

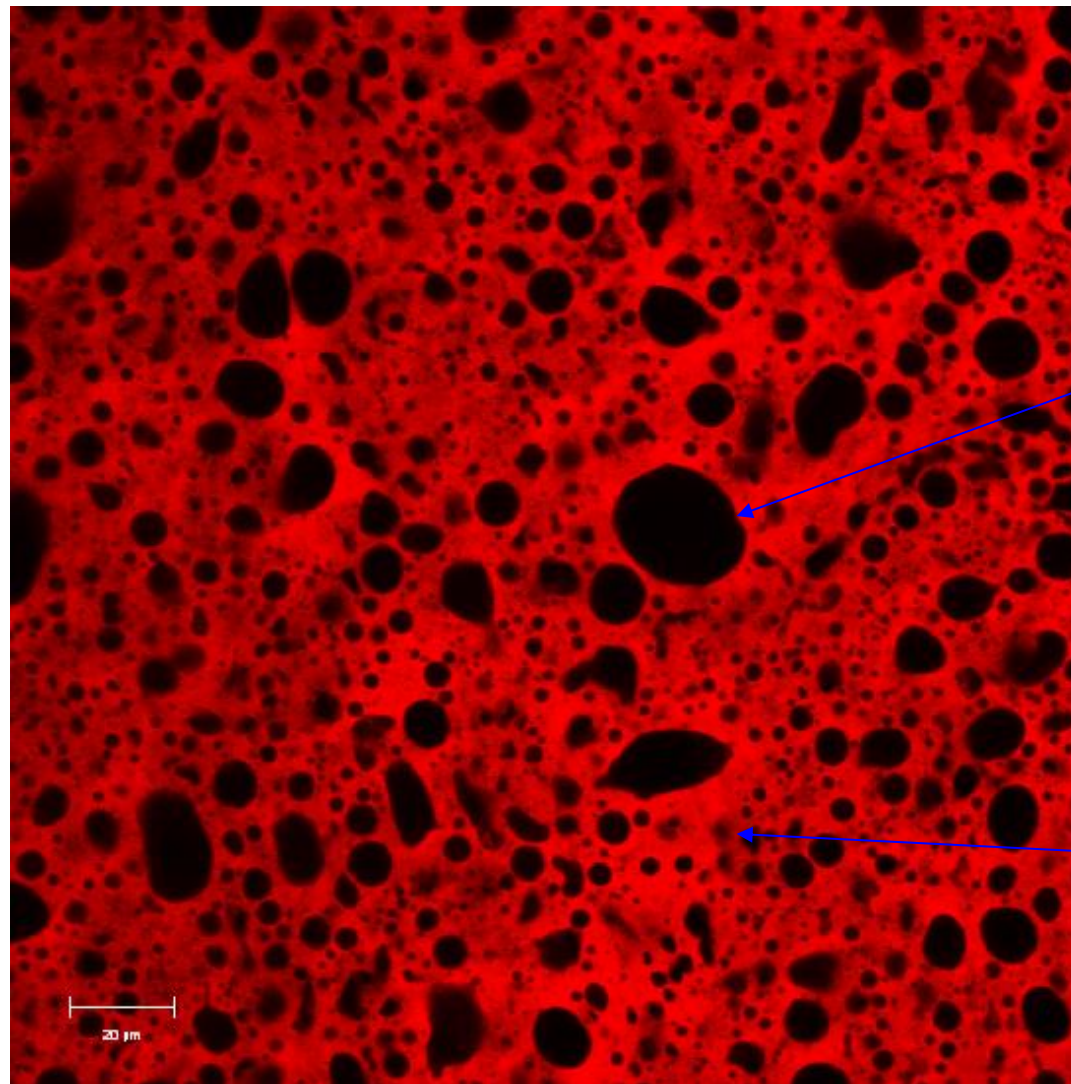
NCDEA/Dairy Australia

Microbiology of Butter

Steve Flint

November 2014

Confocal Microscope Image of Butter



Water

Fat

Microbiological Issues with Butter

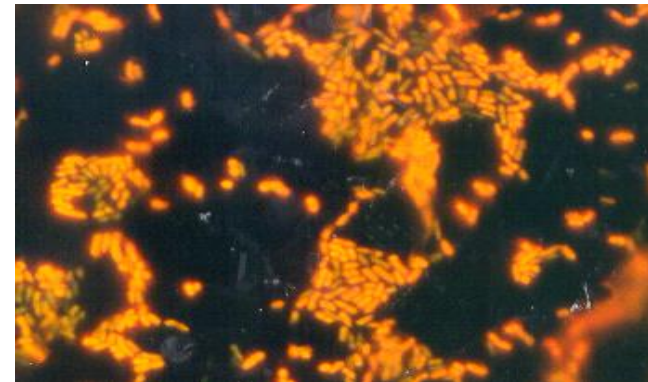
Primary Causes:

Spoilage issues
Specification limits

Coliforms

E. Coli

APC



Microbiological Specifications for Butter

MARGARINE AND SALTED BUTTER

Aerobic plate count at 35°C (/g)	n = 5	c = 2	m = 2.5 x 10 ⁴	M = 2.5 x 10 ⁵
Coagulase producing staphylococcus (/g)	n = 5	c = 0	m = 0	
Faecal coliform (/g)	n = 5	c = 2	m = 50	M = 5 x 10 ²
* <i>Listeria monocytogenes</i> (/25 g)	n = 5	c = 0	m = 0	
Salmonella (/25 g)	n = 5	c = 0	m = 0	
Yeasts and moulds (/g)	n = 5	c = 2	m = 50	M = 5 x 10 ²

- Ref: 1995 – MOH, New Zealand



Microbiological Specifications for Butter

Microorganism	n	c	m	M
APC/g	5	1	5×10^4	10^5
Coliforms	5	1	10	10^2
Psychrotrophs	5	1	10	10^2
Coag + Staph	5	0	10^2	

ANZFA Standard 1.6.1, 2001



Micro Issues – The NO. 1 cause of downgraded butter – general trends

- Primarily in Fritz plants
- Numerous small incidents of coliform contamination
- Lypolytic contamination
- APC incidents
- Yeast and mould contamination



Micro Issues 2013/2014 Season

Micro. Issue	
APC	
Coliforms	
Yeast and Moulds	
Lipolytics	
<i>Pseudomonas</i>	



Micro problems 2012/2013 season

- Pseudomonas issues – several sites
 - Water and poor cleaning of water systems
- Intermittent coliform issues
- Thermophiles in buttermilk
 - Fat rework (Fritz plant)
 - Fouling of cream concentrators (AMF plants)



Buttermilk Quality – biggest issue 2013/2014

- Thermophilies
 - *Anoxybacillus flavithermus* & *Geobacillus stearothermophilus*
 - Specification limits and spoilage concerns
 - Milk separation and cream holding (poor chilling)
 - Thermalisation not always used
- *B. cereus*
 - Psychrotroph, pathogen and spoiler
- Coliforms
 - As predictor of butter quality



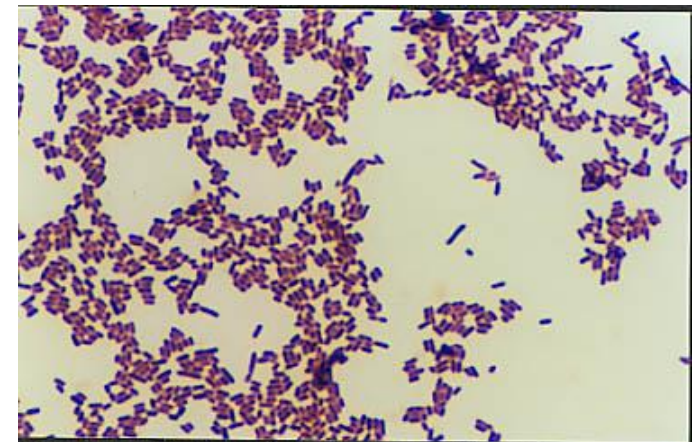
Problems caused by microorganisms in butter

- Exceed customer specifications
- Odours and taints - enzymatic
- Surface discolouration (yeast/moulds and pseudomonads)
- Pathogen concerns



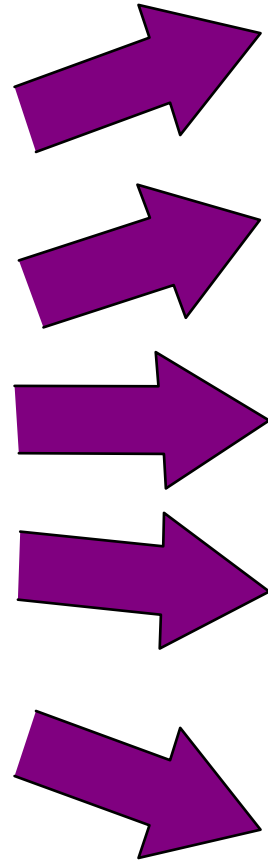
Pathogen Contamination

- Finland outbreak (1999)
 - butter (100-1000 cfu/g *Listeria monocytogenes*)
 - 18 affected, 4 deaths
 - traced to manufacturing plant - several areas
 - product recalled
 - clean up costs



Butter/Cream products

Butter and
Cream Products



Phase reversal

Salt addition

Moisture Removal

Acidification
(Lactic butter)

Refrigeration

Te Kunenga
ki Pūrehuroa



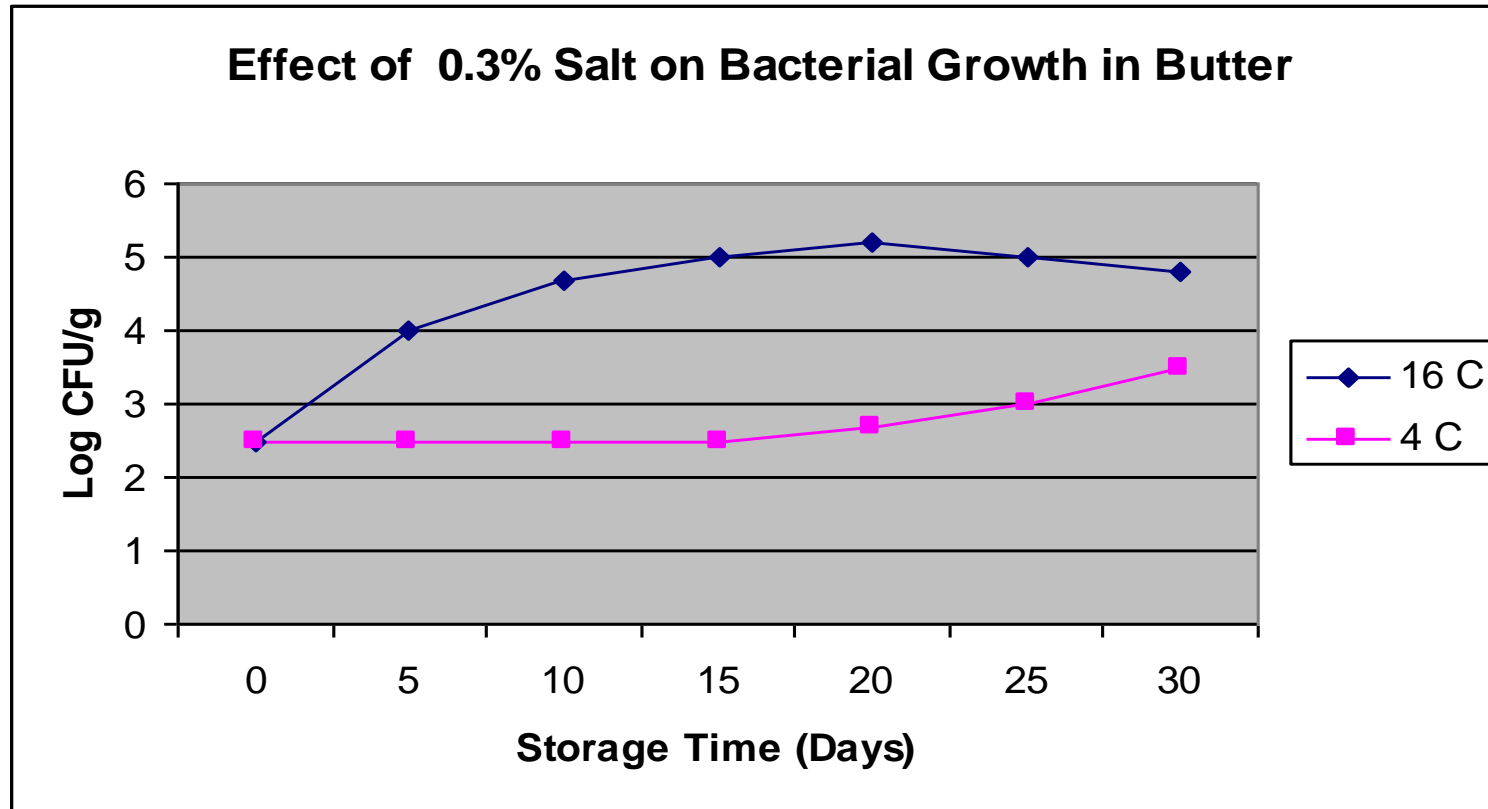
MASSEY UNIVERSITY

Influence of product composition and storage conditions

- Moisture: Small droplets (10 - 30 μm) - restrict bacterial growth
- Freezing / refrigerated storage -
Minimises most microbial growth
(Moulds can grow slowly $<10^{\circ}\text{C}$)
- pH: The acidity of lactic butter -
(pH 4.5 - 5.2) inhibits many bacteria
- Salt: 2% salt (12.8% salt-in-moisture) - inhibits most bacteria
 $(2 \div 15.9 \times 100 = 12.8)$

