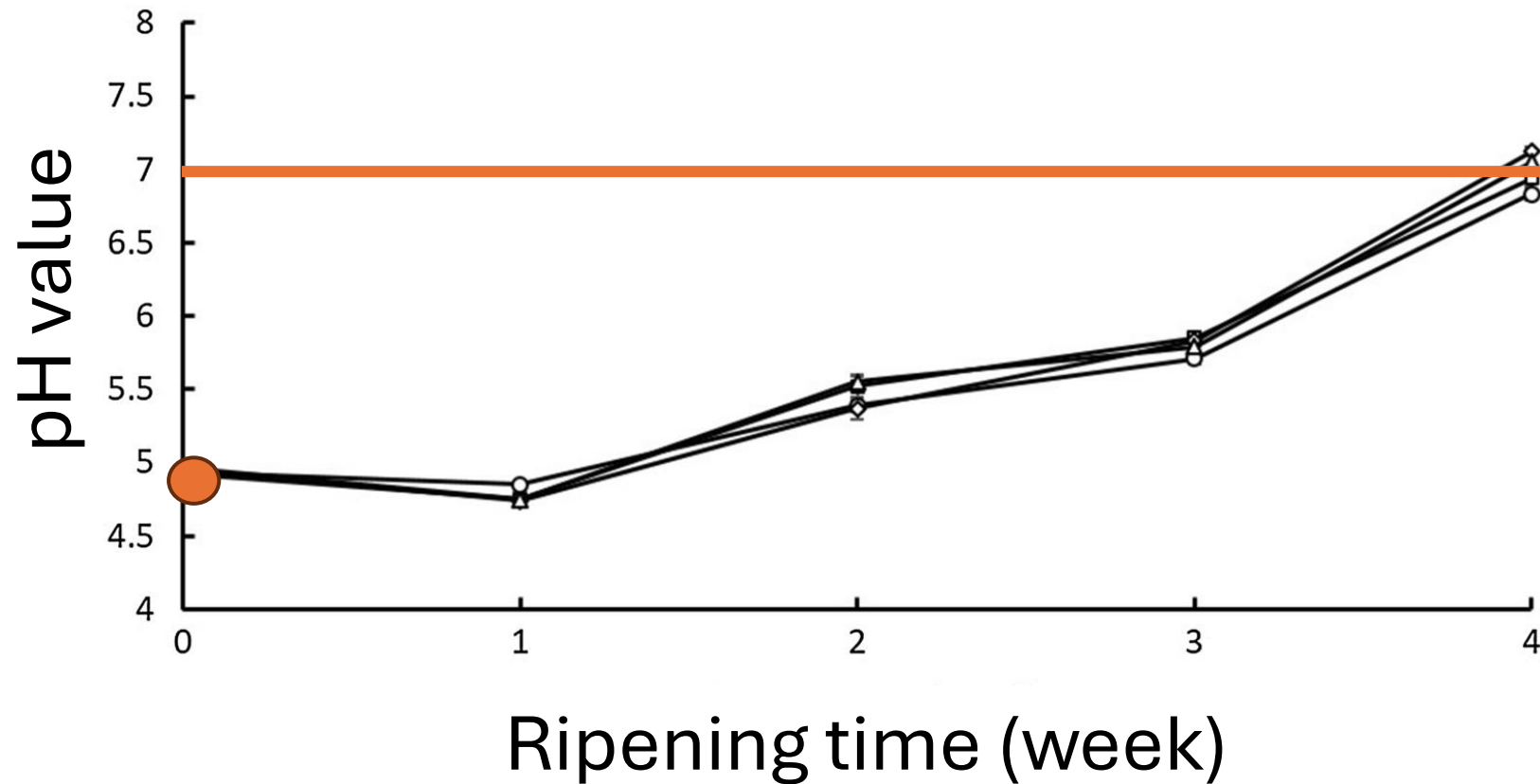
- Soft-ripened cheeses show vulnerabilities
 - Brie, Camembert
- To develop the rind → No lactose left for the mold to grow on the surface
- What does the mold feed on?
 - Protein → Protein breakdown → Peptides → Amino acids

Amine (NH_2) → Ammonia (NH_3) **Alkaline!!**



pH to ~ 7.0-7.5 in the rind

Camembert cheese ripening



Raw milk
cheese is an
issue after 45
days in **soft-
rind cheese**

Bae et al. (2020)

Pasteurized vs unpasteurized outbreaks

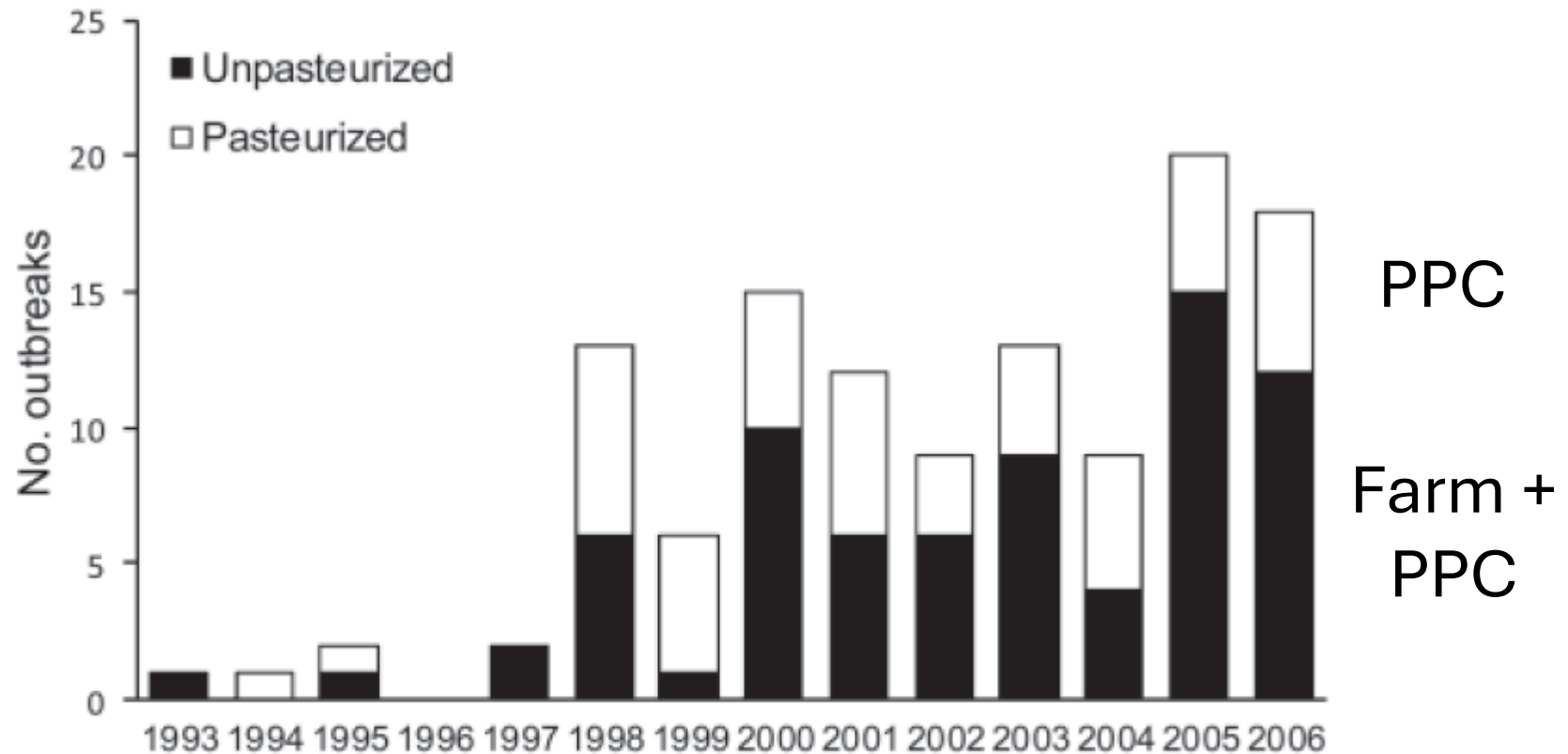
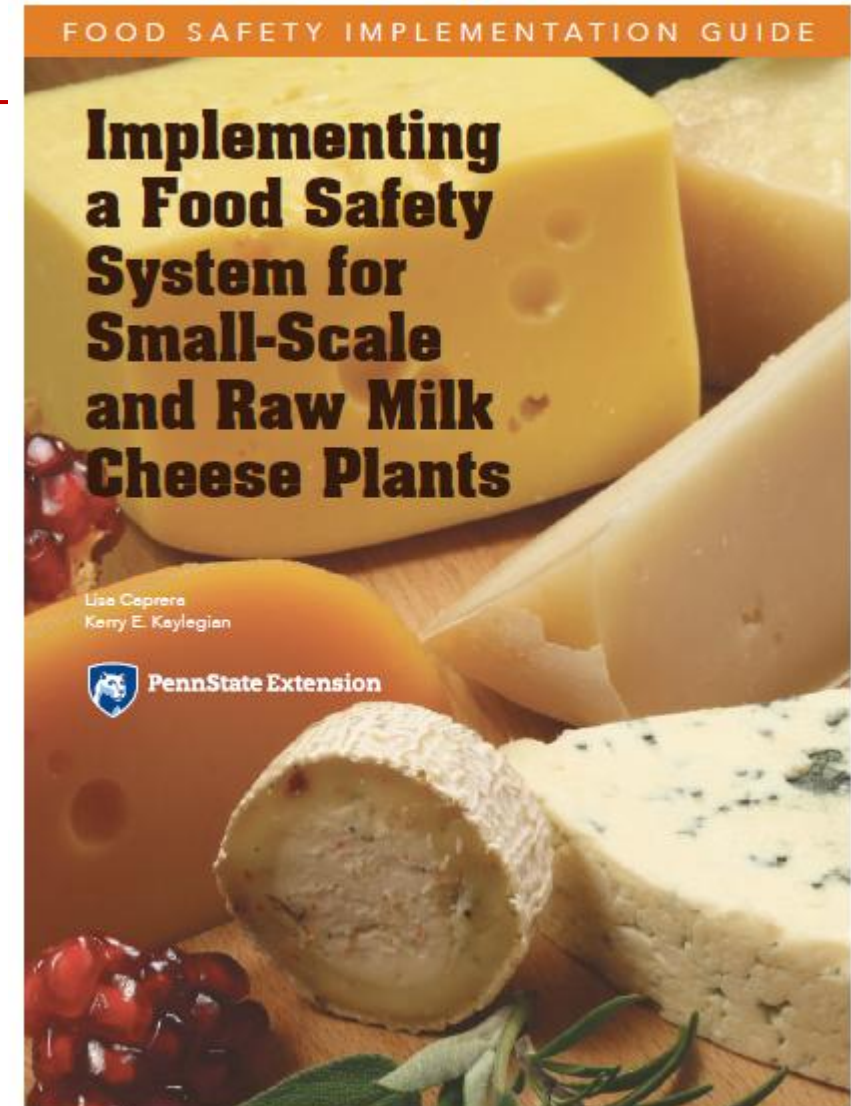
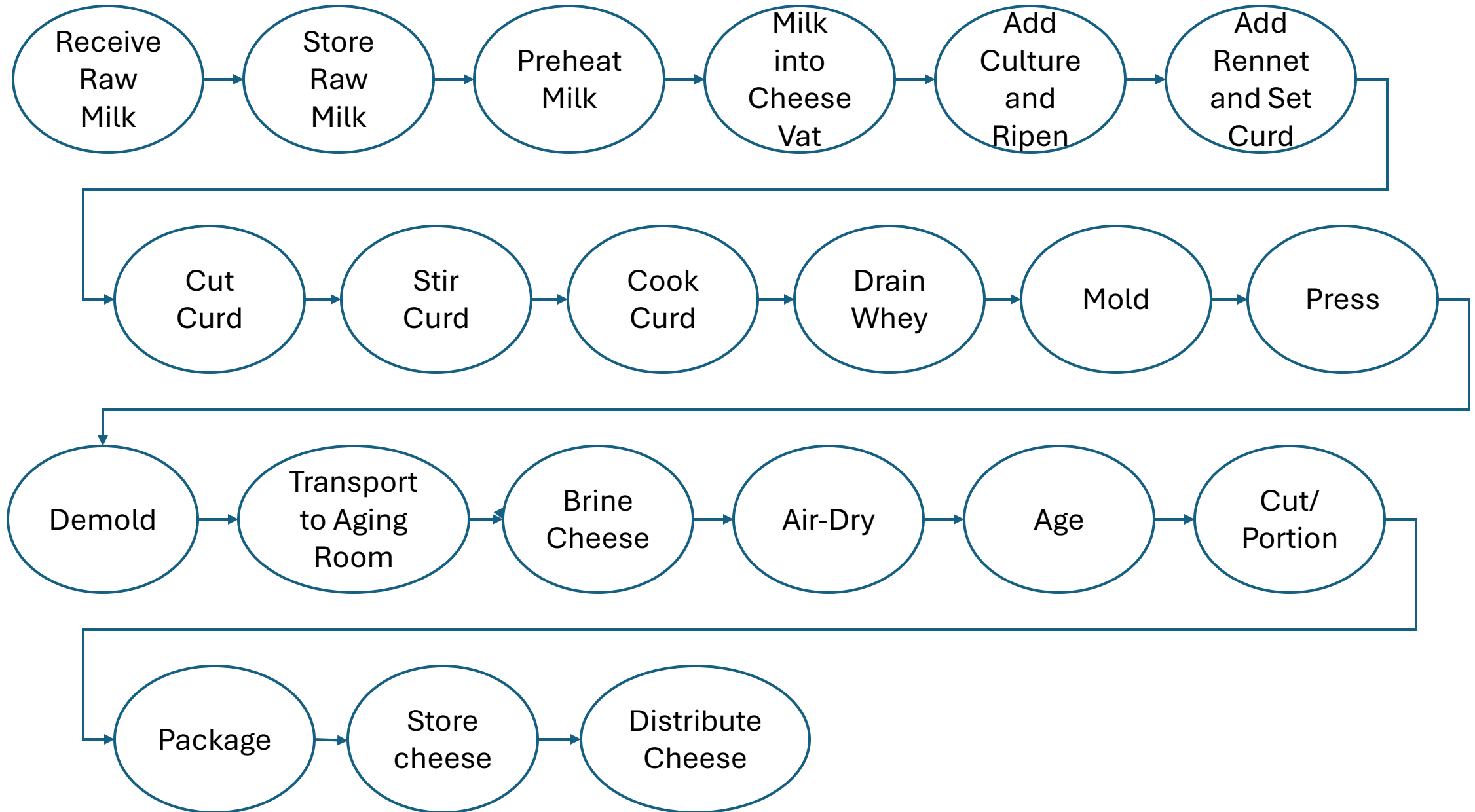