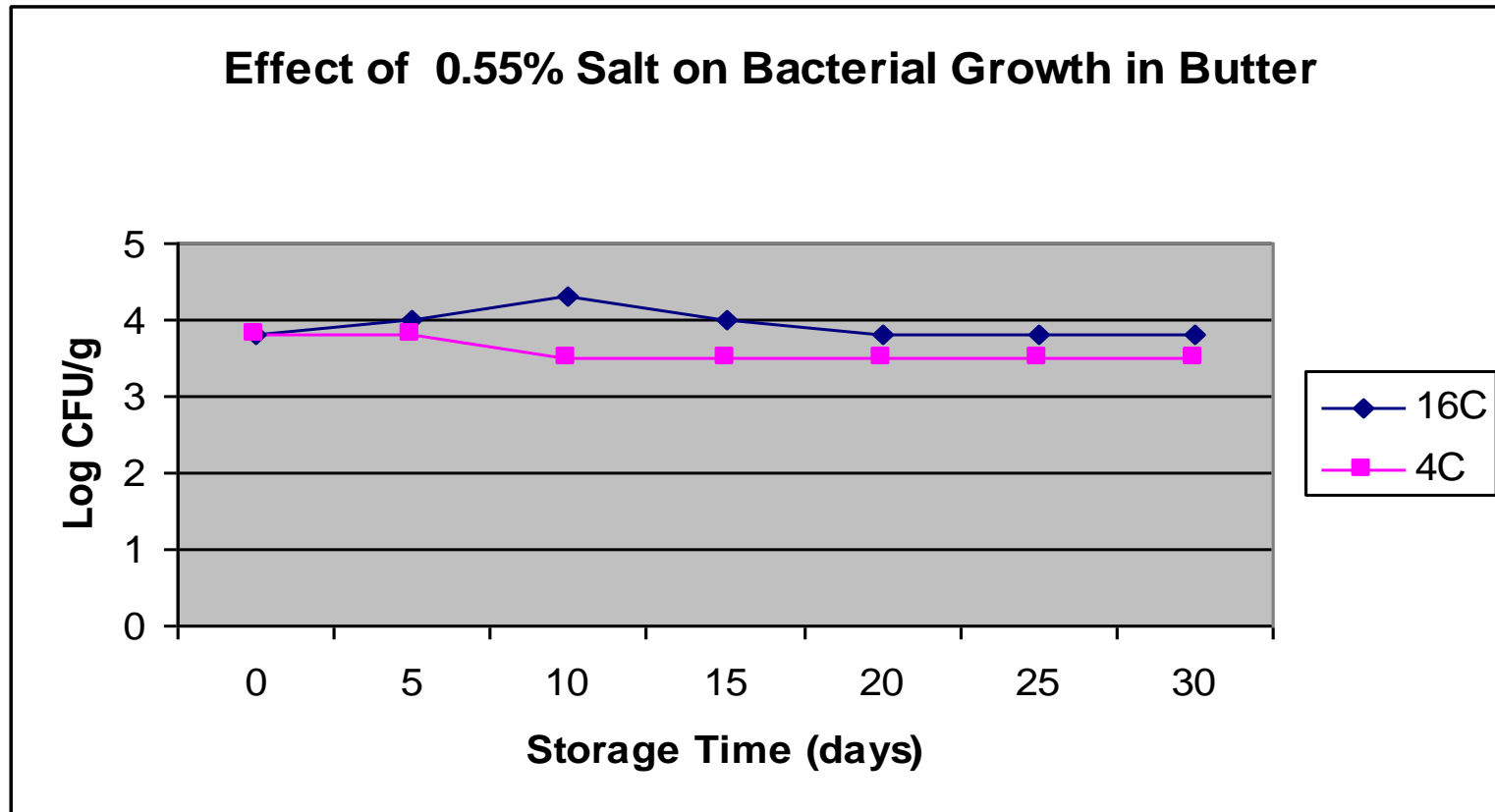


The effect of salt in butter



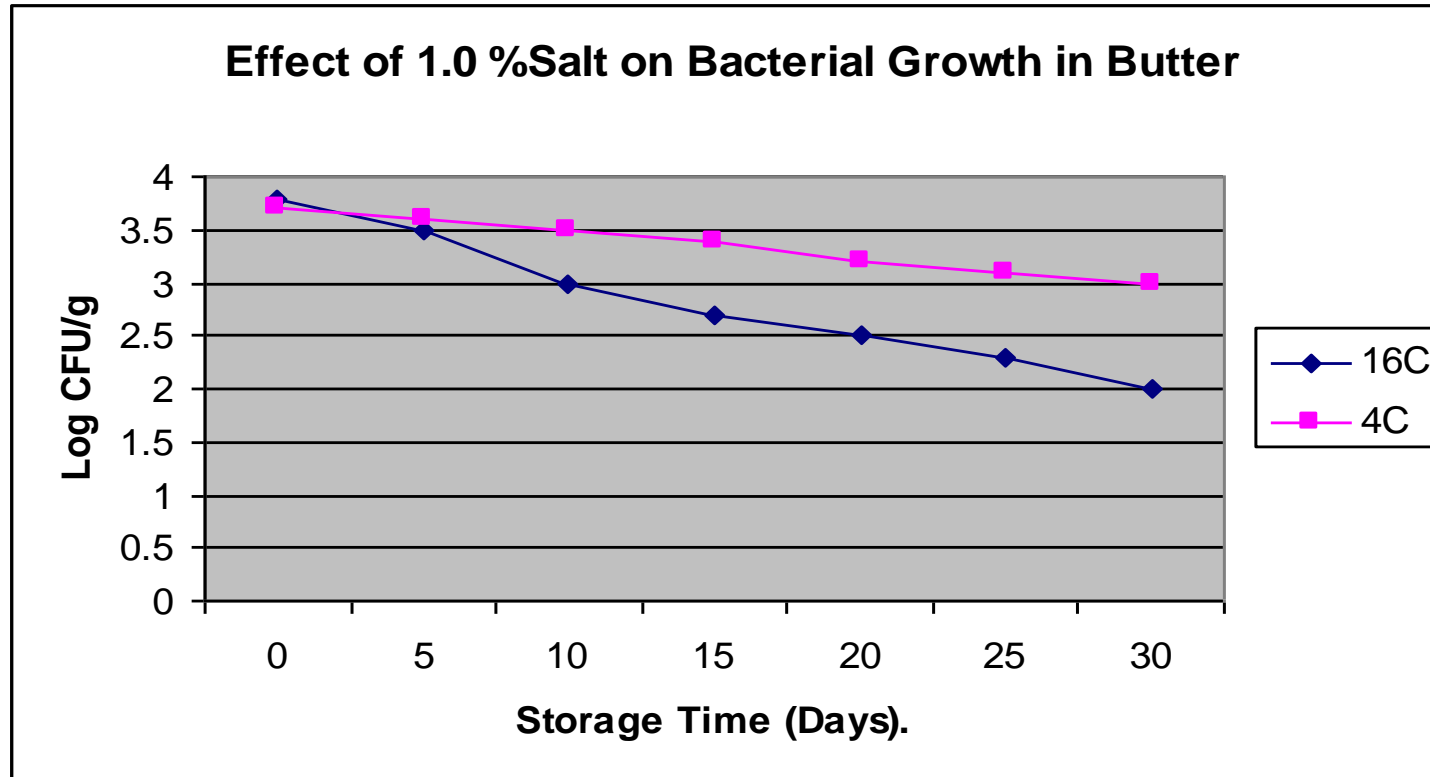
Major R.M (1983) Factors affecting bacterial growth in butter

The effect of salt in butter



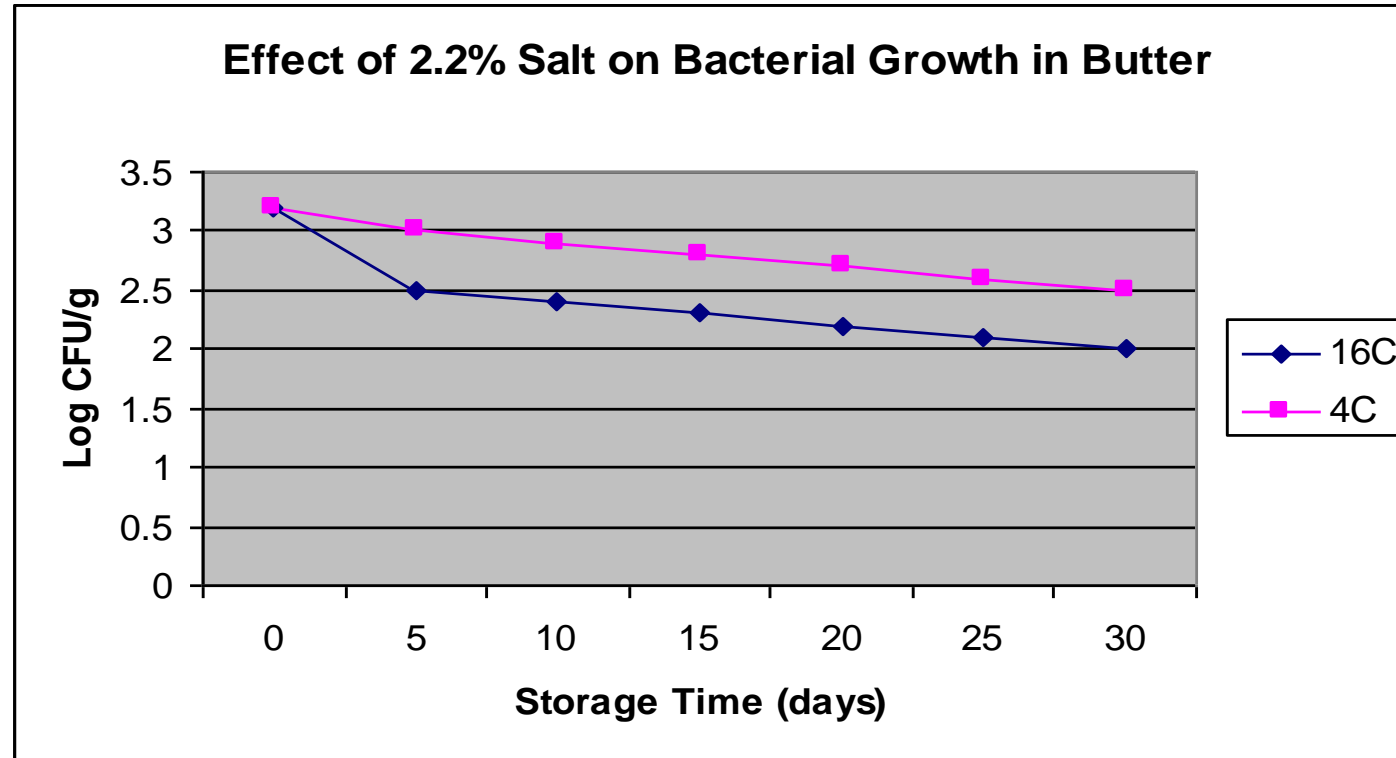
Major R.M (1983) Factors affecting bacterial growth in butter

The effect of storage temperature on butter



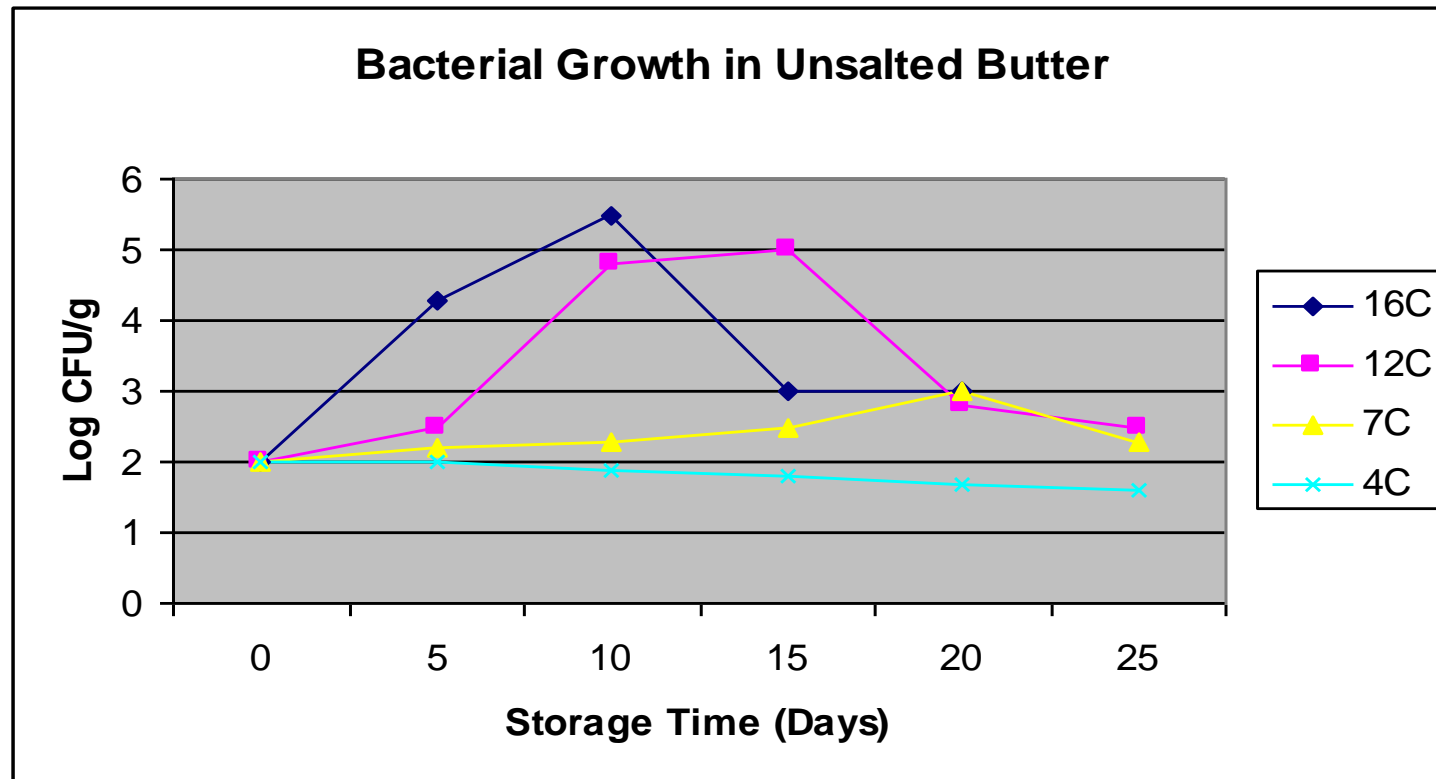
Major R.M (1983) Factors affecting bacterial growth in butter

Effect of salt on bacterial growth in butter



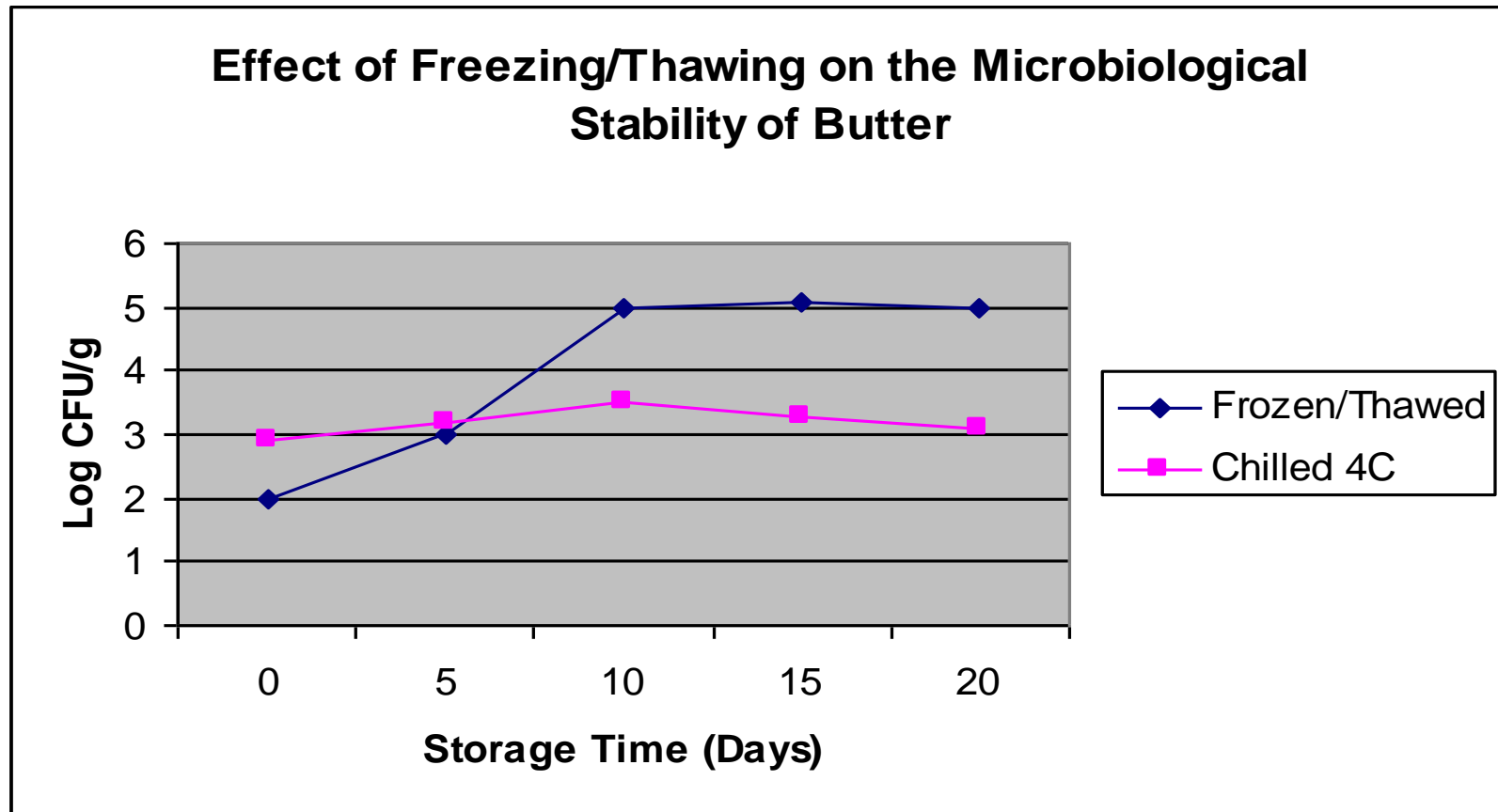
Major R.M (1983) Factors affecting bacterial growth in butter

Bacterial growth in unsalted butter



Major R.M (1983) Factors affecting bacterial growth in butter

The effect of freezing and thawing butter



Major R.M (1983) Factors affecting bacterial growth in butter

Control of microbial growth in butter - summary

- Salt concentration
- Moisture dispersion (10 μm)
 - Butter with $10^6 > 10 \mu\text{m}$ – poor quality
 - Butter with 10^5 or less $>10 \mu\text{m}$ – good quality
- Storage conditions
 - Cool to $< 6^\circ \text{C}$ in 24 h



The source of microorganisms affecting butter

- Dirty plant and equipment
- Raw cream
- Water
- Personnel
- Air



Action of microorganisms on cream

- Acid production - eg lactic acid bacteria
- Enzyme production = off flavours/odours
 - Lipases
 - Proteases
 - Phospholipases

Note pasteurisation/vacreation/flavourtech treatment does not destroy microbial enzymes

Typical source - Pseudomonads



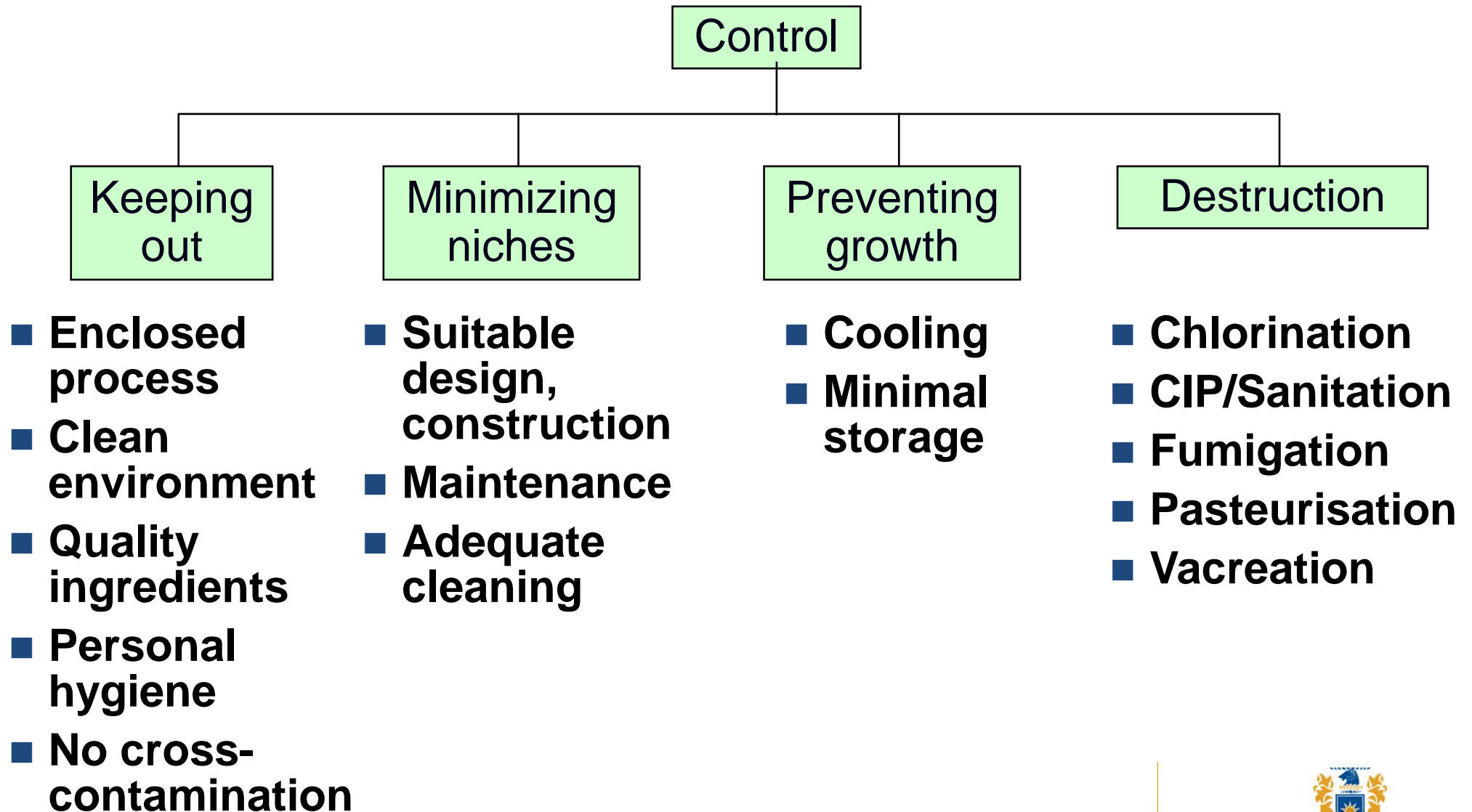
The types of microorganisms found in NZ butter

Microorganism	Percentage of Isolates	
	Unsalted Butter	Salted Butter
<i>Bacillus</i>	18	34
<i>Pseudomonas</i>	18	12
Coliforms	16	17
<i>Vibrio</i>	15	7
<i>Acinetobacter</i>	12	7
Yeast	11	2
Other	10	21

Lypolytic species – 55% of isolates (*Pseudomonas*, *Bacillus*, *Enterobacter*, Yeast)

Proteolytic species – 20% of isolates (*Pseudomonas*, *Bacillus*, *Serratia*)

Control strategies in manufacture



The Fritz manufacturing process

- Vaccination - 99% kill
- Crystallisation - microorganisms double
- Churning - 75% bacteria lost
- Working - moisture dispersion
- Packing - air exposure
- Cooling - critical ($<6^{\circ}$ C in 24 h)



HAZARDS: RAW MILK STORAGE

- **Poor quality milk received**
 - **Dirty silos**
 - **Inadequate cooling (10 - 15° C)**
 - **Long storage (>24h)**
-
- **OUTCOMES**
 - **Contamination / Bacterial growth**
 - **Fat damage (Psychrotrophs)**
 - **Acid production**
 - **Irreversible damage**



HAZARDS: PASTEURISATION/ SEPARATION

- Heat-sensitive organisms destroyed
- **Enzymes & breakdown products will survive**
- Ideal thermophile growth temp (45 - 65° C)
- **Long processing runs (>9h)**
- Ineffective CIP
- **OUTCOMES**
 - Uncontrolled thermophile growth
 - **Contaminated cream stream**
 - Buttermilk / BMP contamination



HAZARDS: FAT RECOVERY

- Uncontrolled fat reprocessing
 - **Ineffective CIP**
 - Contaminated fat stream re-injected
-
- OUTCOMES
 - **Contaminated cream stream**
 - Cycle of thermophile contam. set up
 - **Buttermilk / BMP contamination**



HAZARDS: VACREATION

- **103 - 105° C**
- **Bacterial spore survival**
(psychrotrophic, mesophilic, thermophilic)
- **OUTCOMES**
 - **Thermophilic spores survive (major issue)**
 - **Uncontrolled contamination cycle**
 - **Buttermilk/BMP contamination**



THERMAL DESTRUCTION

Heat Survival

Thermisation Pasteurisation

63° C/15 s

72° C/15 s

Microbacterium

Micrococcus

Streptococcus

Enterococcus

Alcaligenes

Bacillus

Clostridium

Vacreation

103-105° C

Bacillus

Clostridium

HAZARDS: CRYSTALLISATION SILOS

- Ineffective CIP of filters, lines & silos
 - Cracks / pinholes in silos
 - Cracks in agitator shafts, baffles etc
 - Slow growth (9 - 15° C / 8 - 12h)
-
- OUTCOMES
 - Crystallised cream contaminated
(jacket water, deposits, poor sanitation)
 - Coliforms, APC, *Pseudomonas*



HAZARDS; BUTTERMAKING (a)

- **Lines and cream balance tank**
- **Feed pump: Servicing, CIP, seals**

- **Churn screen: CIP**
- **Churn / Shute-Seal: Sanitation**

- **Shute / Separation section: Splash / Sanitation**
- **Separation section: Sprayballs / Sanitation**



HAZARDS: BUTTERMILKING (b)

- Working Section
 - **Buttermilk injection (buttermilk quality, line, pump, dosing point sanitation)**
 - **Cracks in chilled water jacket**
 - **Vacuum system / lamp housing**
- OUTCOMES
 - **Recontamination of cream / butter stream**
 - **Coliforms, APC, *Pseudomonas***
 - **(No “downstream” controls)**



HAZARD: BUTTER SILO

- **Insanitary design / construction / maintenance**
 - e.g. **Pressure plate: Poor fit**
 - Teflon gasket: Crevices**
 - Pump seals**
- **Ineffective CIP**

OUTCOMES

- **Deposits, poor sanitation**
- **Recontamination of butter stream**
- **Coliforms, APC, *Pseudomonas***



HAZARD: BULK PACKER

- **Ineffective CIP**
- **Non-potable water used (splashing)**
- **Air exposure**

- **OUTCOMES**
 - **Recontamination of butter stream**
 - **Surface growth e.g. *Pseudomonas***
 - **Visual & sensory defects**



HAZARD: PATTING MACHINES

- **Ineffective CIP**
- **Breakdowns / human intrusion**
- **Air exposure**

- **OUTCOMES**
 - **Recontamination of butter stream
(e.g. Coliforms, APC, *Pseudomonas*)**
 - **Visual & sensory defects**



HAZARD: BUTTER STORAGE

- **Slow cooling (e.g. centre of pallet)**
- **OUTCOMES**
 - **Continued bacterial growth**
 - *Pseudomonas* (surface), coliforms etc
 - **Sensory defects**