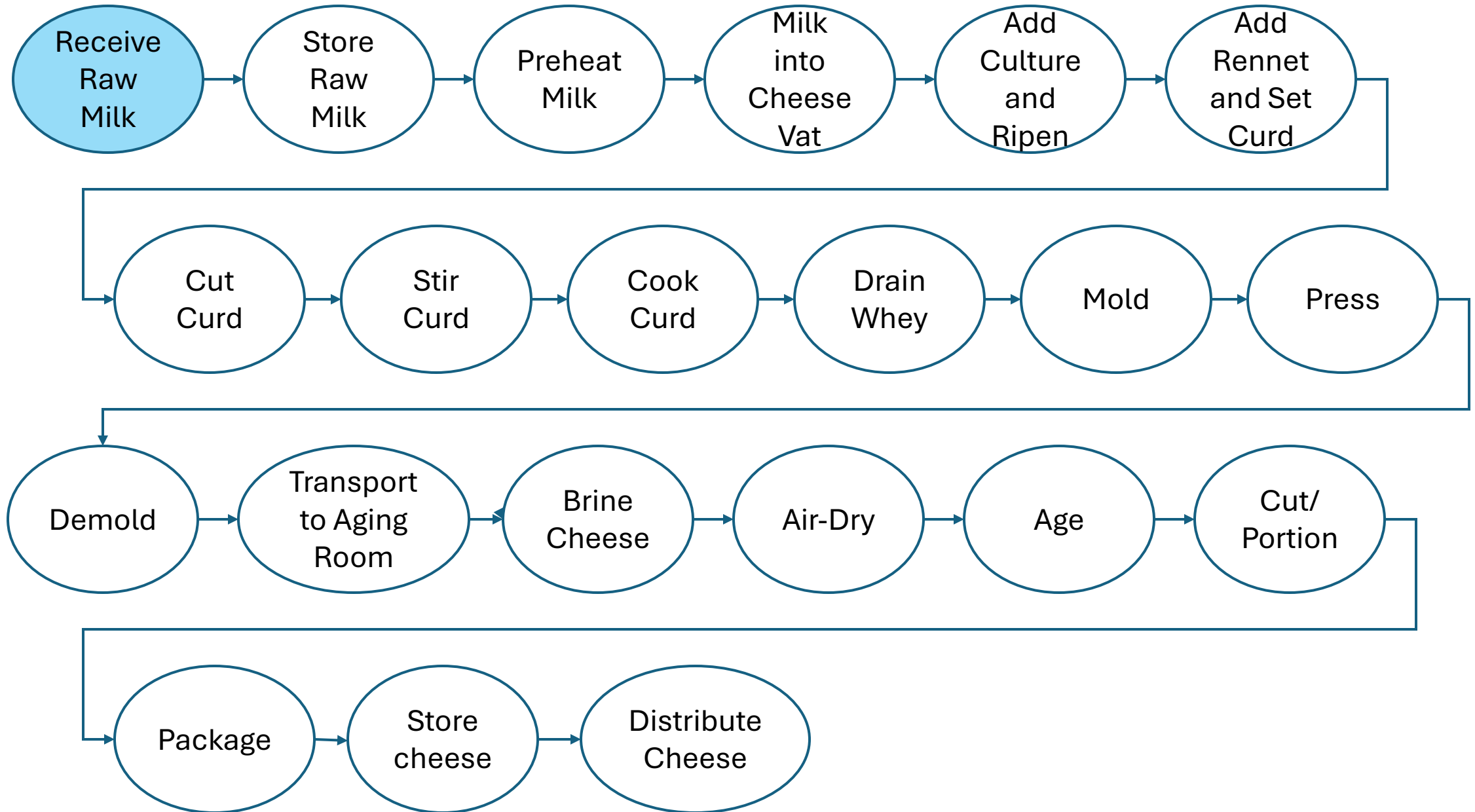
Figure 1. Number of dairy product-associated outbreaks, by year and pasteurization status of product, United States, 1993–2006.

Best practices from a FSMA perspective for raw milk cheese making

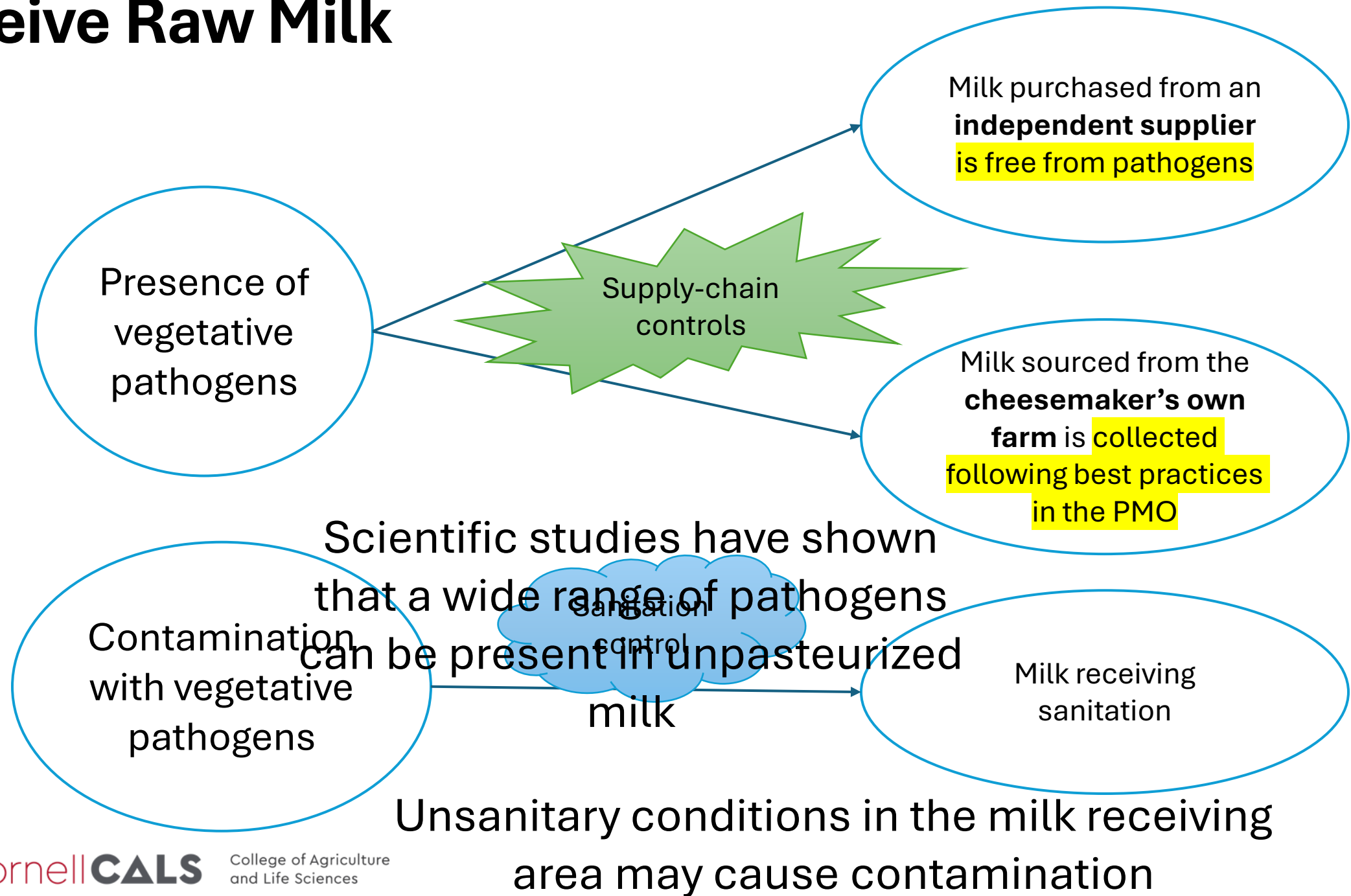
- Hazard Analysis for Biological Hazards ONLY
- Emphasizing critical steps in cheesemaking
- Teaching Example for Raw Milk Gouda