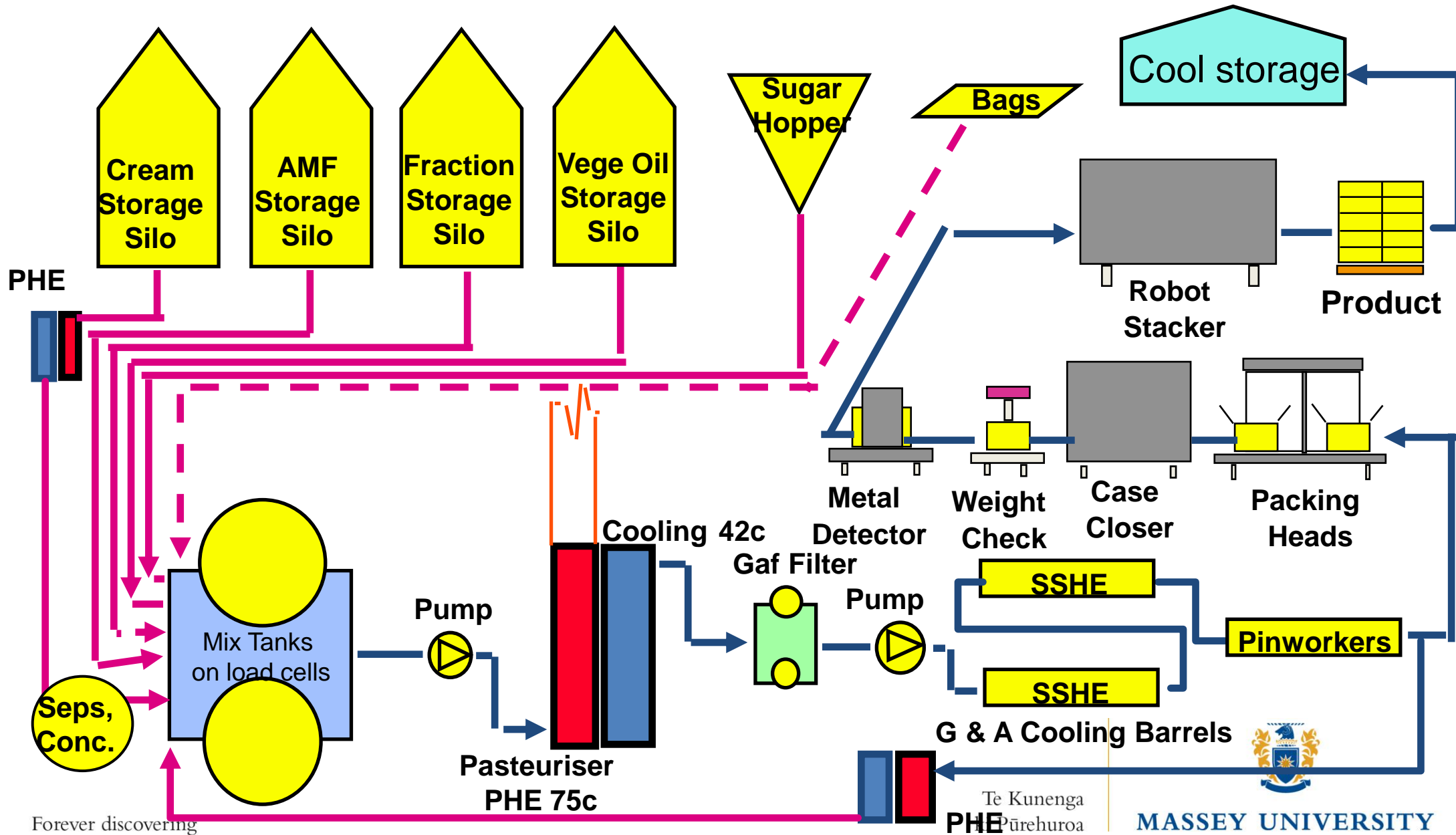


The Ammix manufacturing process

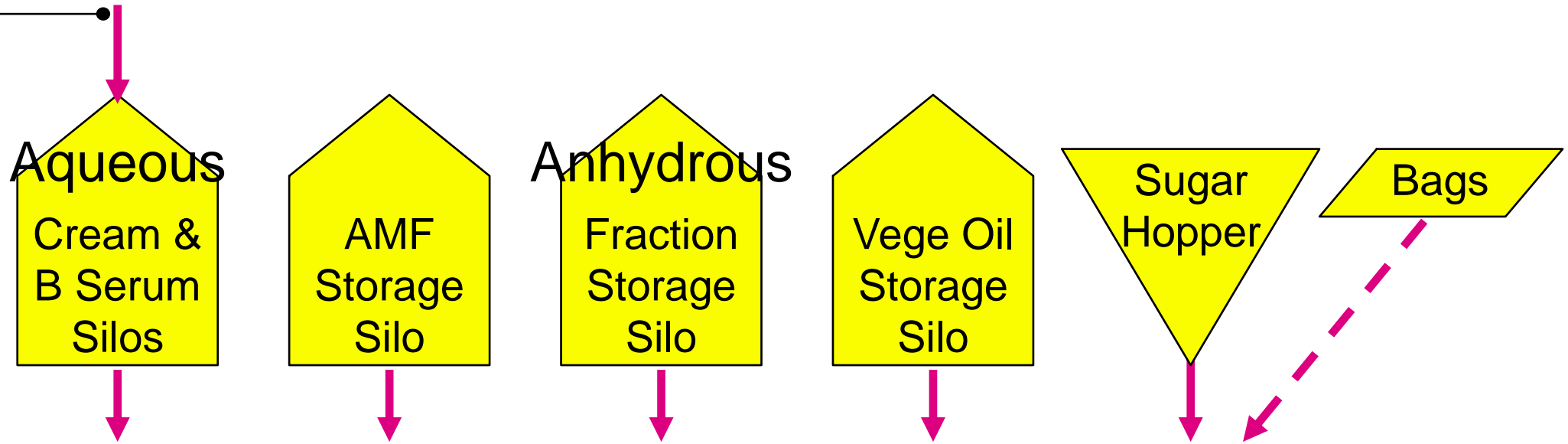
- Cream treatment (Flavourtech)
- AMF
- Salt slurry
- Blending - growth of thermodurics at 40° C
- Pasteurisation - 99% reduction in bacteria
- SSHE cooling
- Pinworking
- Resting
- Packing
- Cooling



Ammix plant layout



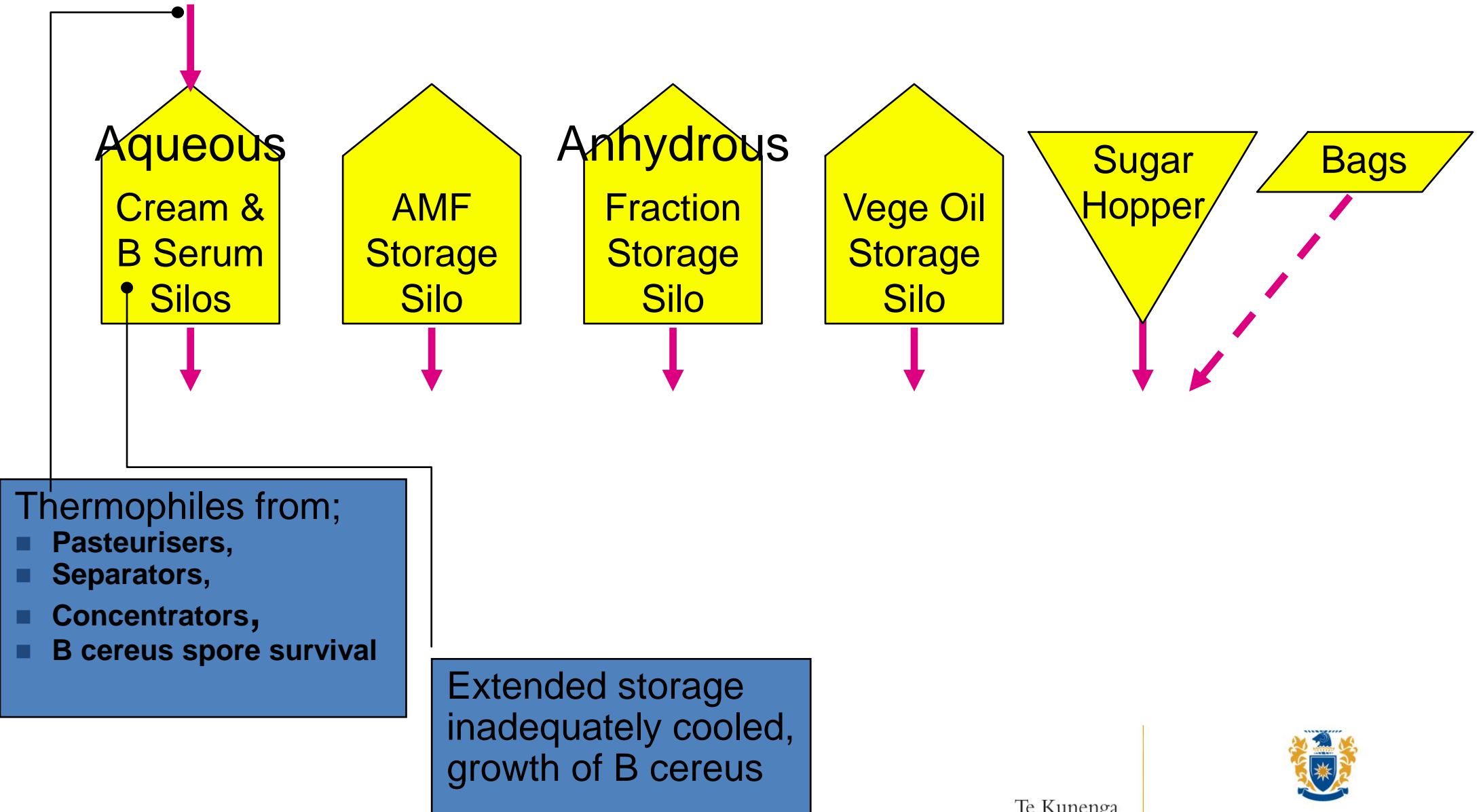
Raw Materials



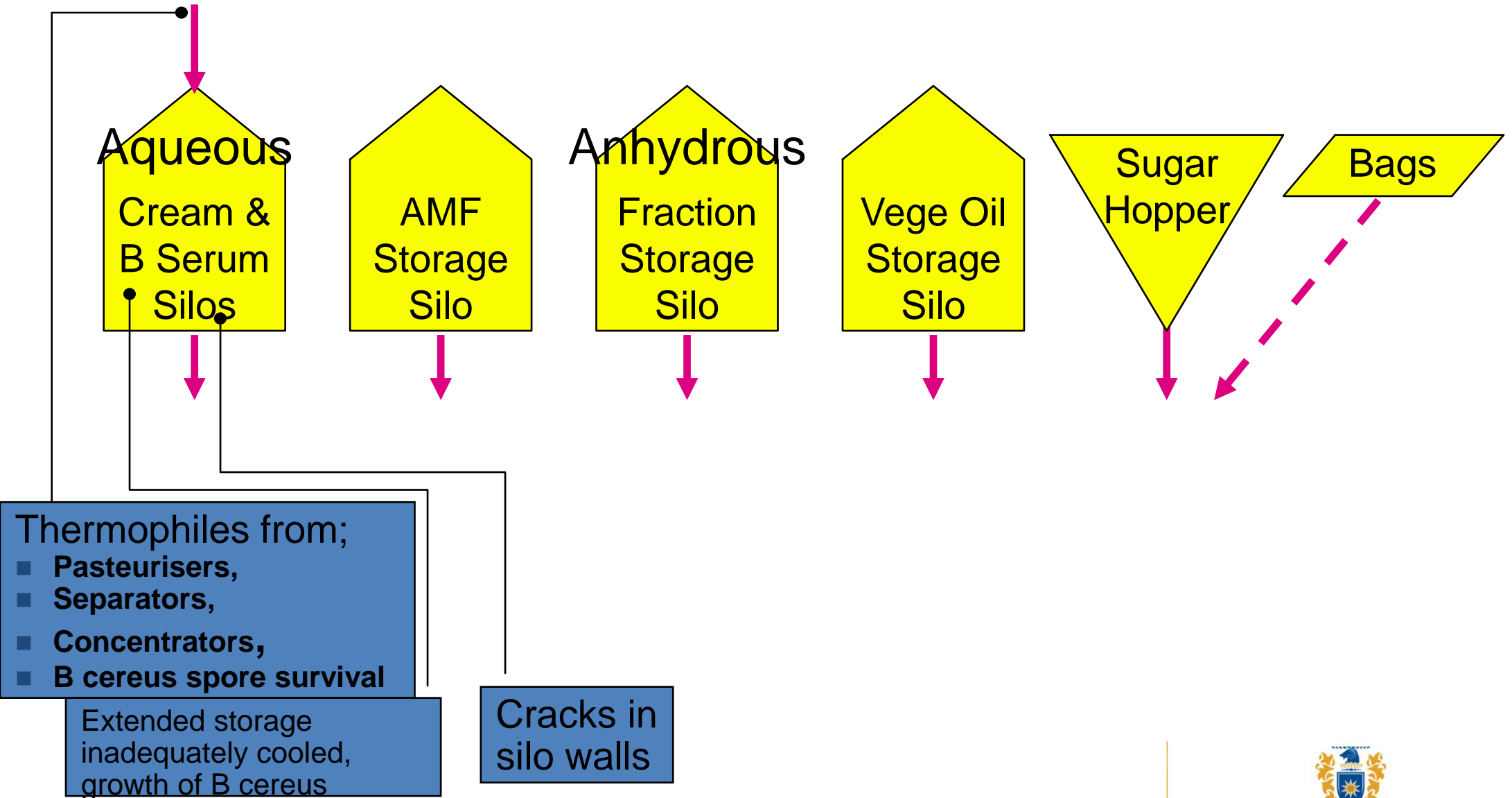
Thermophiles from;