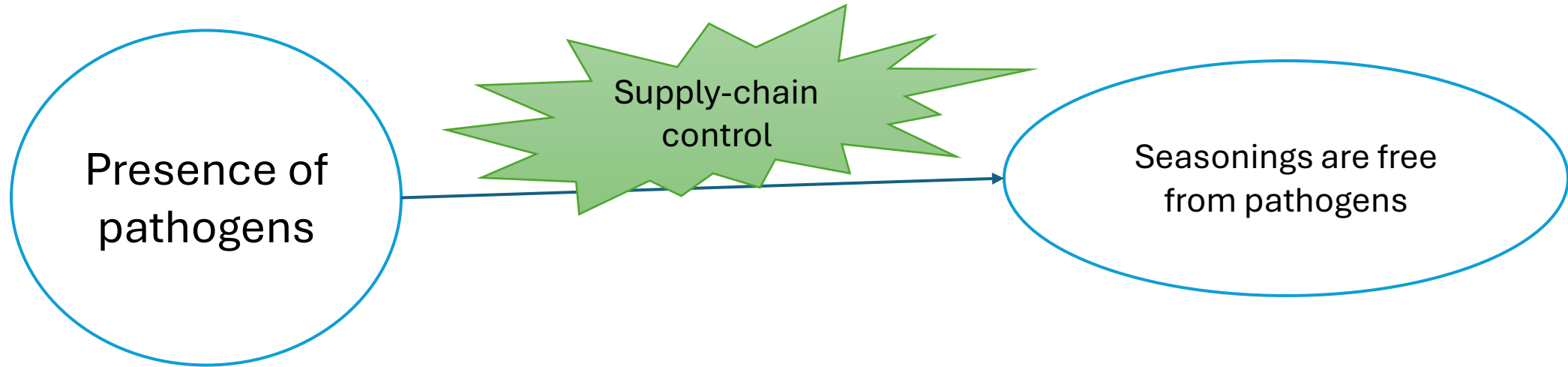




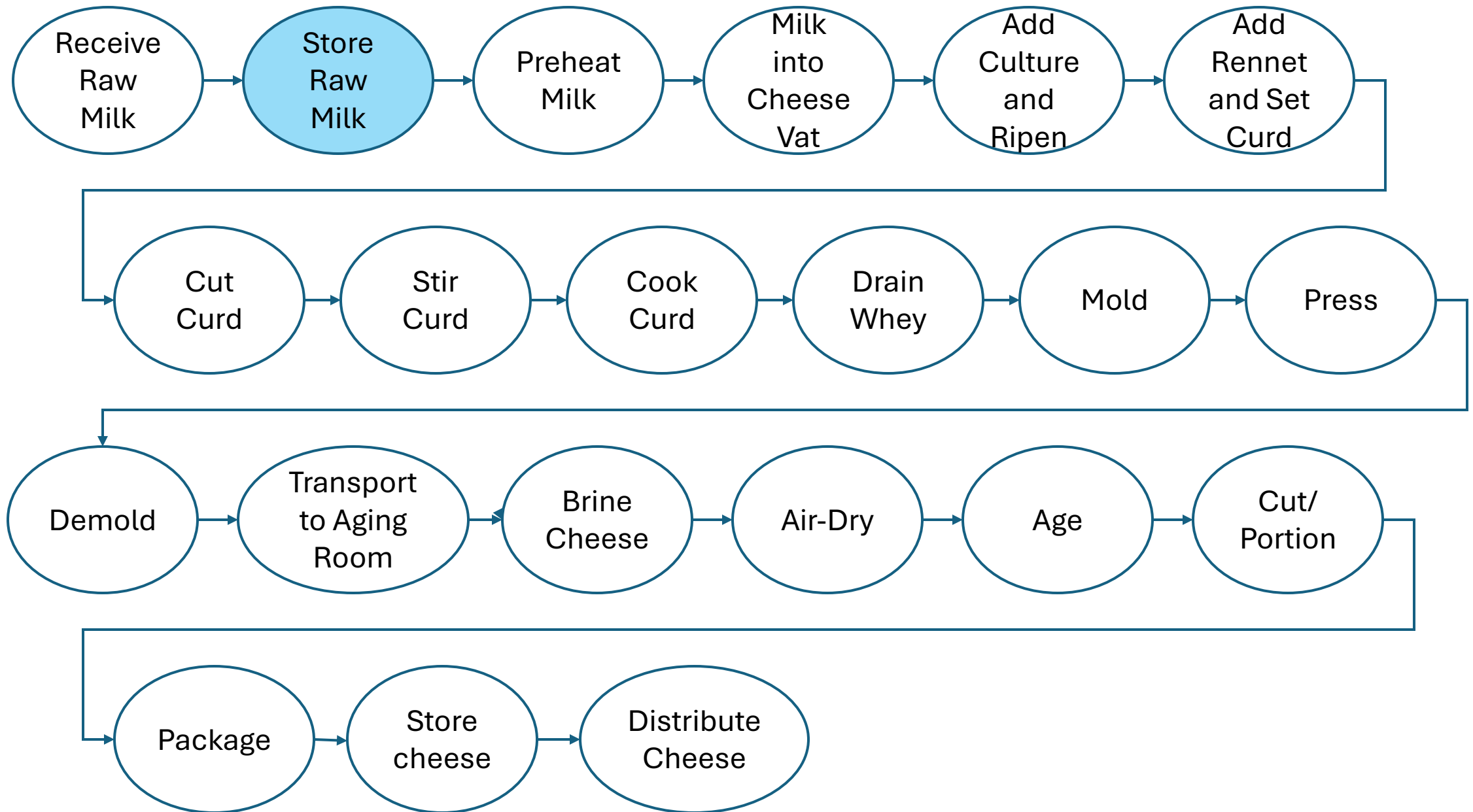
Receive Raw Milk



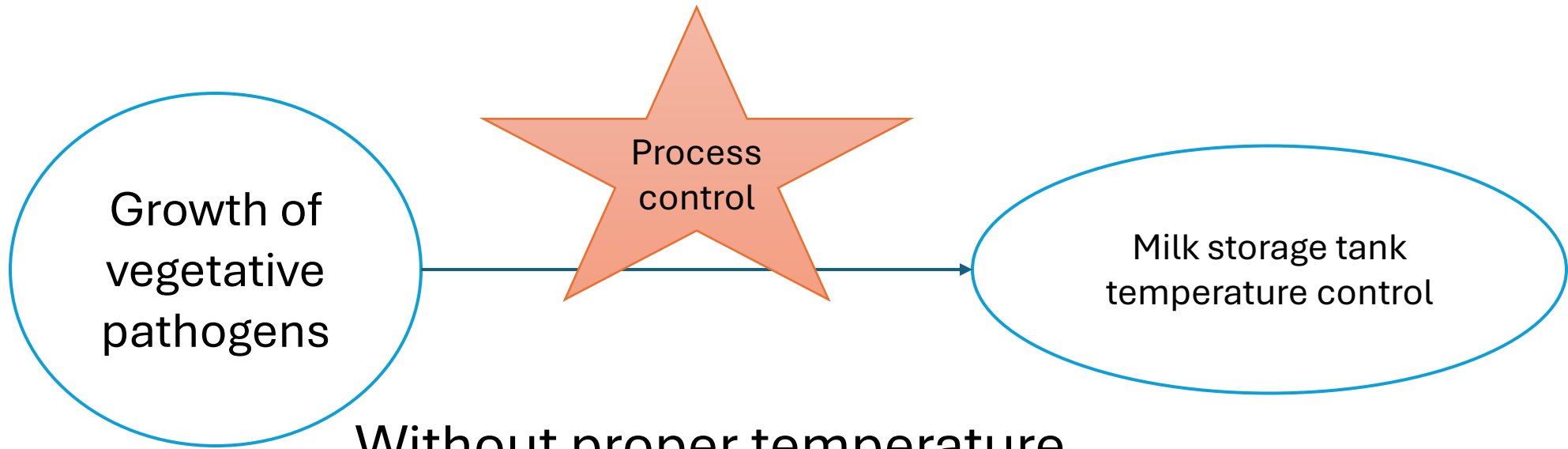
Receive Shelf-Stable Ingredients



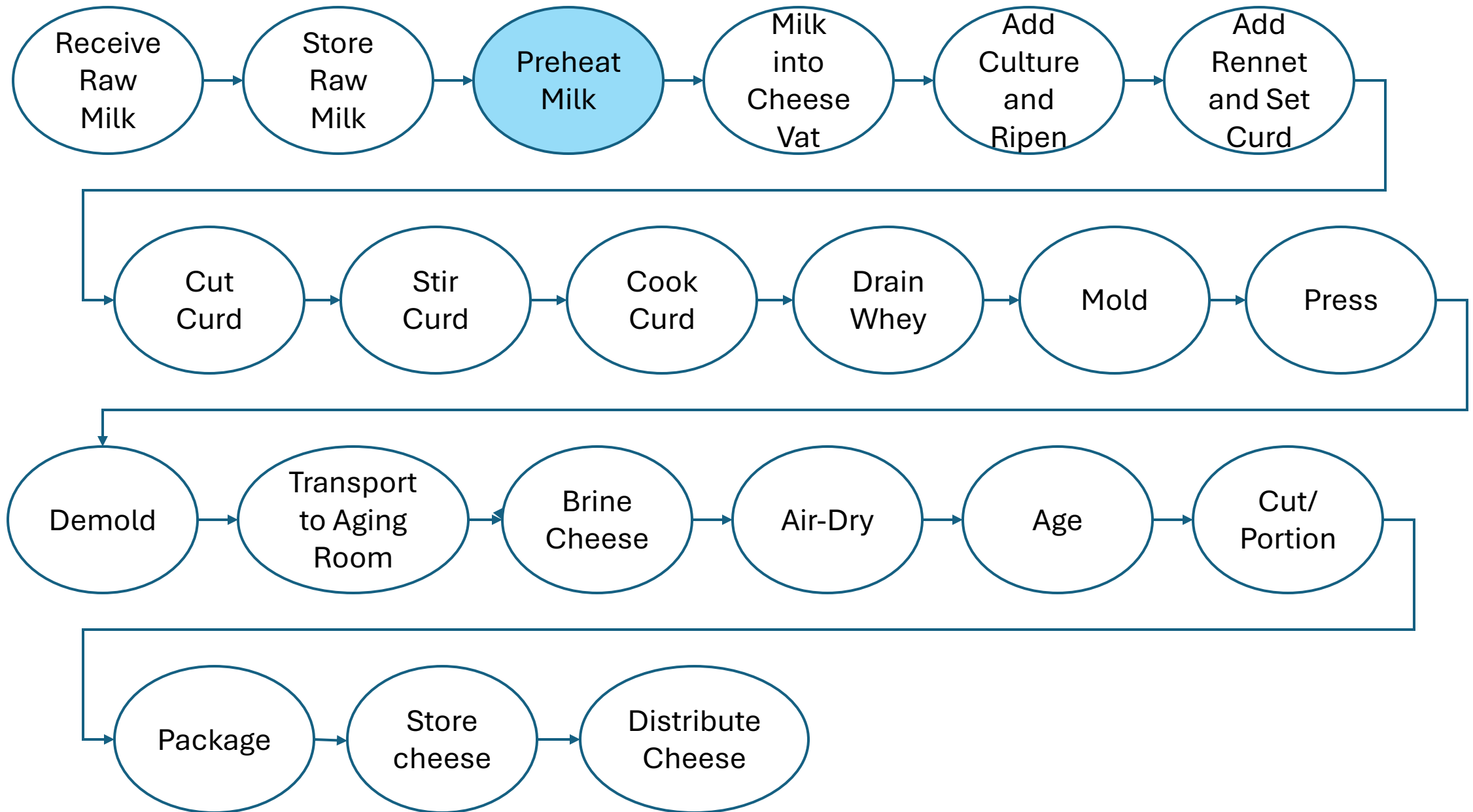
Dry seasonings, including pepper and dried herbs, have been associated with pathogens such as *Salmonella*



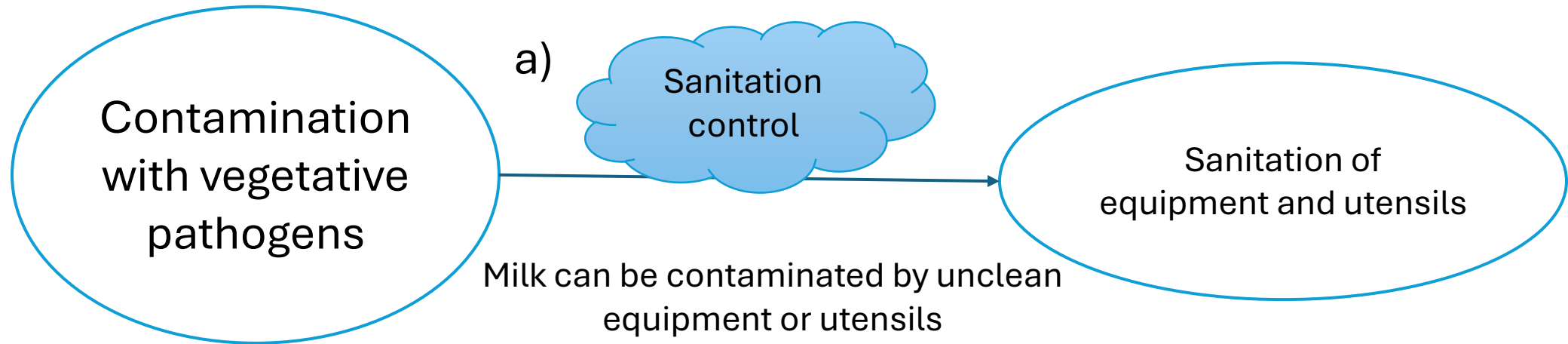
Store Raw Milk



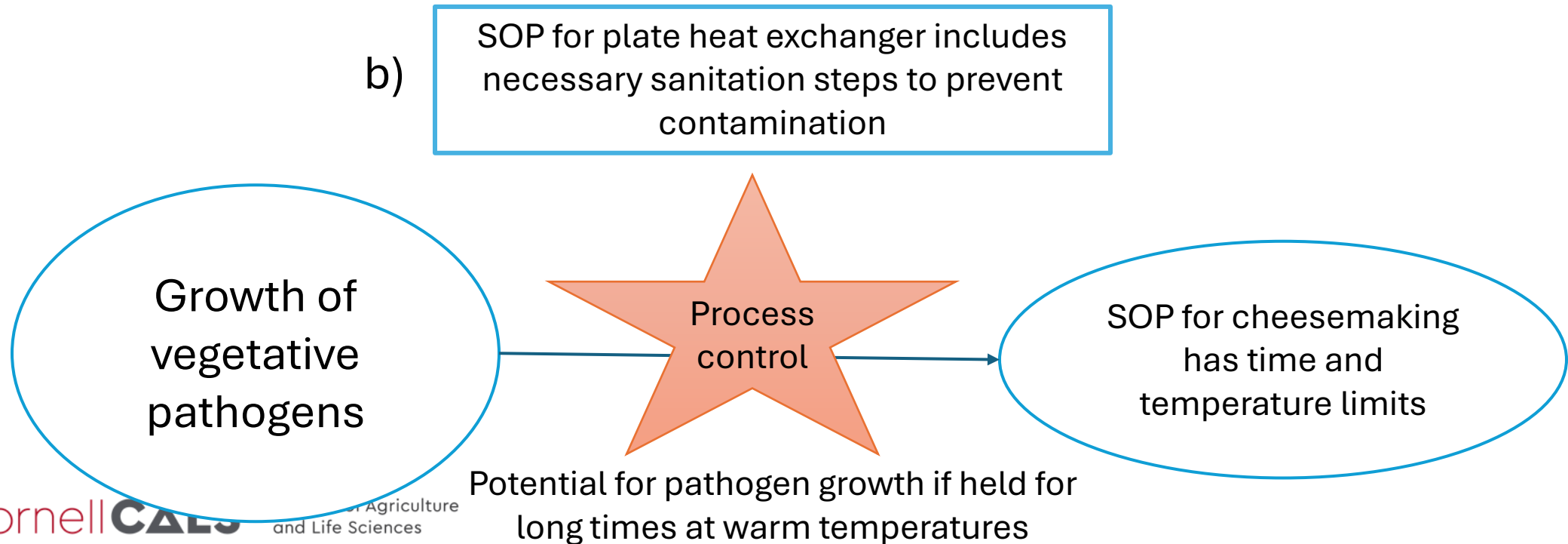
Without proper temperature controls, vegetative pathogens can multiply

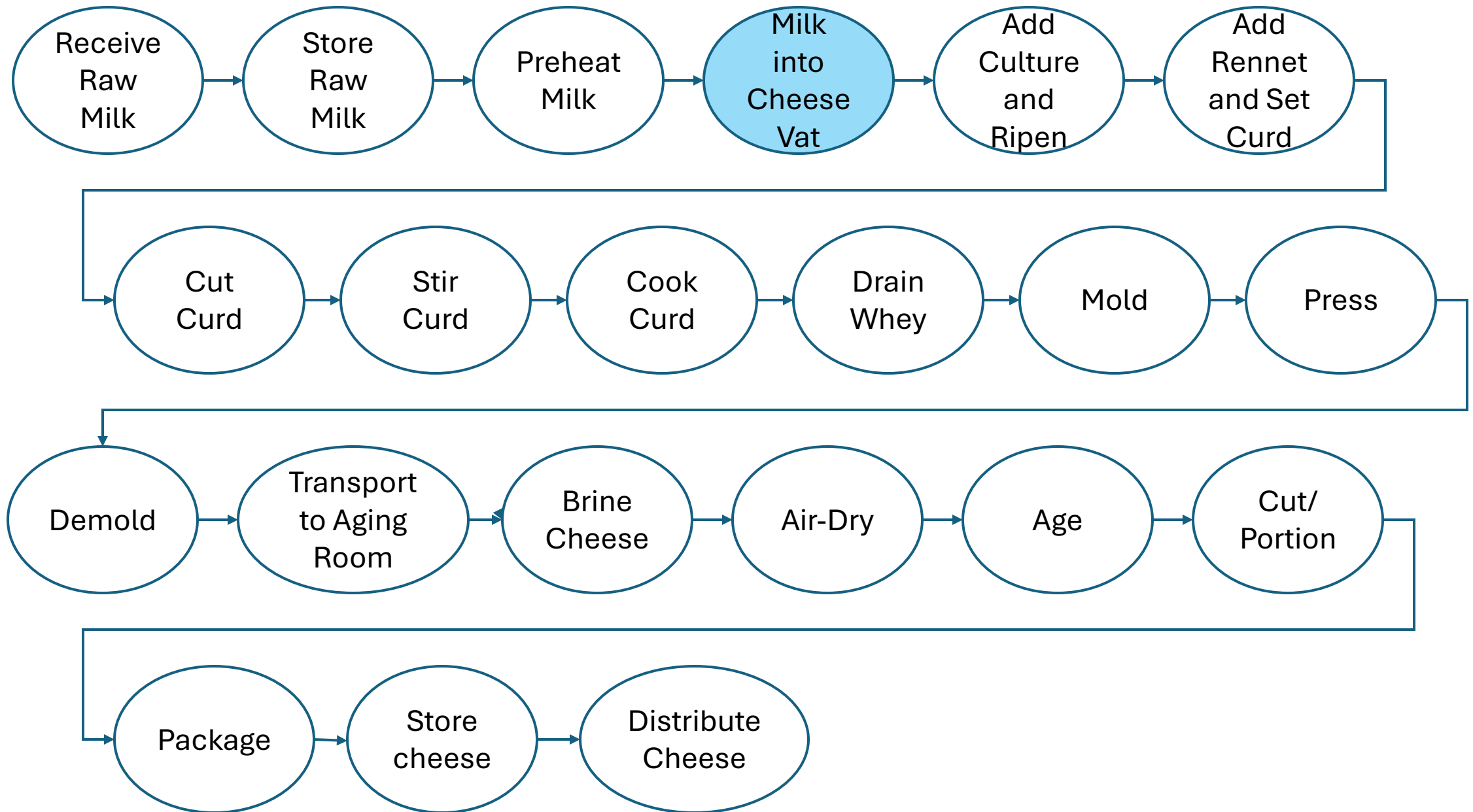


Preheat Milk

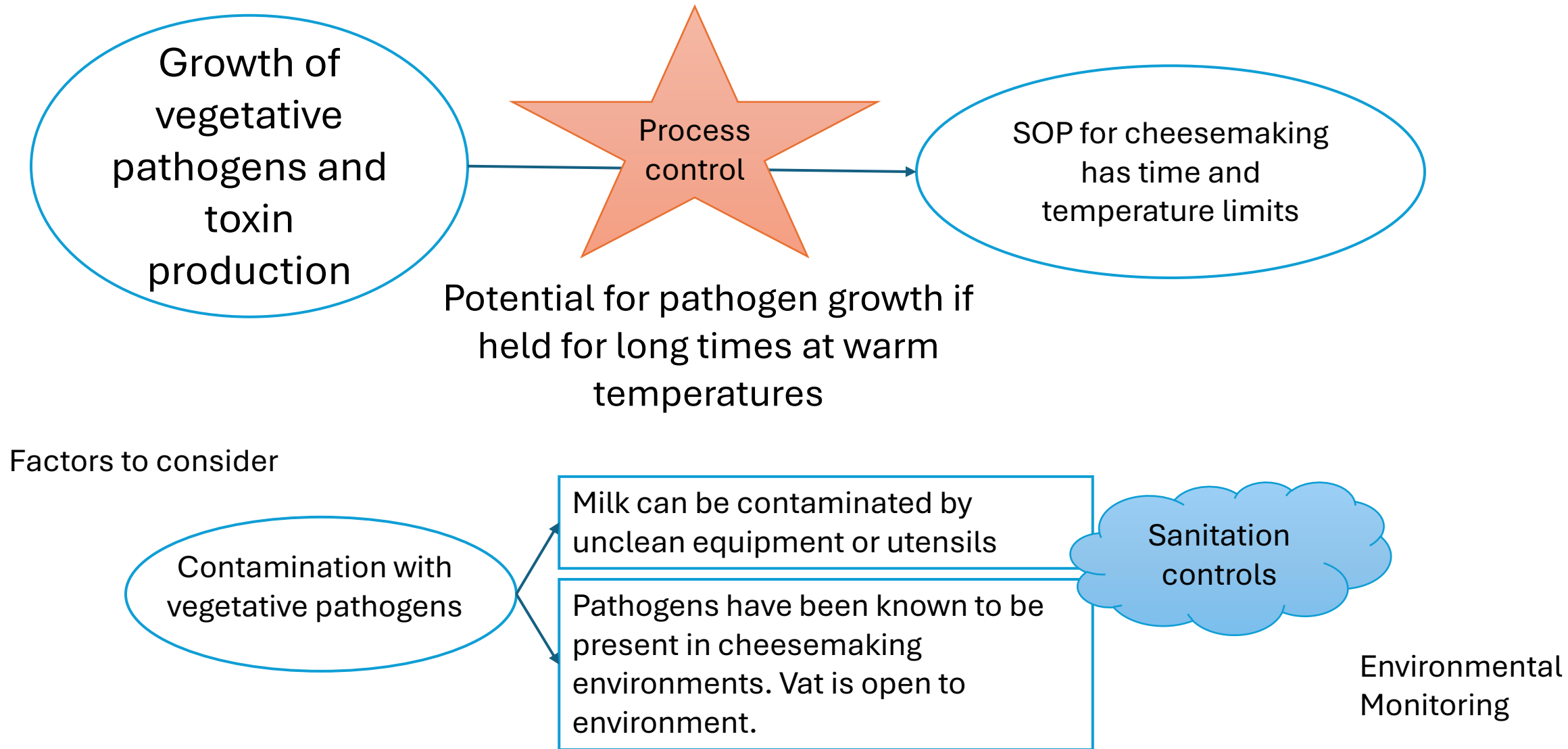


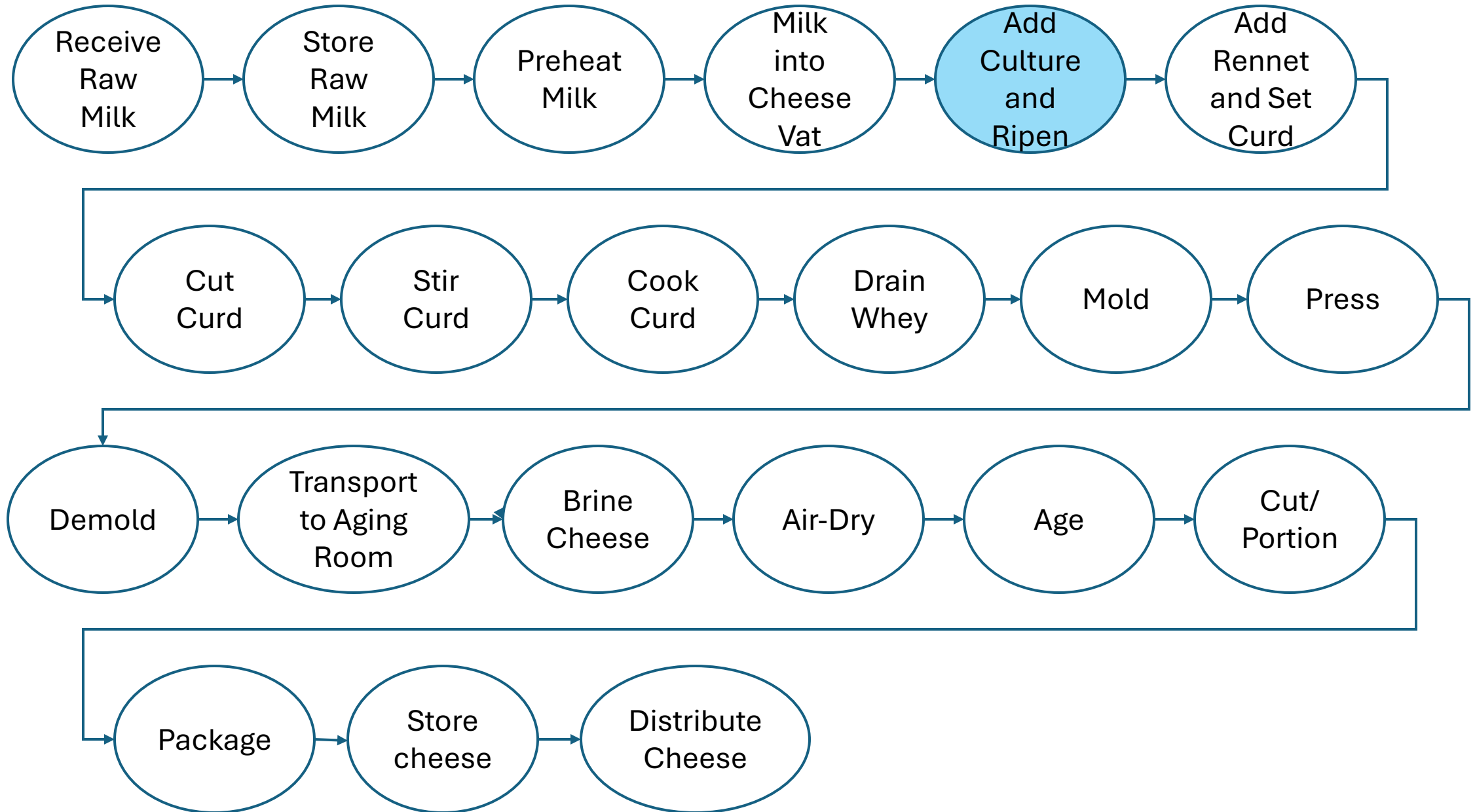
or



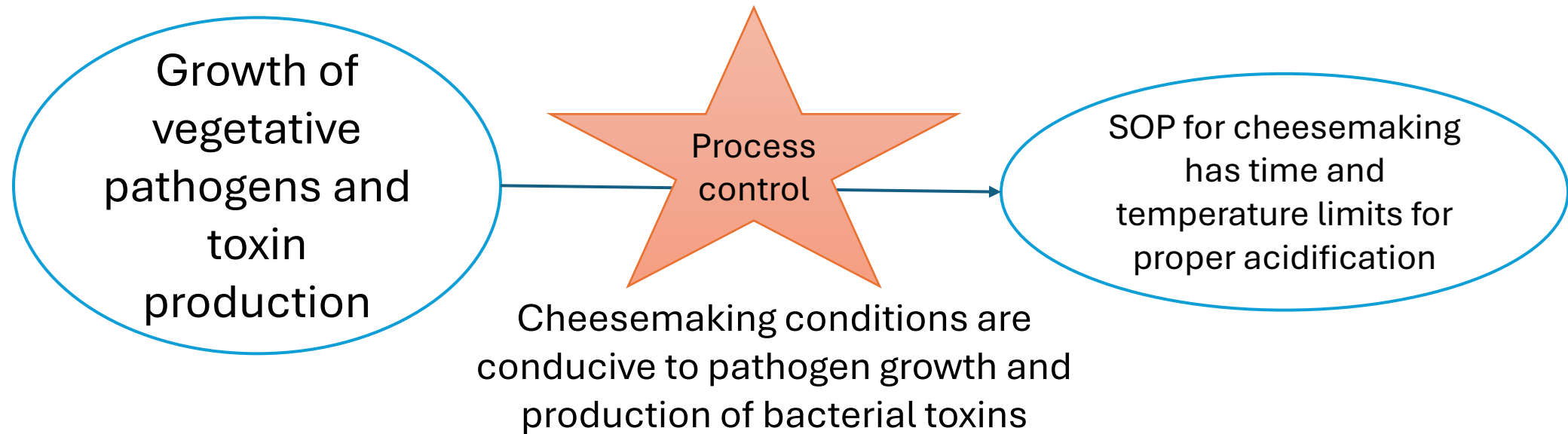


Milk into Cheese Vat

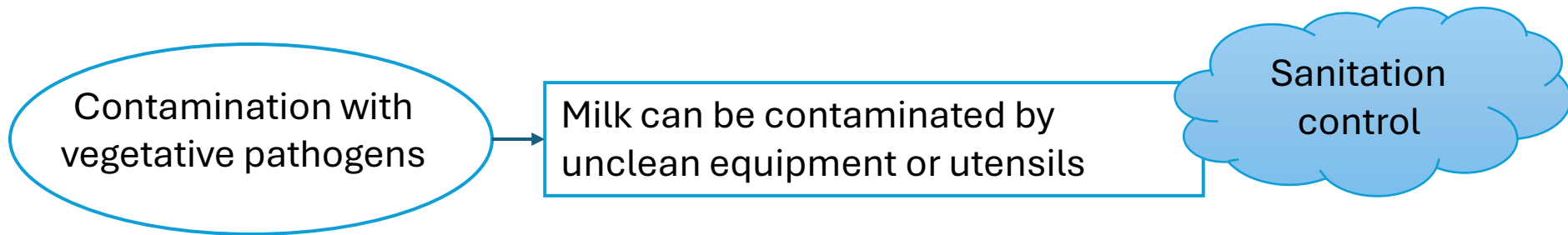


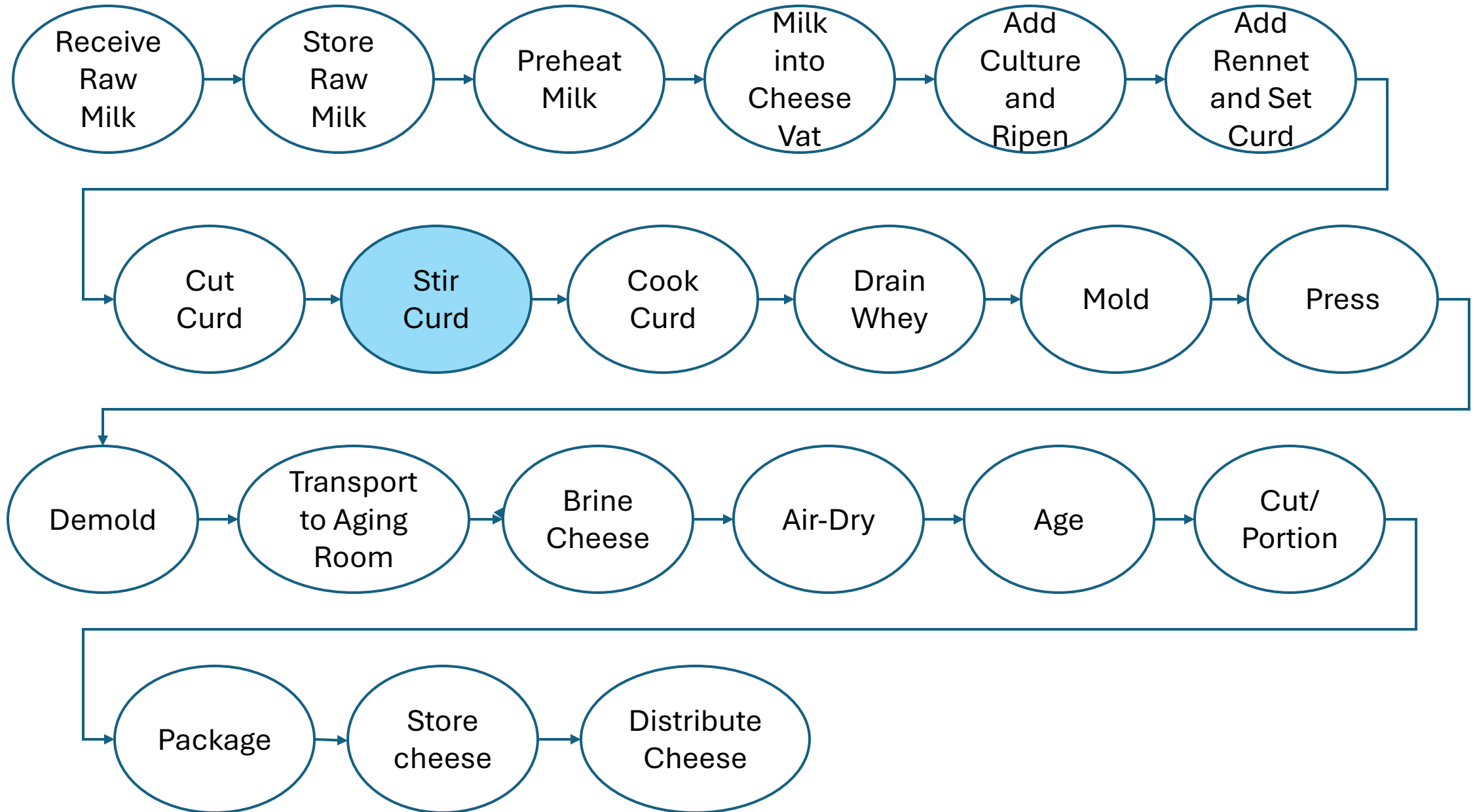


Add Culture and Ripen