- Pasteurisers,
- Separators,
- Concentrators,
- B cereus spore survival

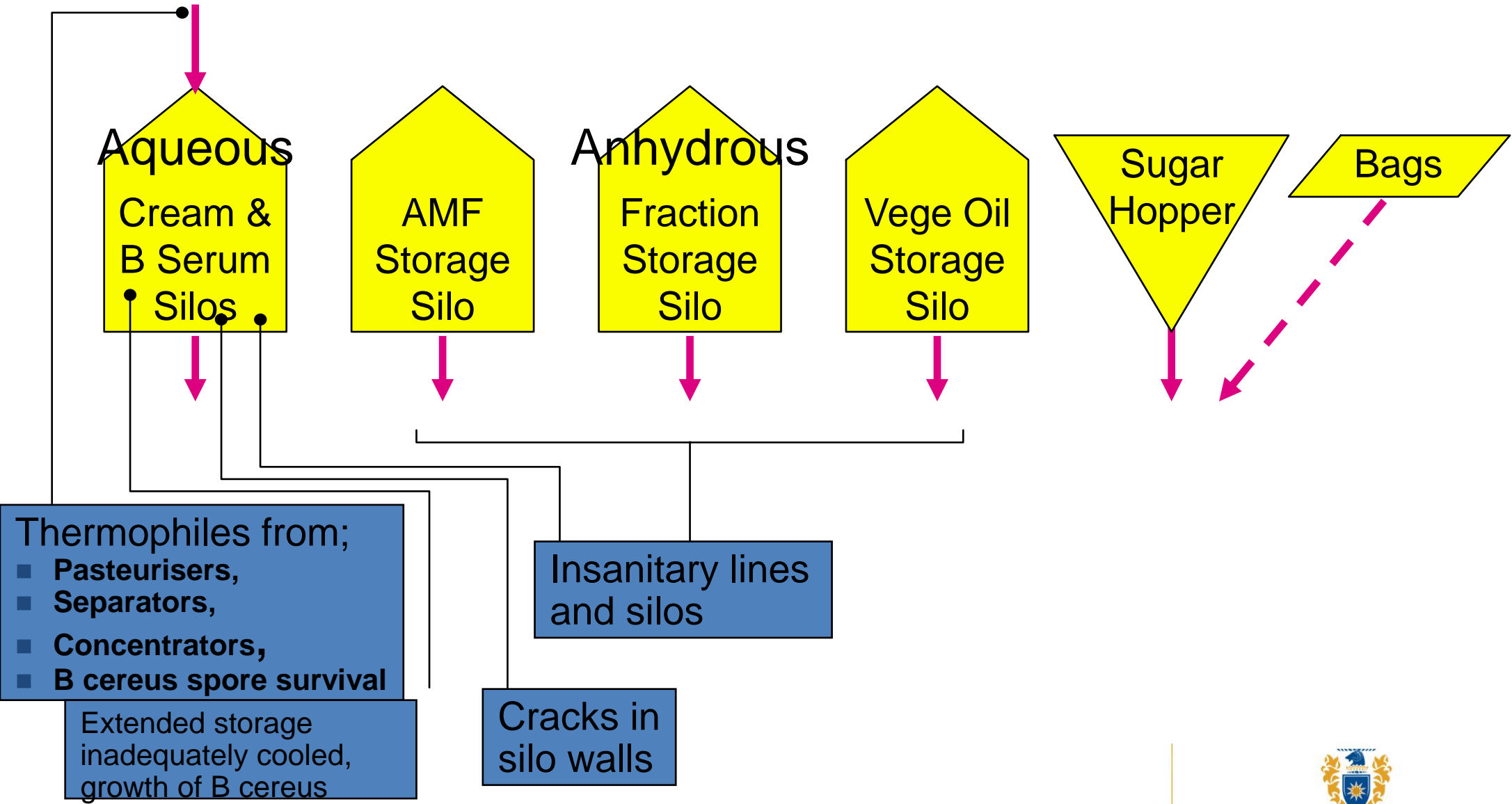
Raw Materials



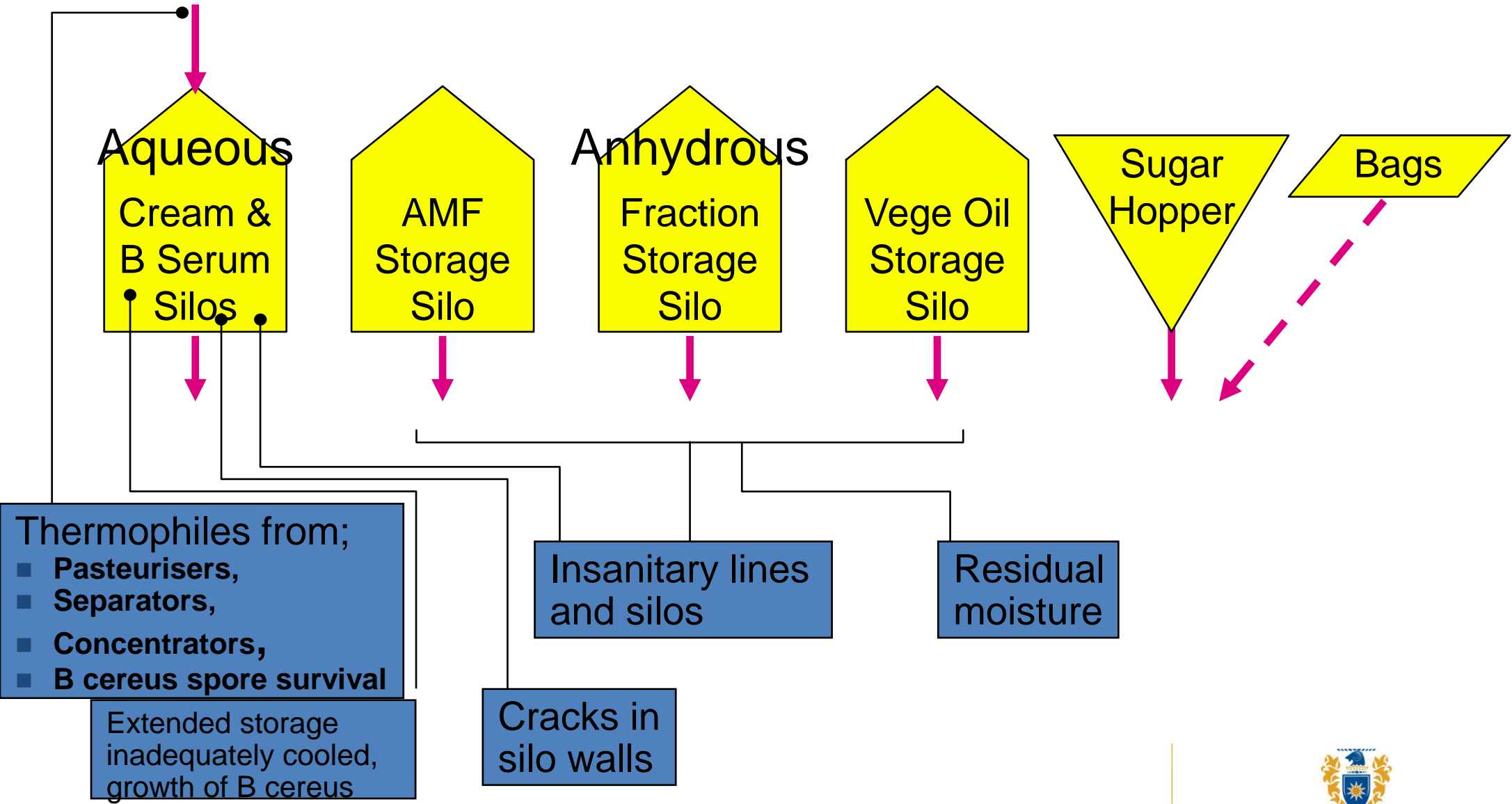
Raw Materials



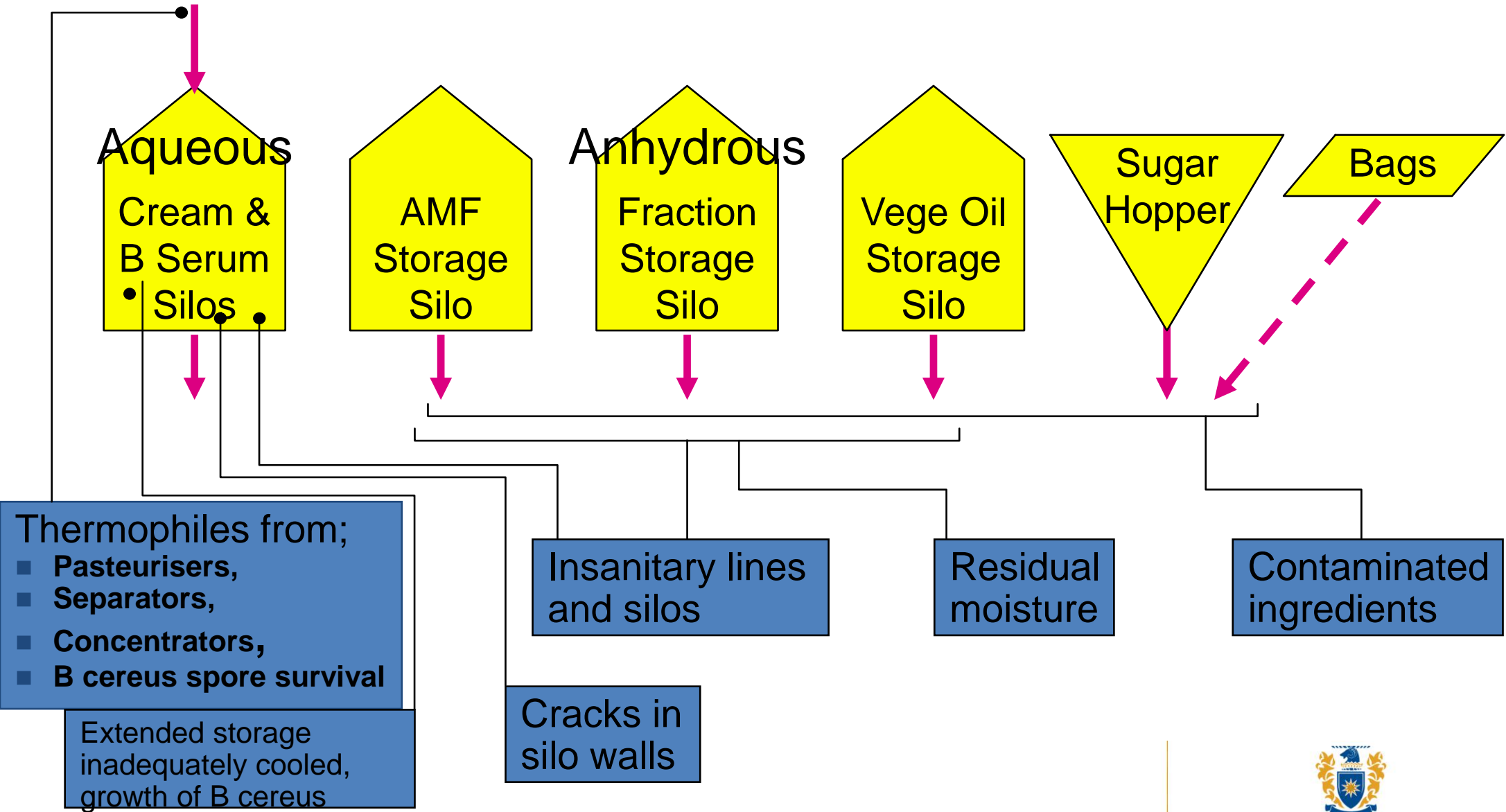
Raw Materials



Raw Materials



Raw Materials



Thermophiles from;
■ Pasteurisers,
■ Separators,
■ Concentrators,
■ B cereus spore survival