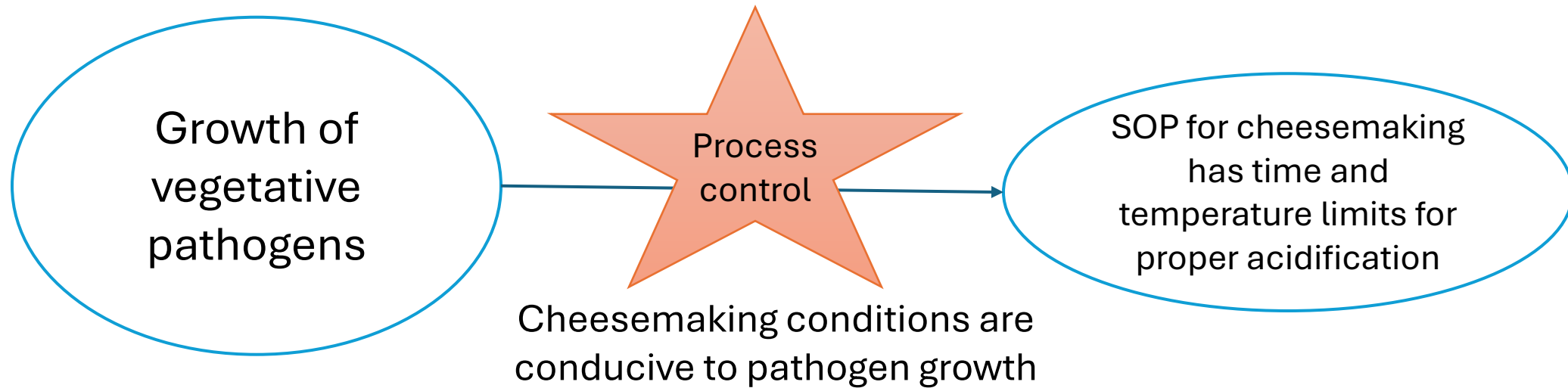


Factor to consider

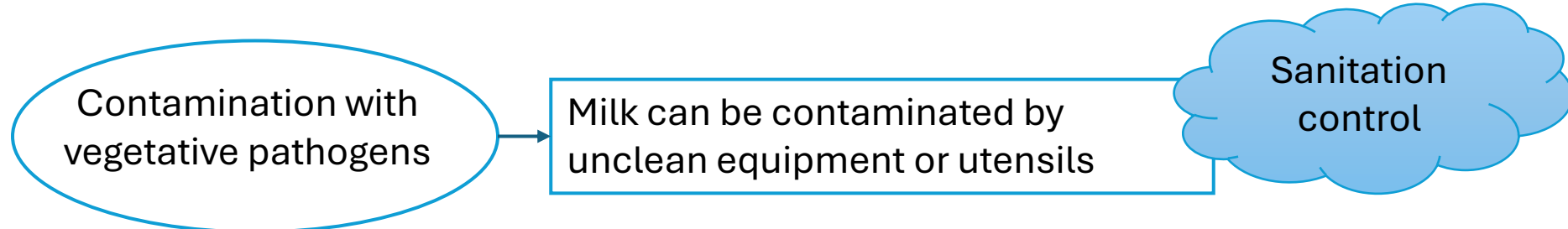


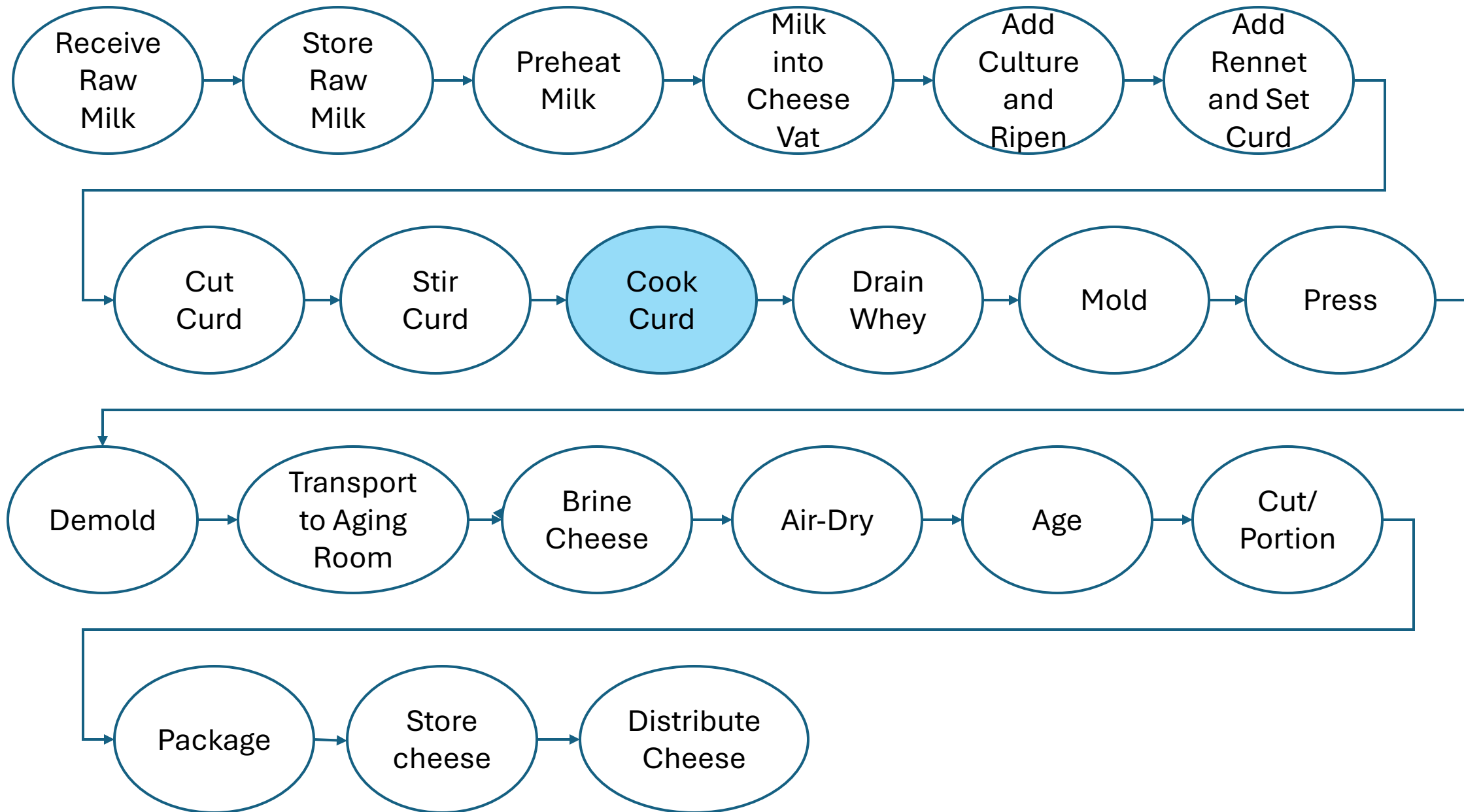


Stir Curd

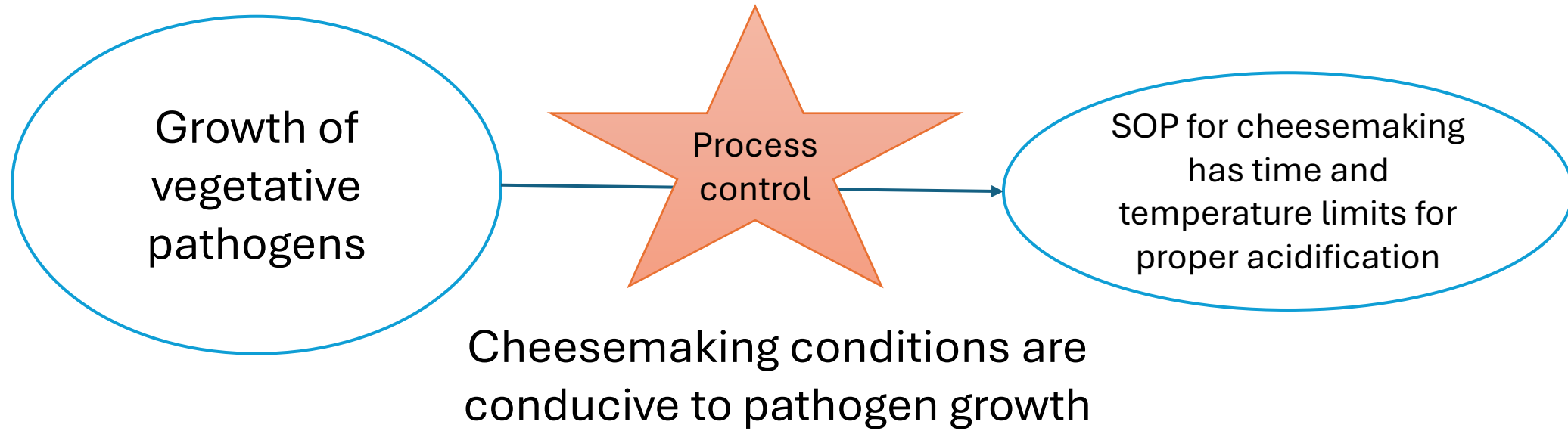


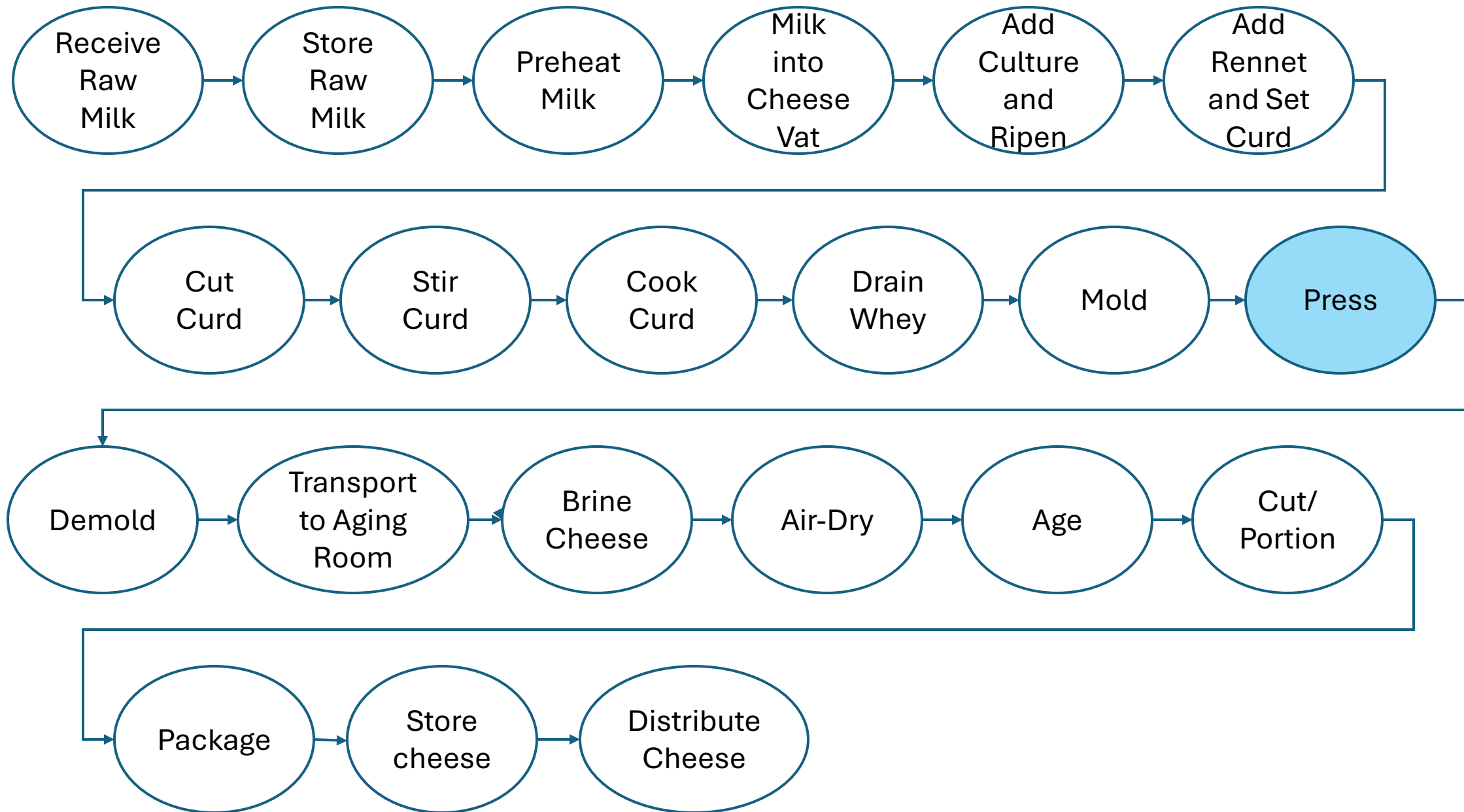
Factor to consider



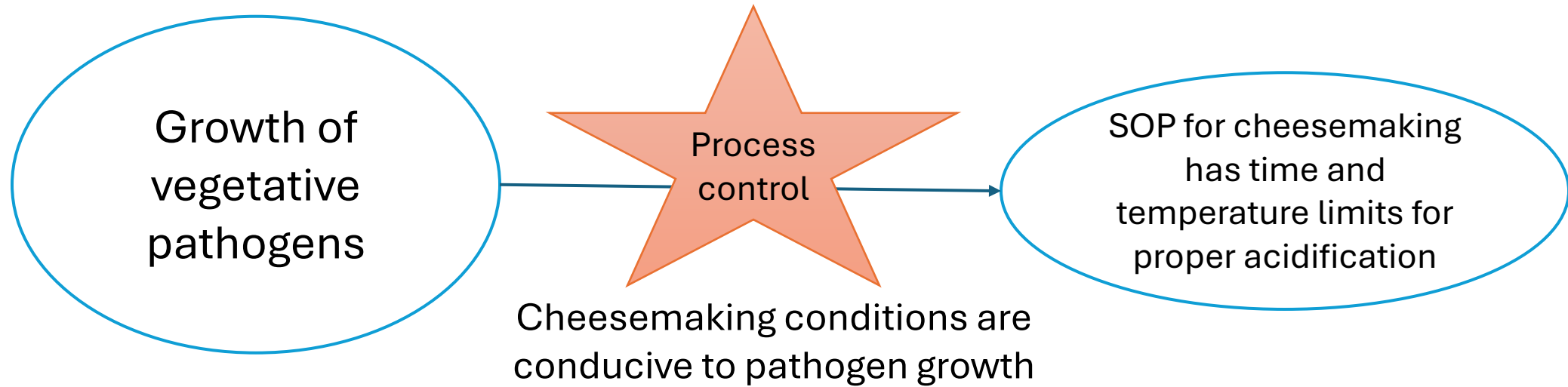


Cook Curd