Extended storage inadequately cooled, growth of B cereus

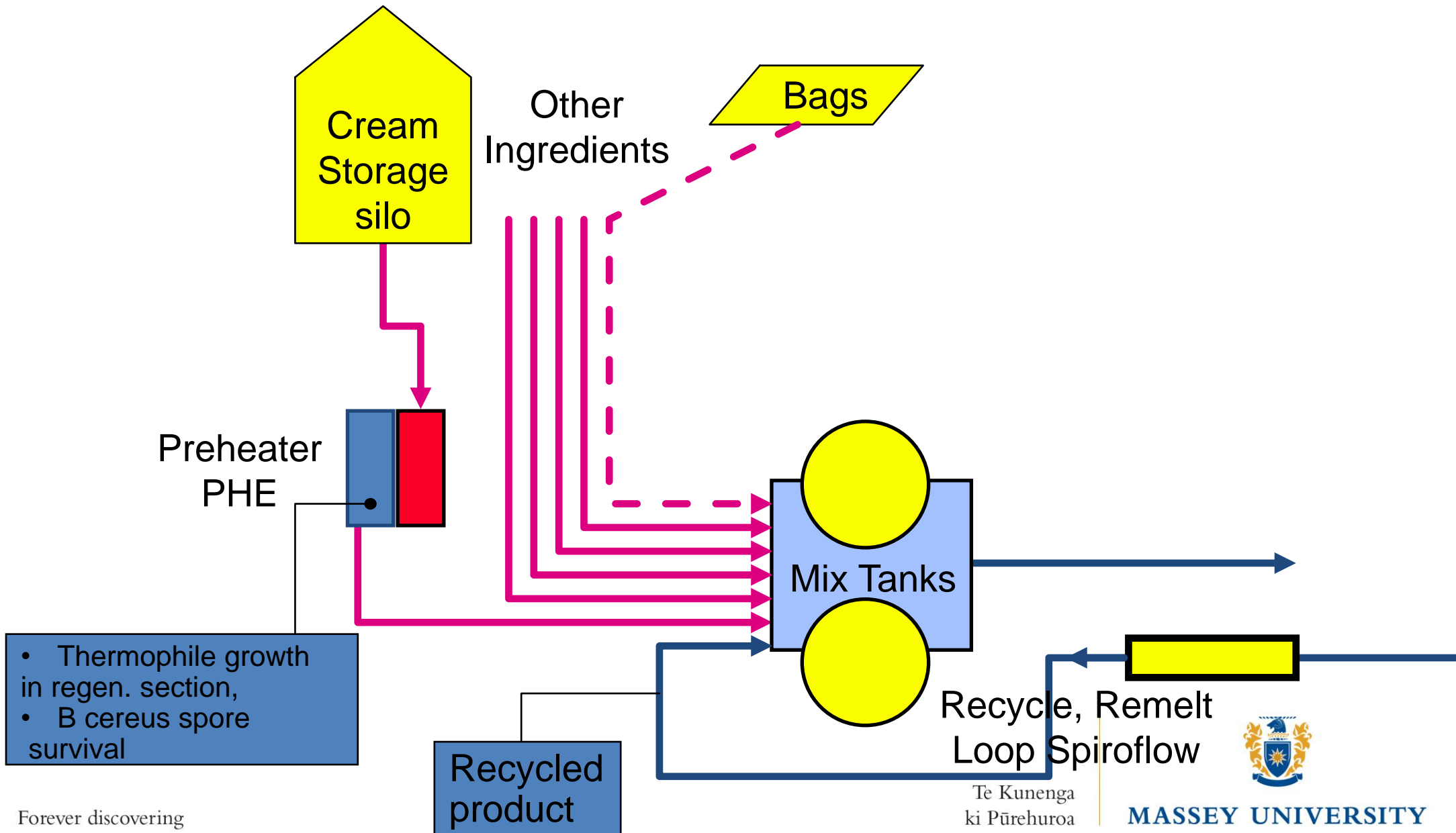
Cracks in silo walls

Insanitary lines and silos

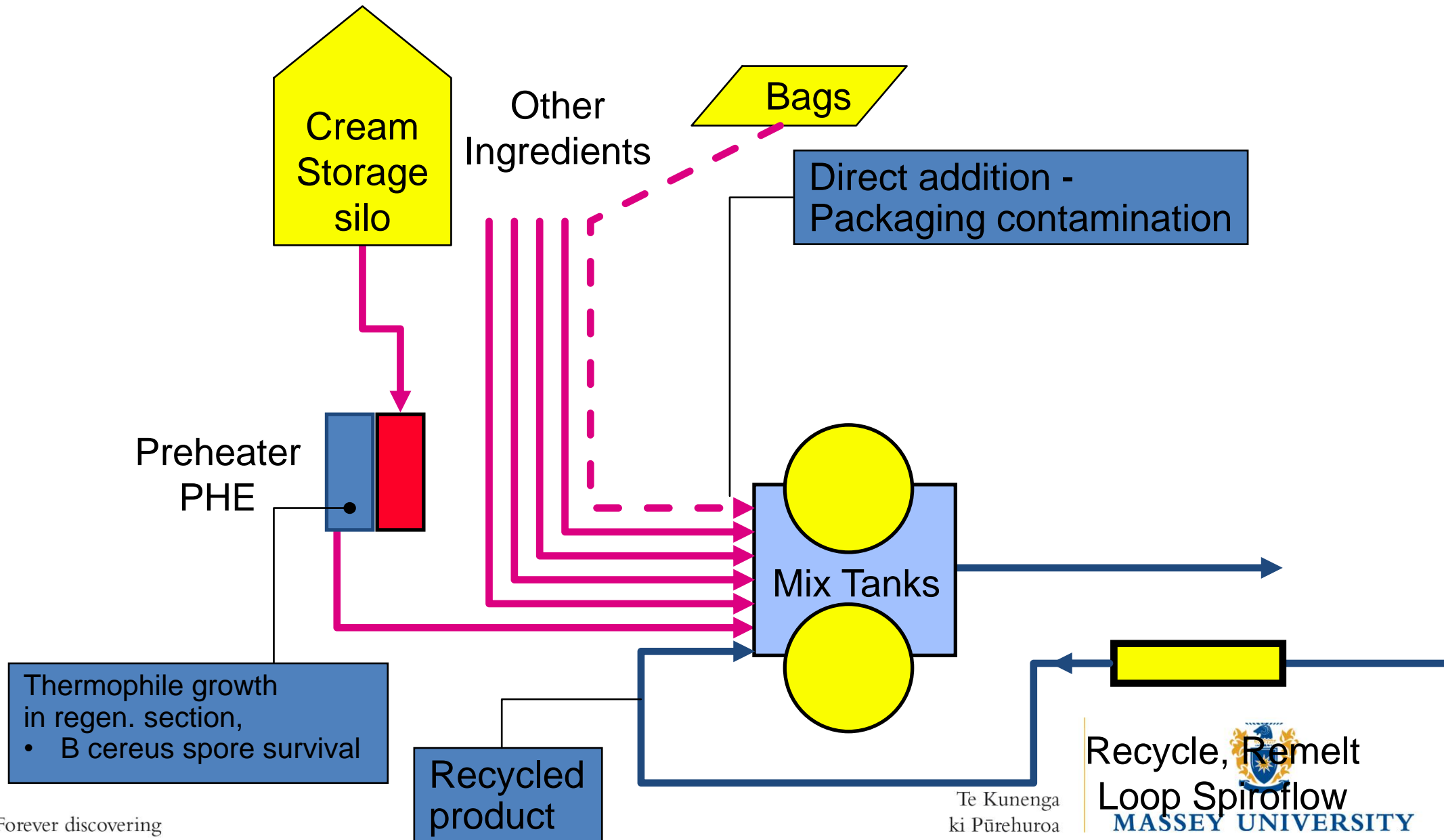
Residual moisture

Contaminated ingredients

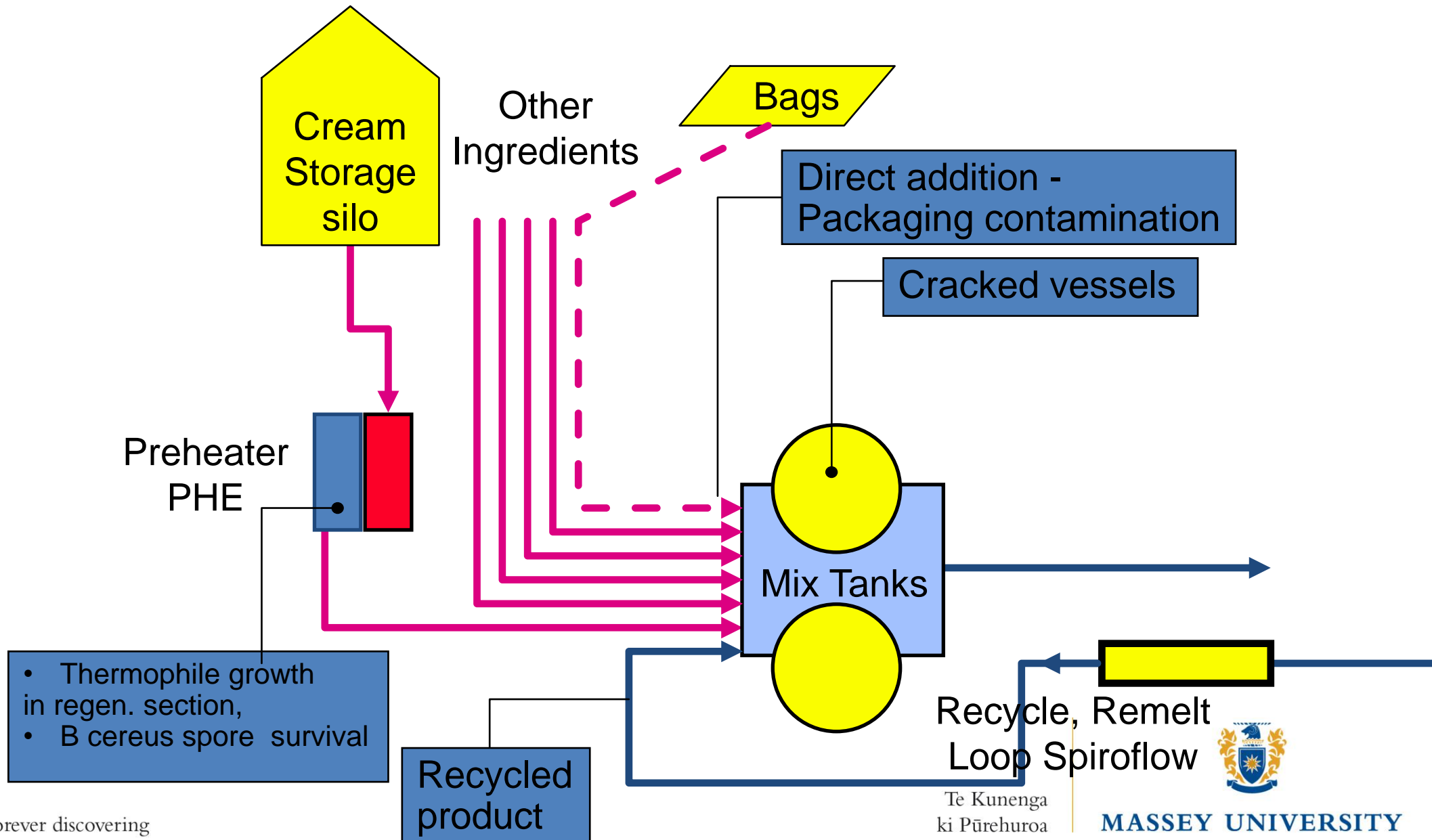
Product Mixing



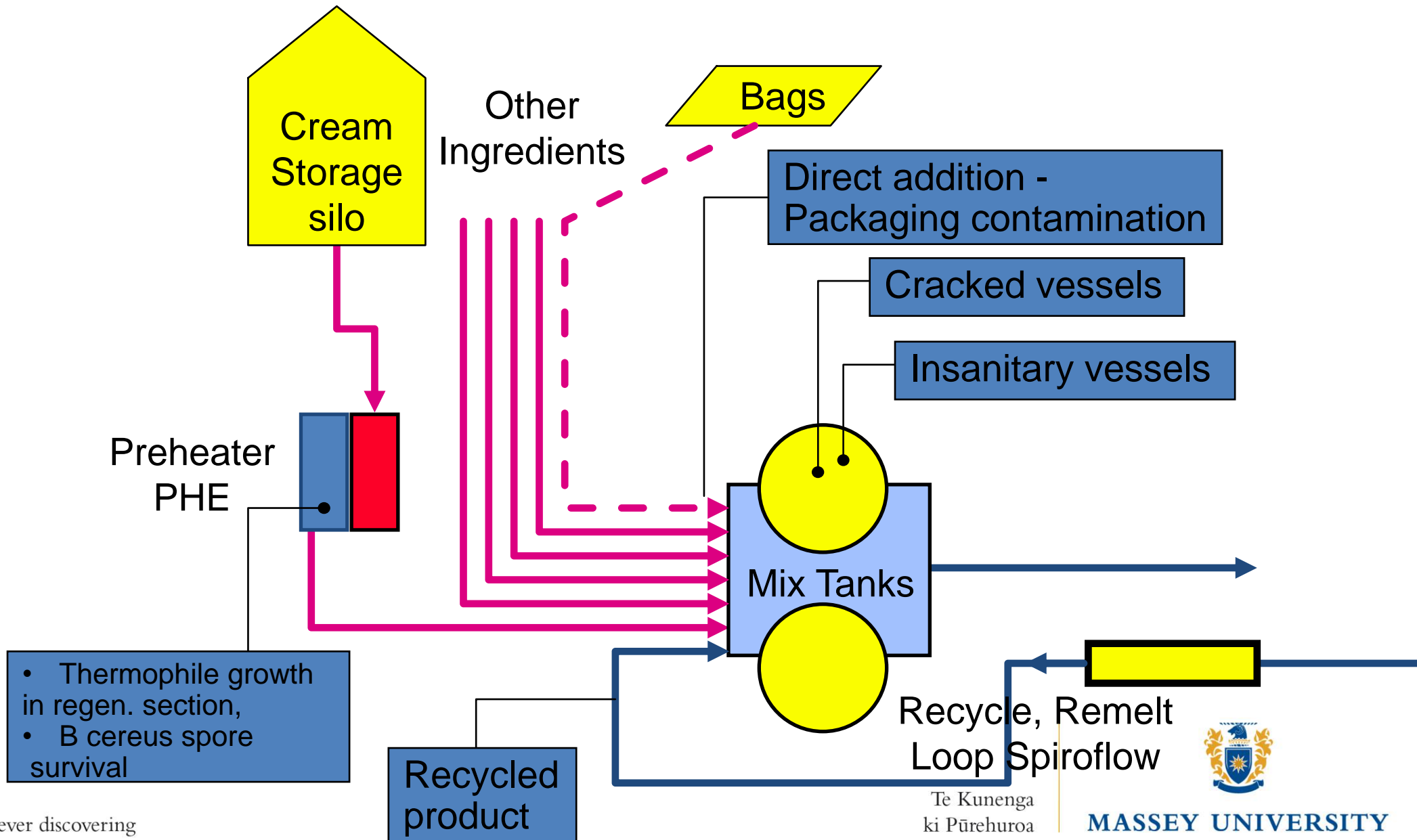
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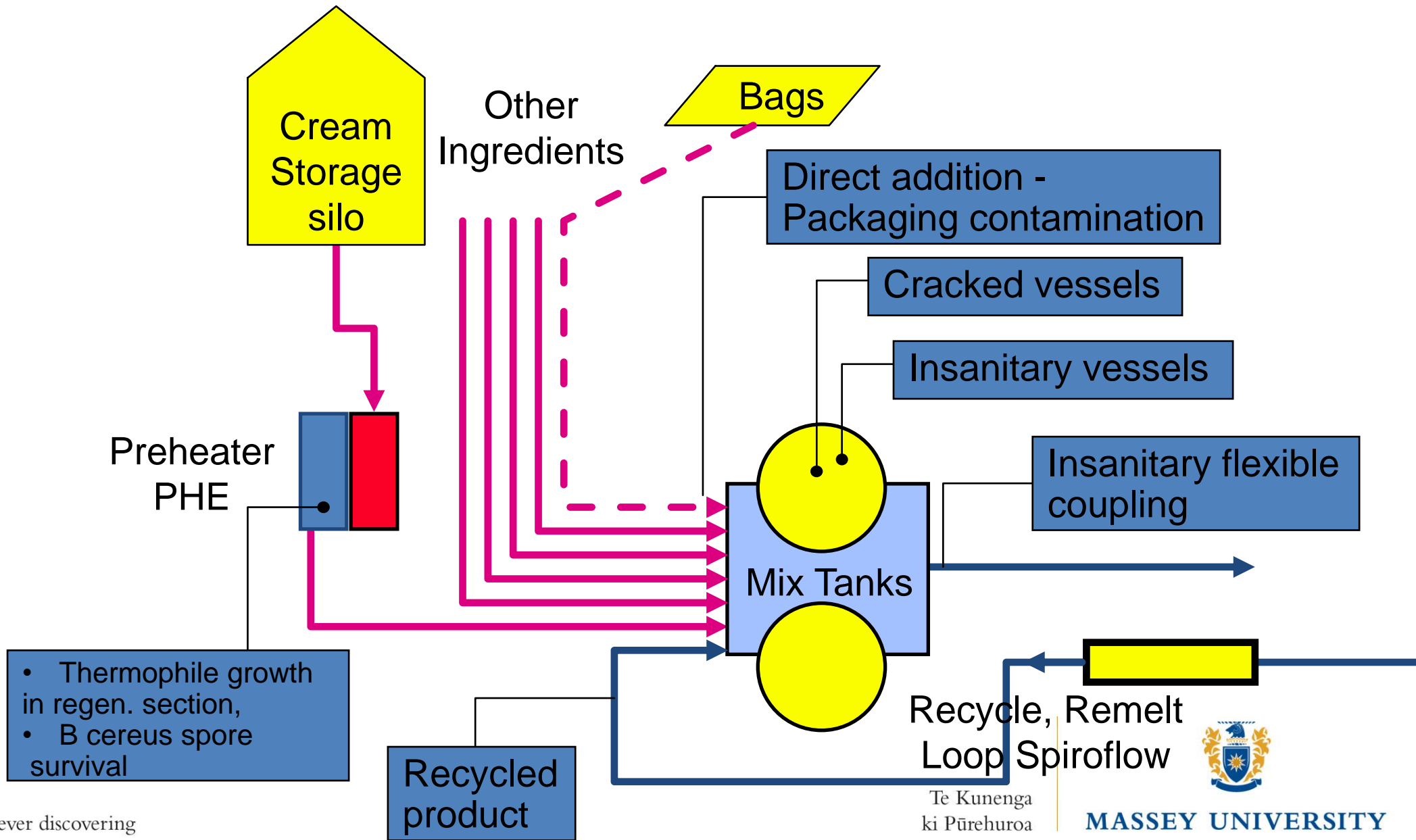
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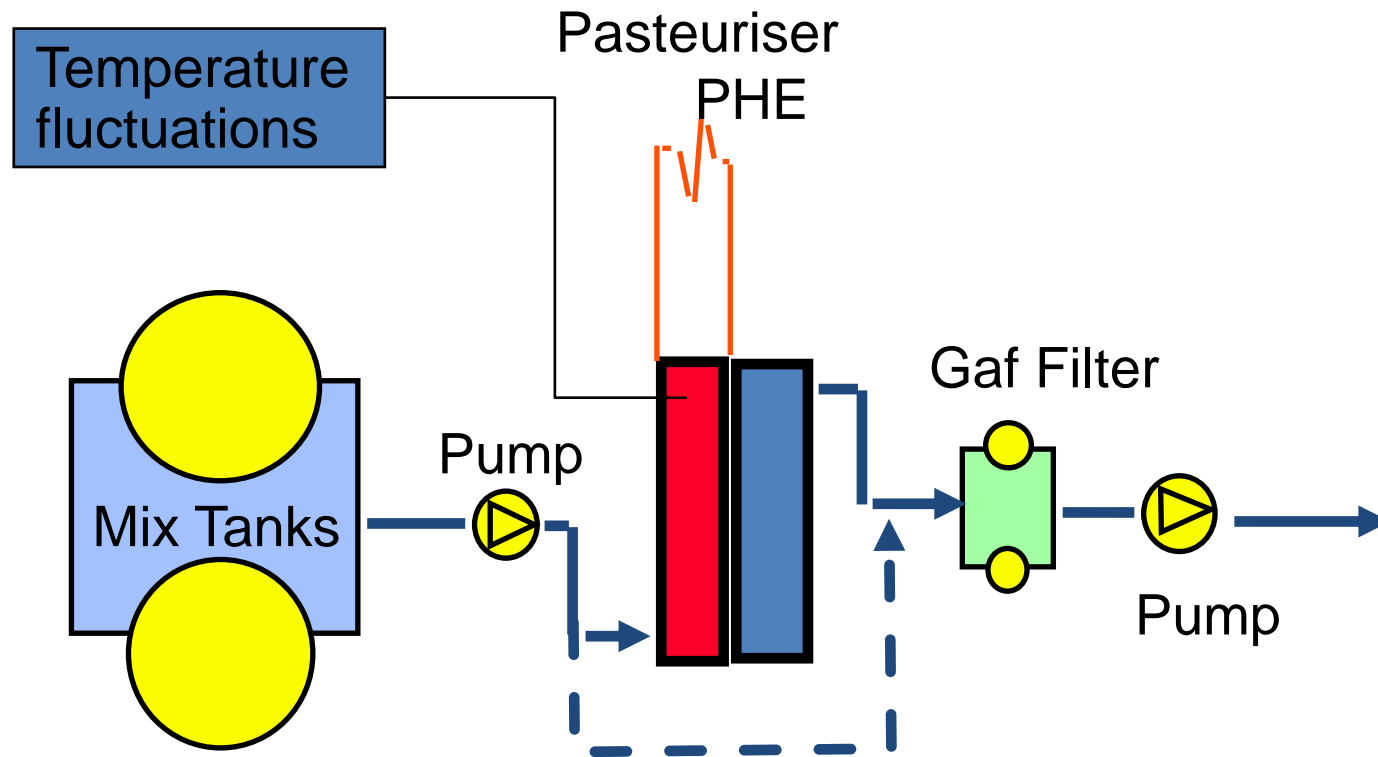
Product Mixing



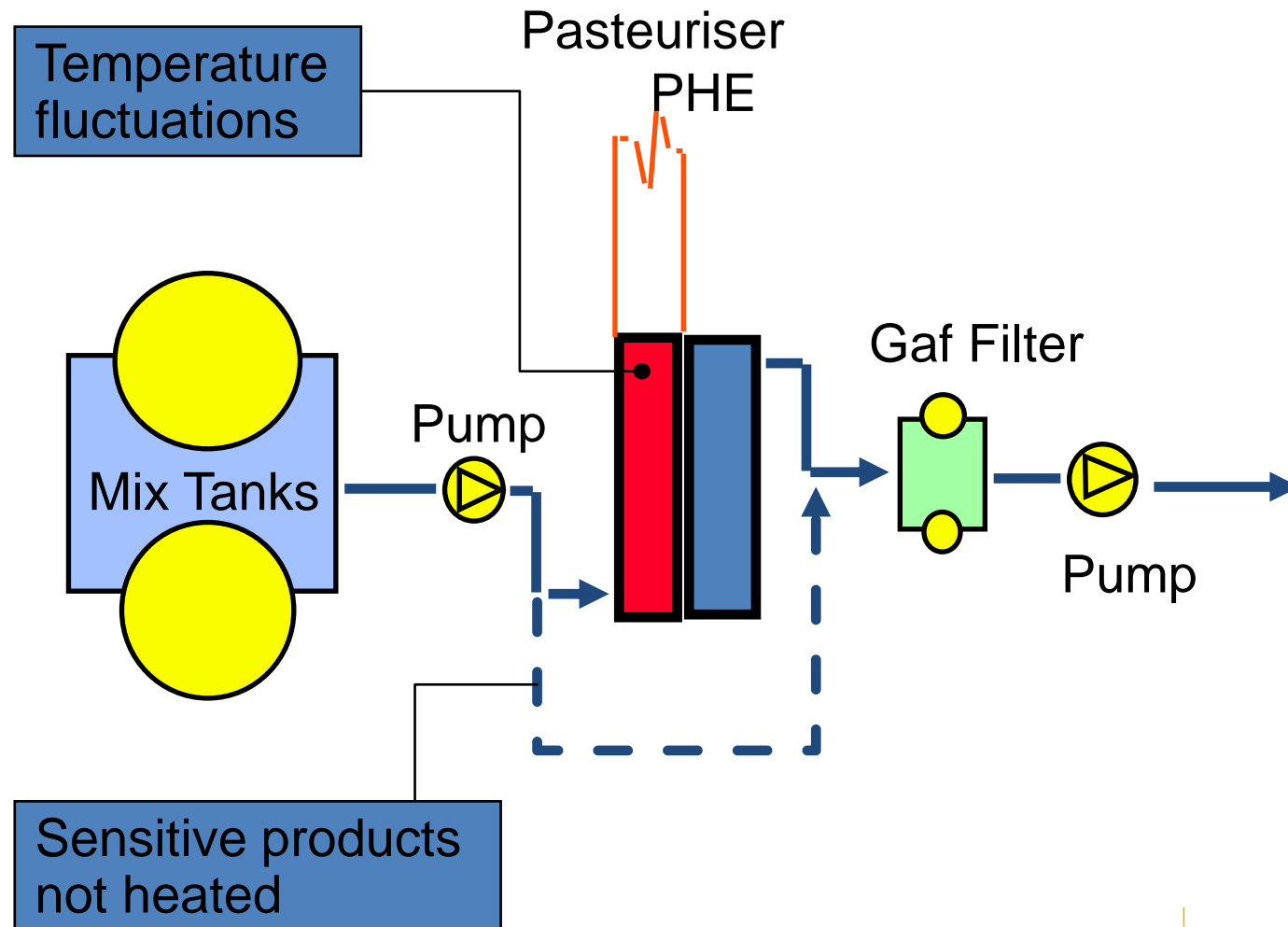
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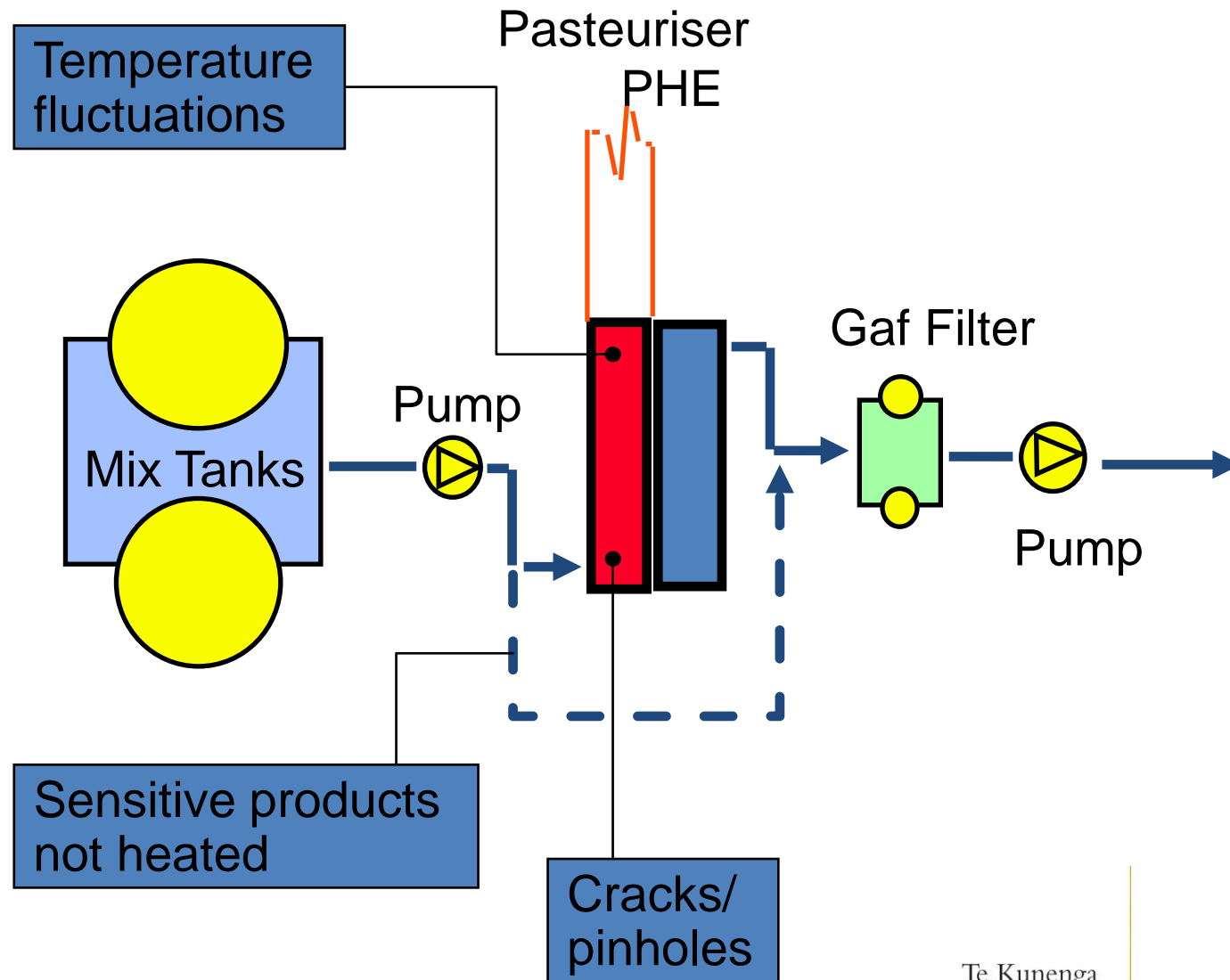
Heat Treatment & Filtration