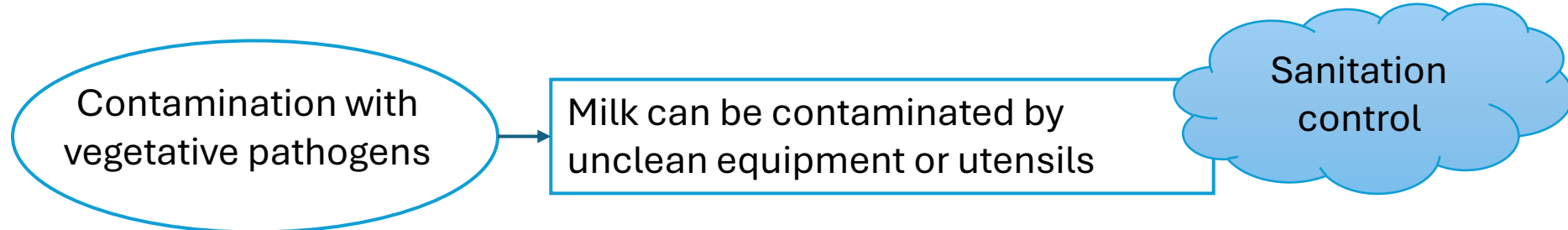


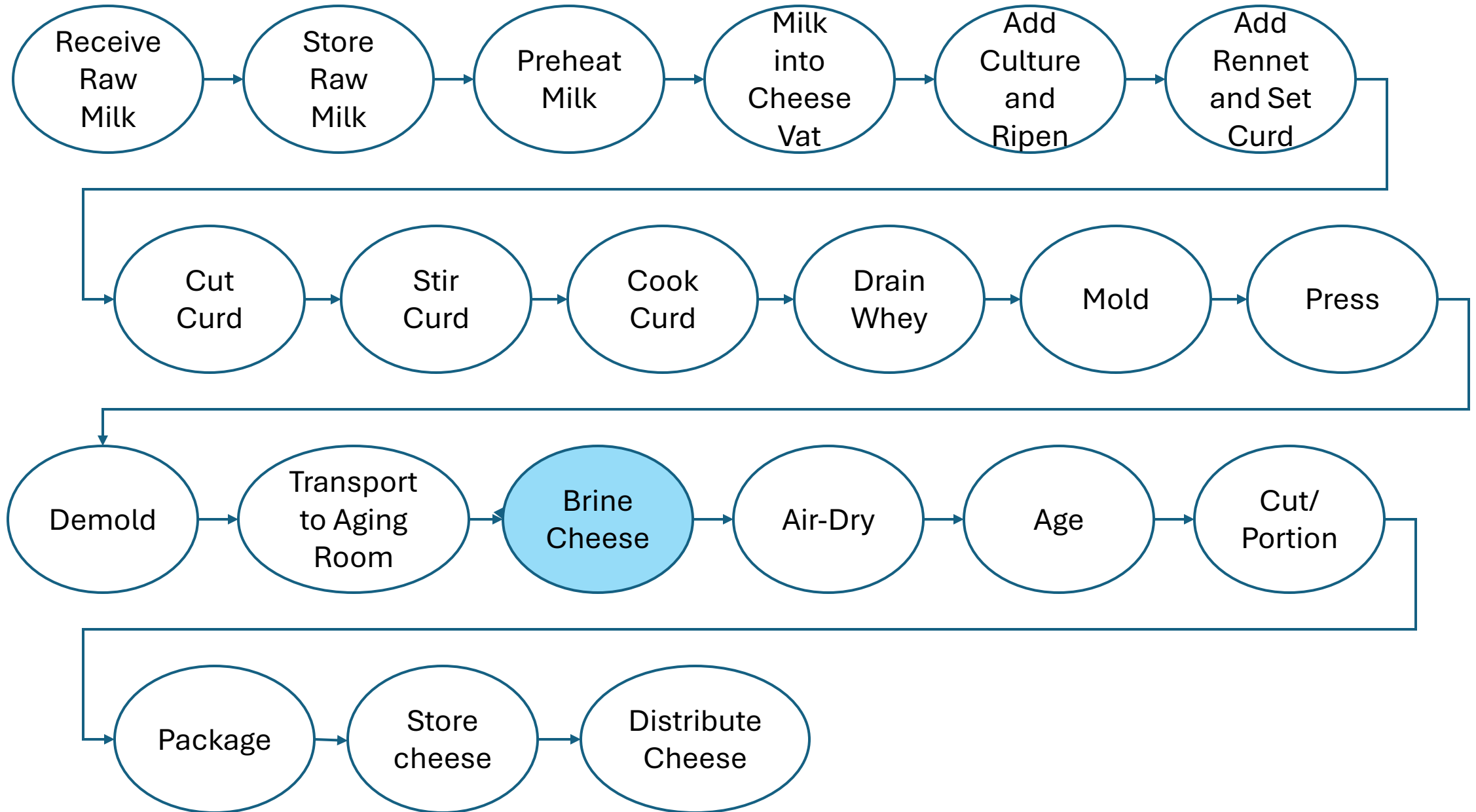


Press

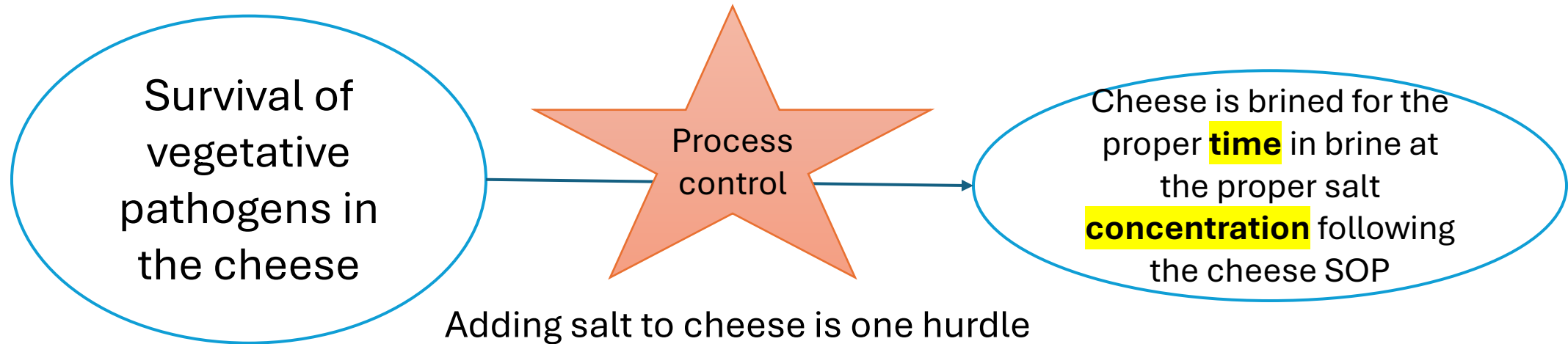


Factor to consider



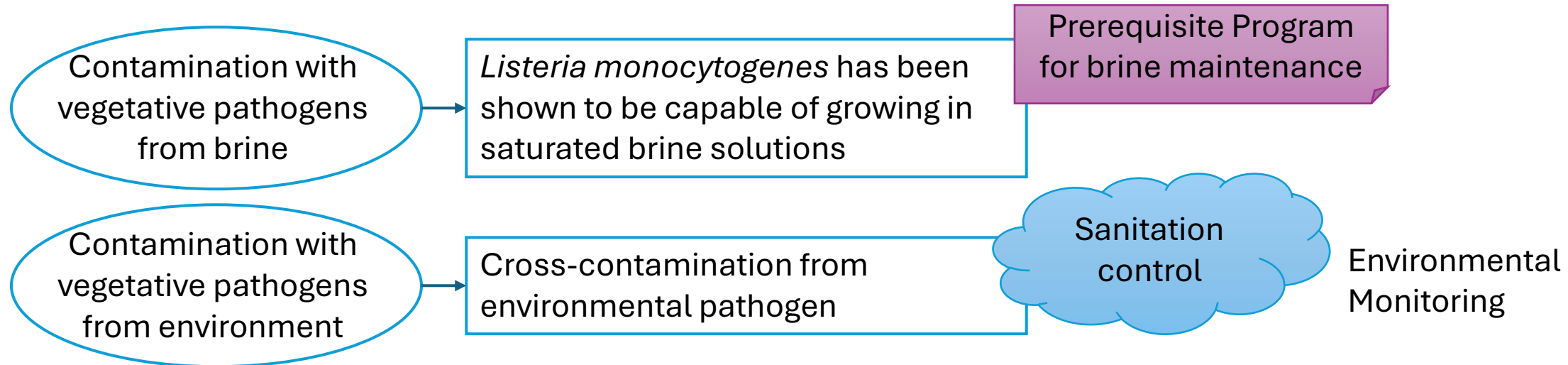


Brine Cheese



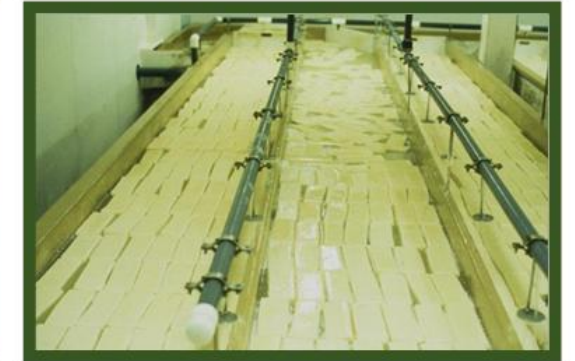
Adding salt to cheese is one hurdle needed to limit the growth of vegetative pathogens

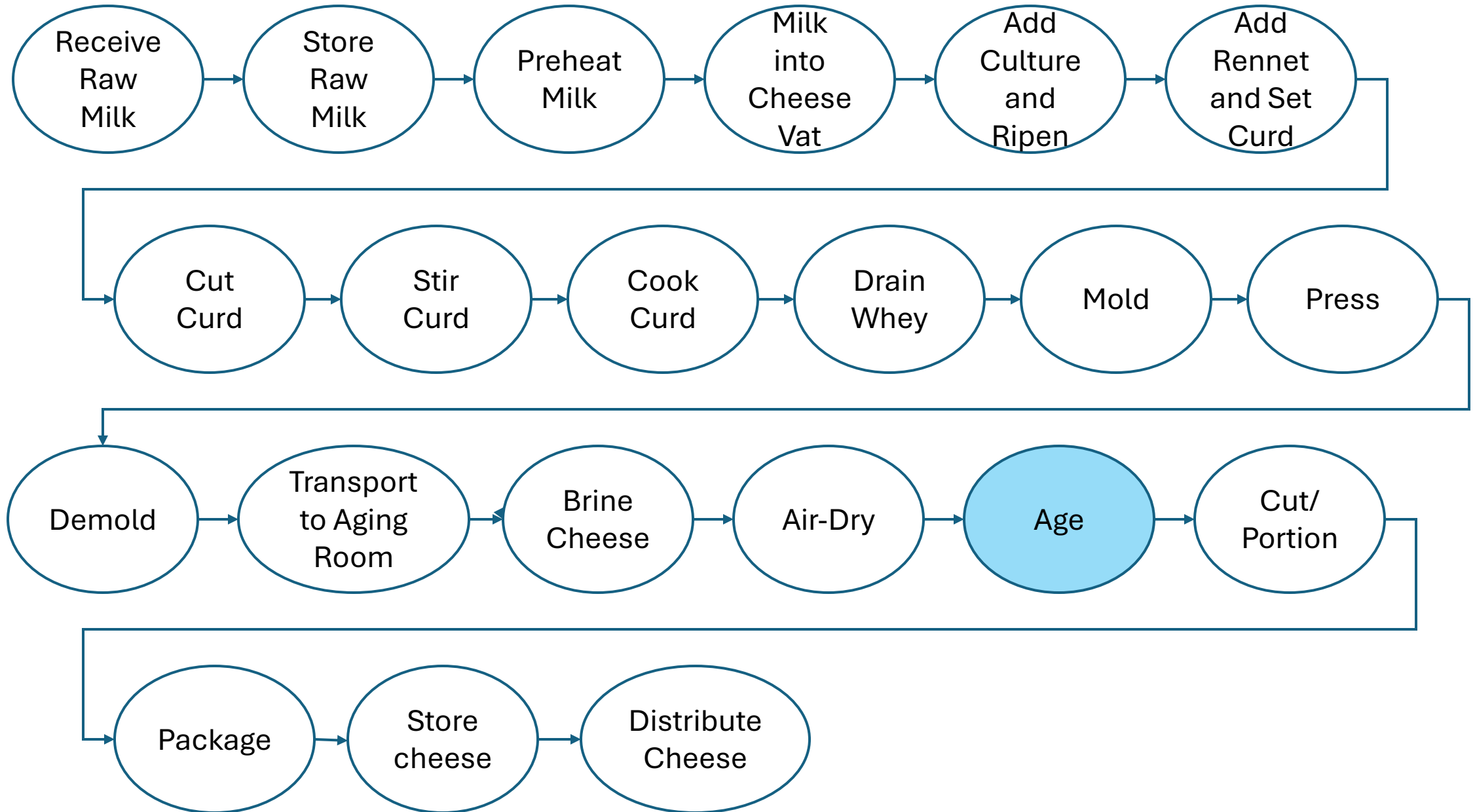
Factors to consider



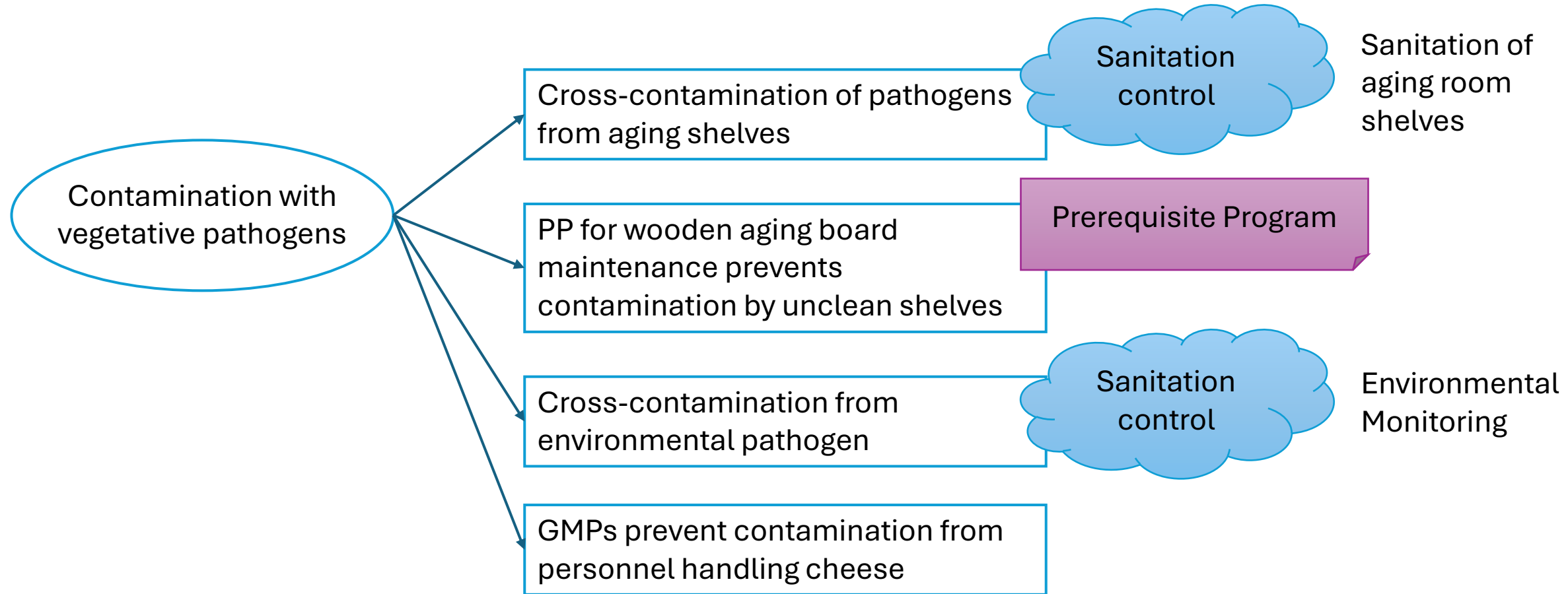
Brine

- Visual examination
- Salinity (NaCl) 21-23%
- Calcium: 0.1-0.3% CaCl₂
 - Depending on the cheese type
- pH < 5.4 (same as the cheese)
- Temperature < 50 °F

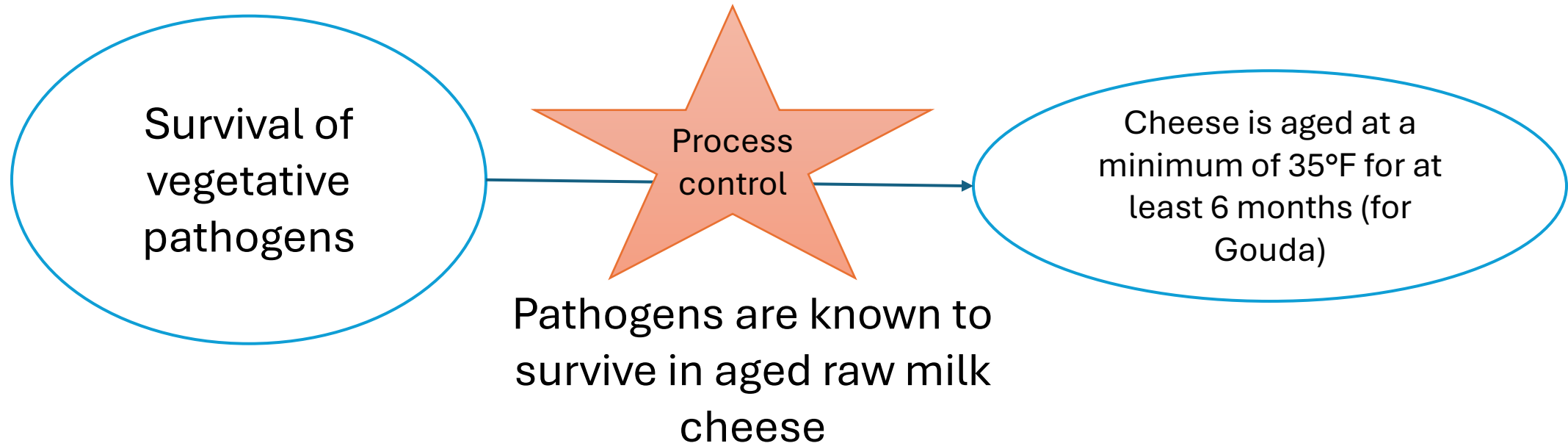




Age



Age

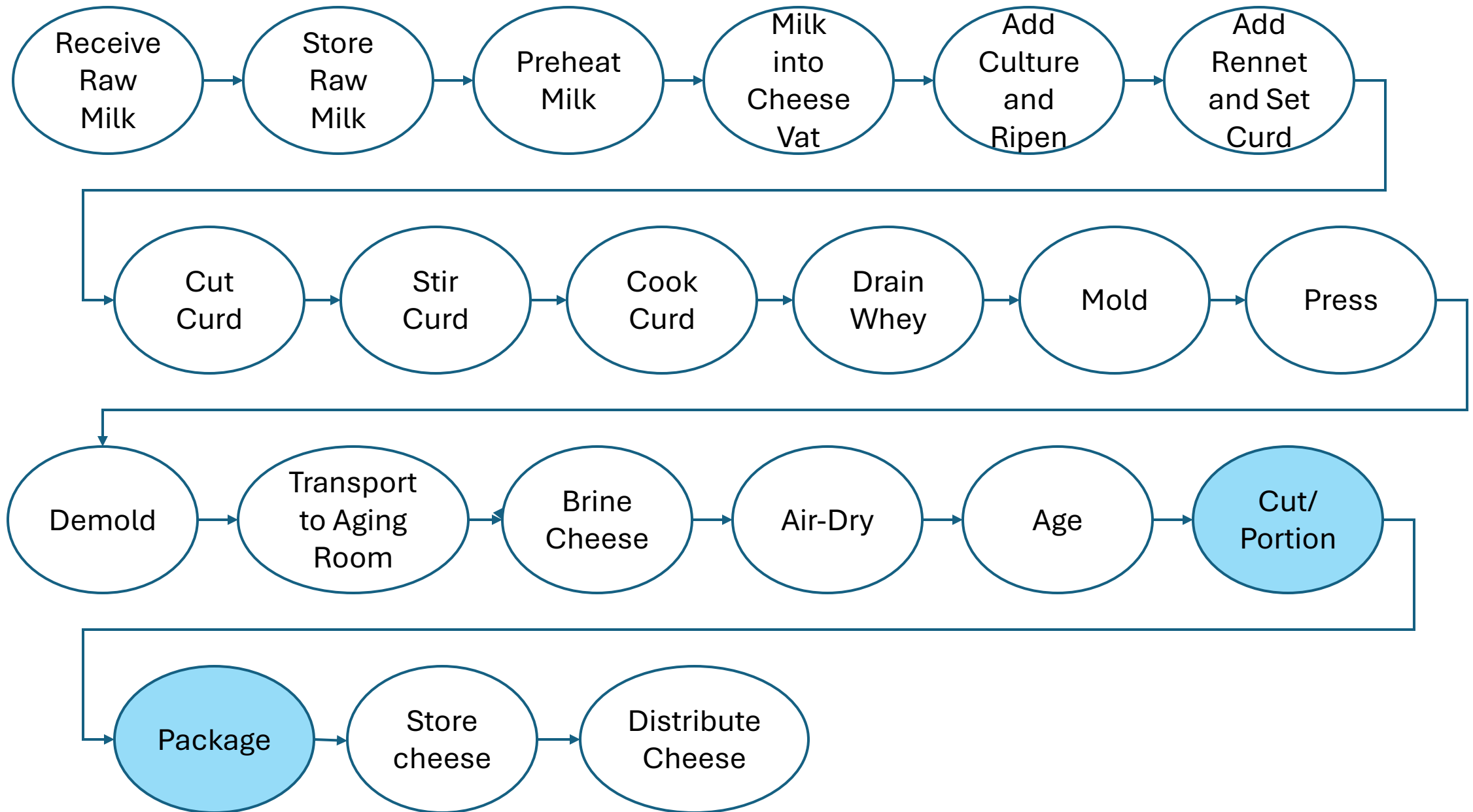


The aging time and temperature process controls meet or exceed those required by the CFR for cheese made using unpasteurized milk. Additional hurdles to pathogen survival include the **salt content, moisture content, low pH, competitive inhibition from cheese cultures**, and **reduced likelihood of contamination due to sanitation and supply chain controls**.

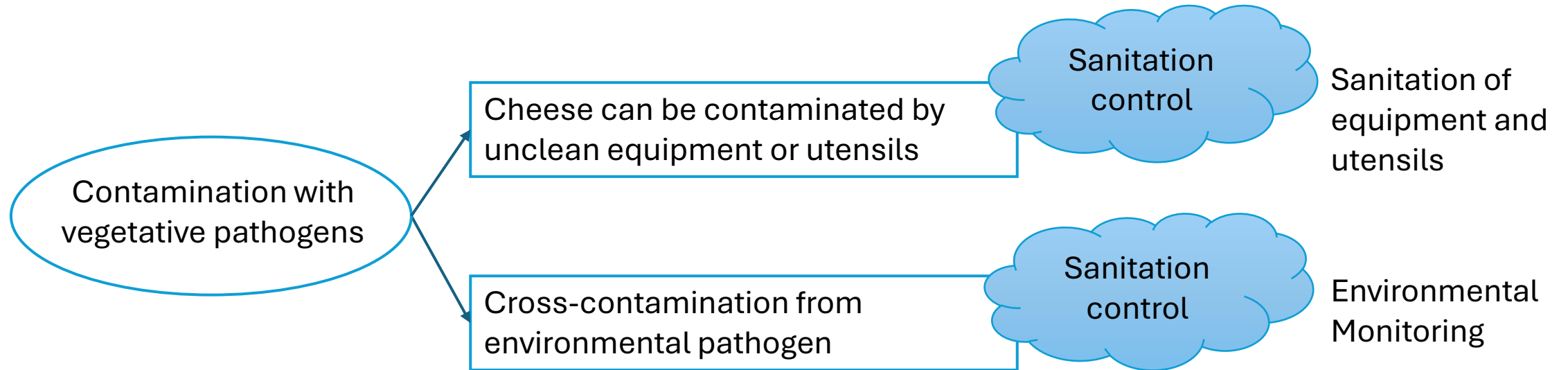
Wooden boards

- Should be cleaned and dried in the same building as the aging room to avoid outside contamination
- Should not come in contact with the floor or other unsanitary surfaces at any time
- The minimum suggested cleaning conditions are:
 1. Wash and scrub boards with 140°F soapy water.
 2. Rinse boards with 140°F water.
 3. Sanitize boards with either a 200 ppm chlorine solution or a 10% hydrogen peroxide solution. Do not rinse off the sanitizing solution.
 4. Dry boards thoroughly using air or in a drying kiln. Air-dried boards should be placed on metal shelves with sufficient space between the boards for proper air flow.
 5. Store clean, dry boards in a sanitary manner until next use.
 6. Fill out cleaning and sanitizing records.

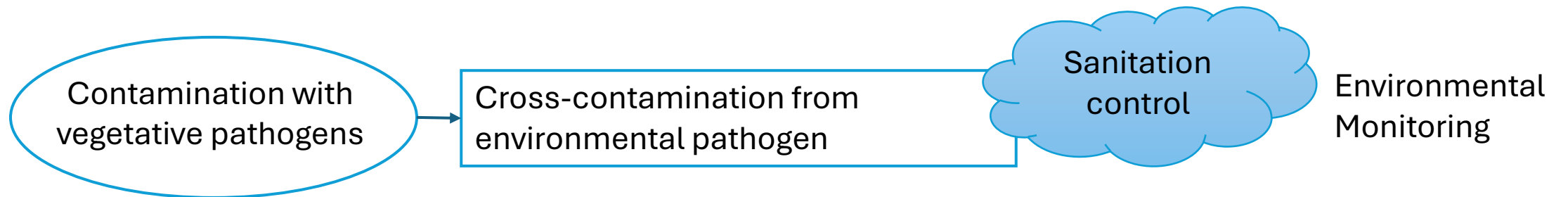
(Kaylegian, 2018)



Cut/Portion



Package



Common denominator?

- Standard Operating Procedures - SOP
- Sanitation
 - Environmental monitoring

Top Ten Places to Find Listeria

1. Drains- production/aging rooms
2. Floors
3. Floor squeegees/brushes
4. Shoes/Boots
5. Pooled water
6. Step stools/ladders
7. Hoses and hose nozzles
8. Wheels
9. Base of milk cans
10. Walls

Top Ten Places to Find Listeria (cont.)



What is an Environmental Monitoring Program?

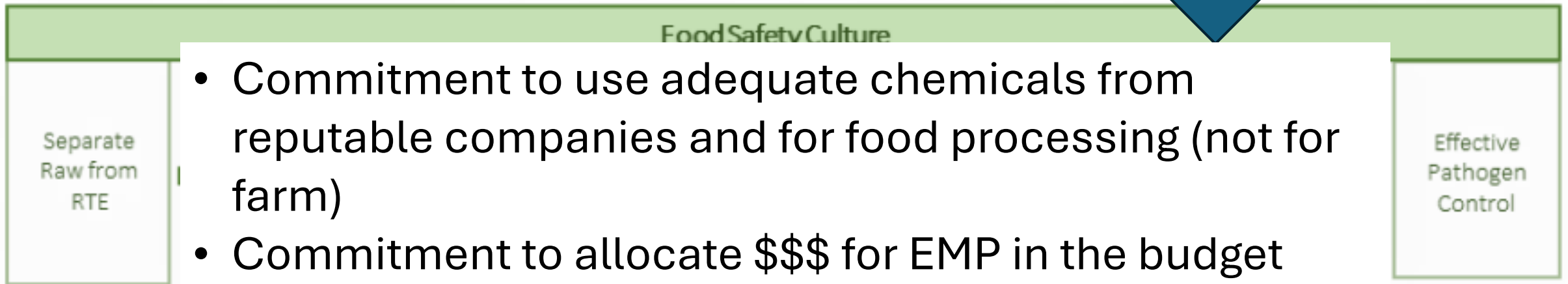
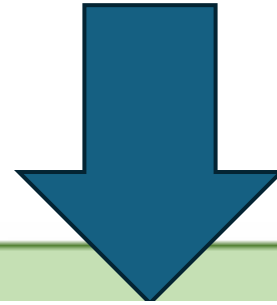
A program that organizes the monitoring process to help prevent cross-contamination of the finished product

EMP may include:

- Cleaning and sanitation procedures
- Sampling and frequency
- Corrective actions
- Data analysis
- Trending

Environmental Monitoring Does Not Control Pathogens

Food Safety culture is key



Why is an EMP needed?

EMP is an early indicator of a problem

- Allows you to identify a contaminant before it contaminates finished product
- Find the contamination, take necessary corrective action to remove the contamination- Seek and Destroy

You can't rely on pasteurization alone for food safety!

- Post pasteurization contamination

Proactive vs Reactive

- Find the problem before the problem finds you!
- Seek and destroy!

Take home message

- Yes, raw milk cheese it's legal but...
 - **High risk:** soft surface-ripened cheese (Brie and Camembert) due to high pH
 - Steer them away from surface ripened cheeses
 - Make sure people understand the longer you age, the better
 - 60-day aging does not provide an appropriate margin of safety in all cheeses
 - If they do surface-ripened cheeses:
 - What controls do they have in place?
 - Minimize your risks
 - Watch out for Sanitation controls, such as wooden boards

Take home message

- Food safety is not just about technical competencies: **Food safety culture**
- "If you're gonna do raw milk cheese, you got to do it right"
- 3-4% sales should be spent on Environmental Monitoring


Resources for raw milk cheese producers

- Cornell: Artisan food safety plan, workshops
- Penn State guide and teaching example
- US Center for Innovation
- American Cheese Society



Cornell Dairy Foods Extension Program





What we do
We explain
the “why”

Dairy Foods Certificate Program

Core Courses

(Dairy Science and Sanitation, a Food Safety Course, and a Pasteurizer Course required)

Dairy Science and Sanitation

Food Safety Course (one required)

- Accredited HACCP
- Preventive Controls Qualified Individual

Pasteurizer Course (one required)

- HTST
- Vat

Specialized Courses

(Choose one specialized course per certificate)

Science of Cheese
(Basic Level)

Science of Yogurt
(Basic Level)

Fluid Milk
Processing for
Quality and Safety

Ice Cream and
Frozen Desserts
(Basic Level)

Membrane,
Evaporation, and
Drying Technology

Advanced Core Courses

(All courses required)

Environmental Monitoring
Programs

SOP and Technical Writing

Leadership Skills for Success

Advanced Specialized Courses

(Choose one advanced specialized course per certificate)

Science of Cheese
(Advanced Level)

Science of Yogurt
(Advanced Level)

Fluid Milk Processing
(Advanced Level)

Ice Cream and Frozen
Desserts (Advanced Level)

Successful completion of Core Courses and appropriate Specialized Course required for Basic Certification. Certificate valid for 3 years. 15 hours every 3 years of approved course work or meeting attendance required for renewal. See examples on the back page.

Dairy Foods Certificate Program

*Example: I want to earn an Advanced Science of Cheese Certificate. What courses should I take? **

Core Courses

Basic Dairy Science and Sanitation

HACCP

Vat Pasteurizer

Specialized Courses

Science of Cheese (Basic Level)

Advanced Core Courses

Environmental Monitoring Programs

SOP and Technical Writing

Leadership Skills for Success

Advanced Specialized Course

Science of Cheese (Advanced Level)

*(*Example progression. Our team will work with you to customize your progression.)*

*I need to renew my Basic and/or Advanced Certificate. How do I do that? **

Example renewal suggestions listed below. Our team will work with you to customize renewal.

Attend Association
meeting

- NYS Association for Food Protection
- NYS Cheese Manufacturers
- Northest Dairy Foods Association
- American Cheese Society
- IAFP
- IFT
- NADRO
- AFDO
- SQF
- Dairy Practices Council
- Other meetings, pending approval

Attend Dairy Foods
Extension Workshop

- Any Dairy Foods Workshop
- Any track
- Other Dairy Foods workshops outside of the Certificate program

Attend State and Federal
regulatory webinar,
training, or meeting

- Processing Plant Superintendent
- Dairy Lab Seminar
- CMI Scool
- CMI Update
- NCIMS

Attendee Locations

- All Northeast States
- Midwest: WI, MN, MI
- West Coast: CA, WA, OR, ID, Alaska, Hawaii
- Southwest: TX, AZ, NV, UT, NM
- South: KY, GA, VA, MS, FL, SC
- International: Canada, Israel, Peru, Columbia, Africa, Venezuela, Argentina, Australia
- State/Province Regulators: Maine, South Carolina, Nevada, Michigan, Alaska, Texas, Florida, Georgia, Vermont, Colorado, Ohio, British Columbia

Spanish-language versions of multiple courses available:

- Dairy Science and Sanitation
- Introduction to Food Safety Principles
- HACCP
- HTST Training materials translated in Spanish
- In-plant trainings
 - GMPs



Sensory Evaluation Workshop

Sensory Immersive Experience in Dairy Foods Workshop

Day 1: Sensory Evaluation in Product Development

- Sensory Fundamentals
- Dairy food lexicons and common methods of sensory testing

Day 2: Sensory Evaluation in Quality Control/Assurance

- Sensory defects in dairy foods (fluid milk, yogurt, cheddar, cottage cheese)



New workshop: Fundamentals of Labeling

- A one-day workshop focused on dairy product labeling fundamentals while exploring real-life examples. Agenda topics included general design, considerations for ingredient and allergen declarations, nutrition regulations, product claims, compliance, and enforcement.
- Delivered October 23, 2024, via Zoom
- 43 participants



New workshop: Aseptic Processing for the Dairy Industry

September 8-9, 2025, Live via Zoom

In-plant Trainings And Consulting





In-Plant Trainings

- Dairy Science and Sanitation
- Sensory
- Environmental Monitoring
- HACCP
- SQF
- Internal Auditing
- Customized trainings

1

Visited plants to oversee and validate sampling

2

Worked with teams to modify and develop environmental monitoring programs

Environmental Monitoring consulting

Gap Audits

- GMP
- Pre-3rd party preparation audit
- Food Safety Plan gap audit



Additional Services

- Process Authority
- Food Safety Plan Review
- Food Safety Culture Assessment