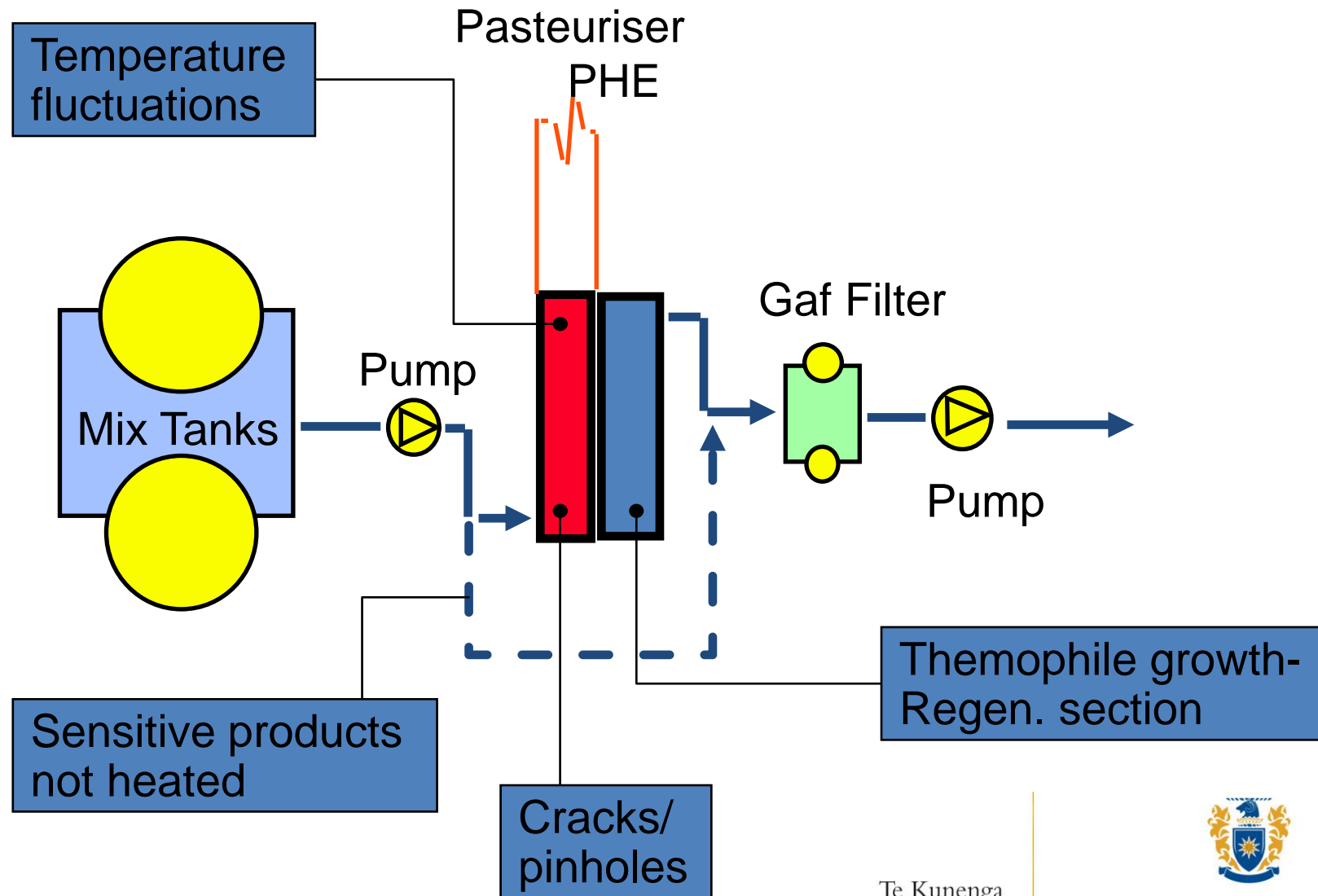
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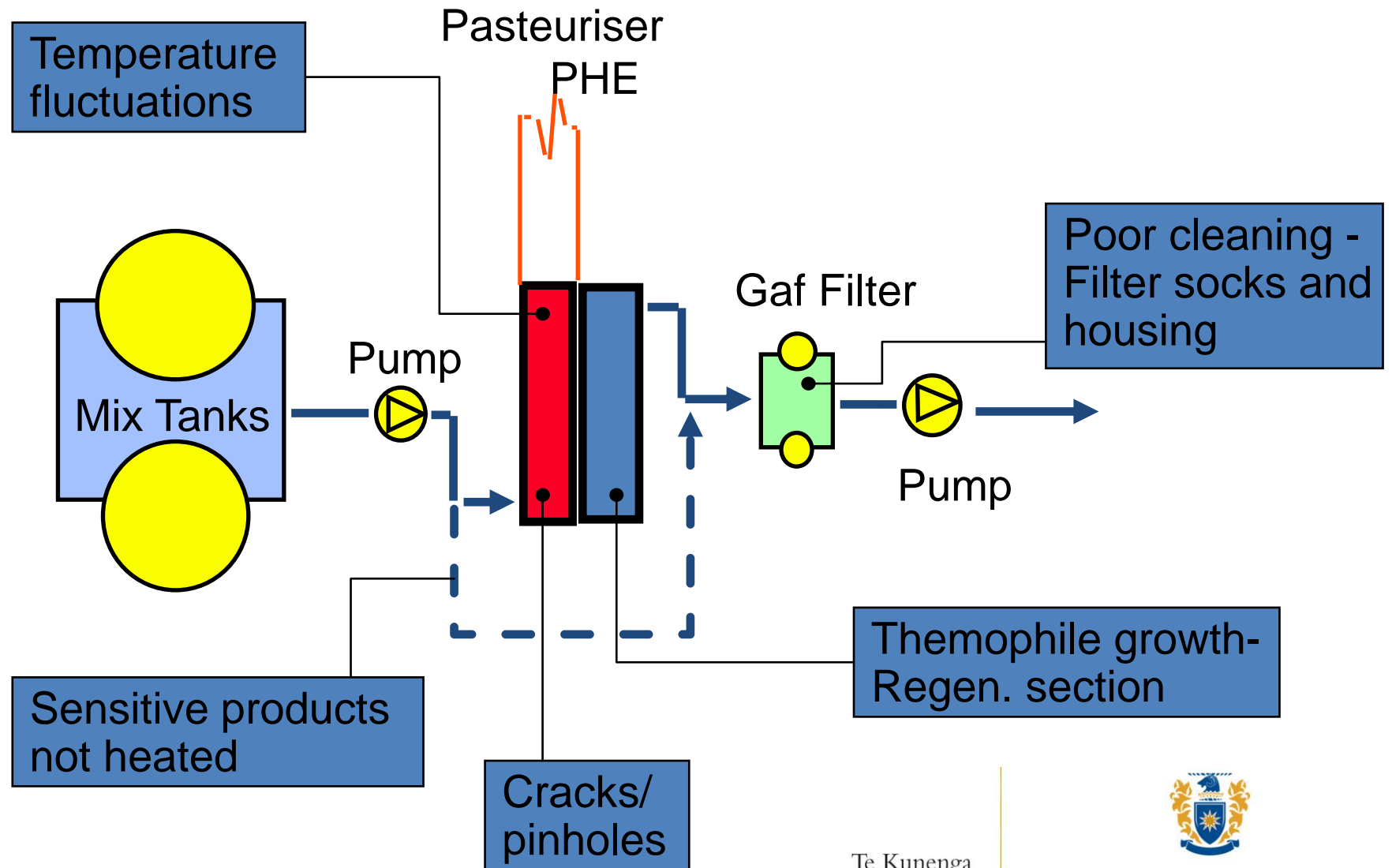
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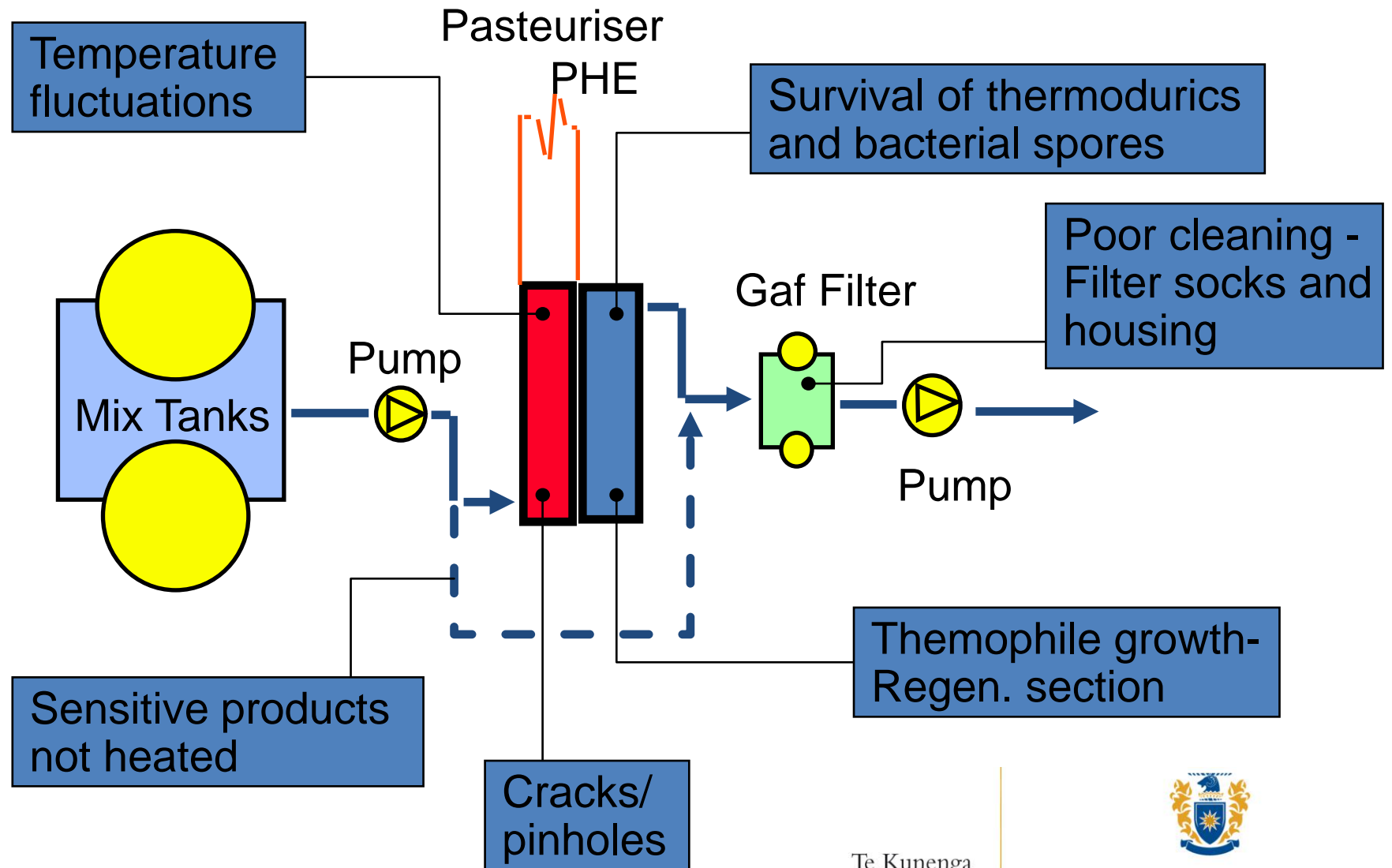
Heat Treatment & Filtration



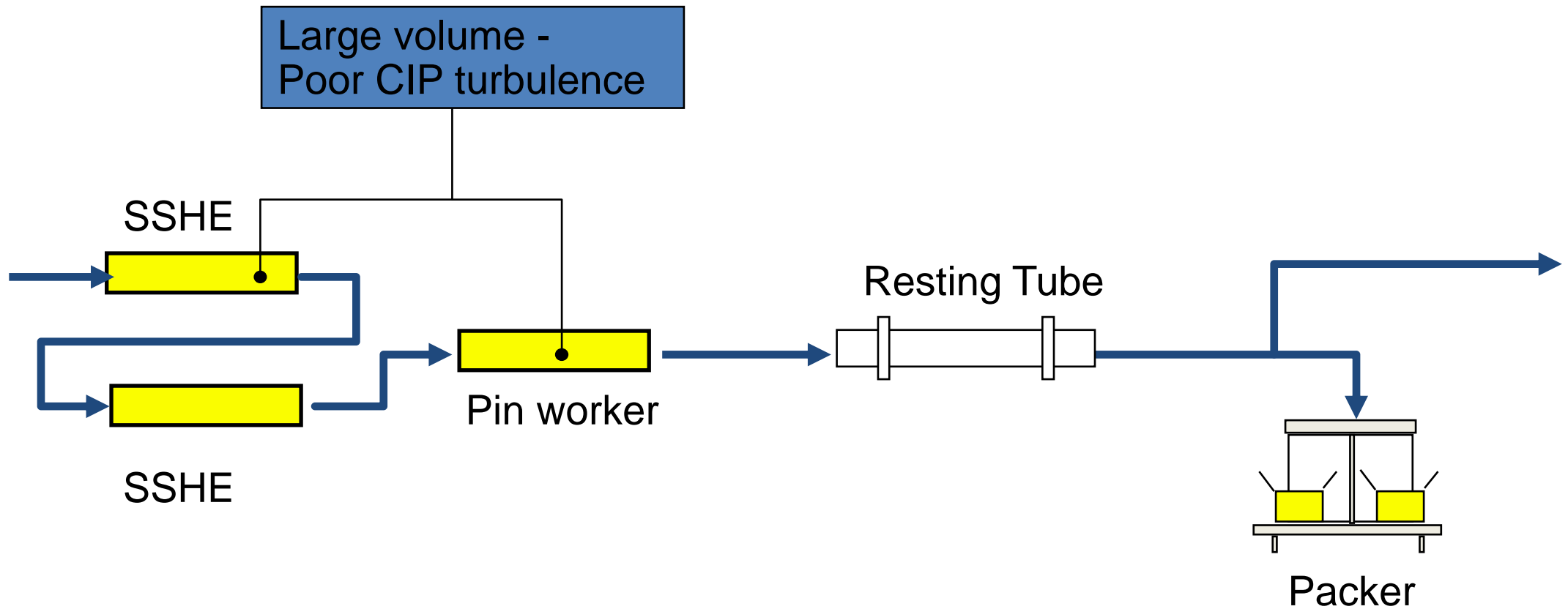
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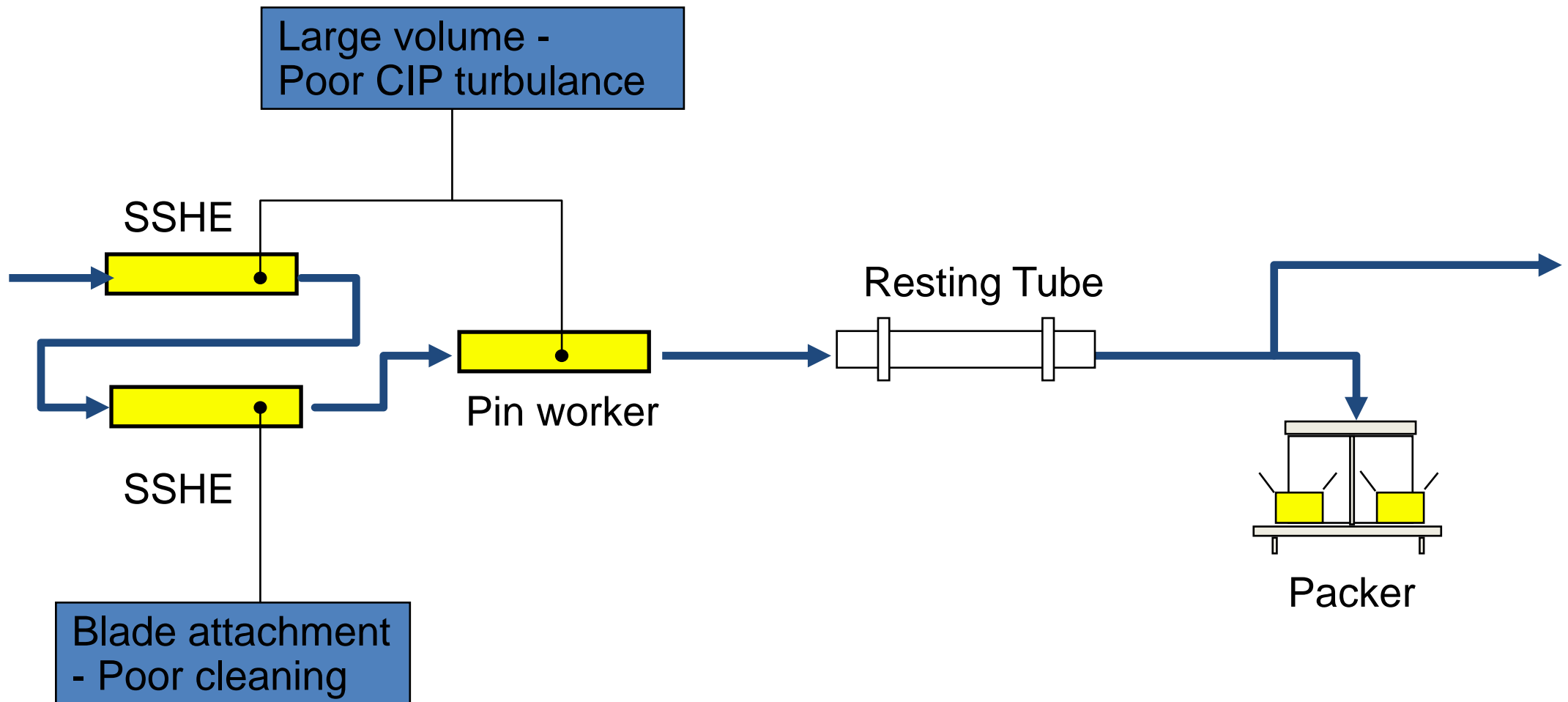
Heat Treatment & Filtration



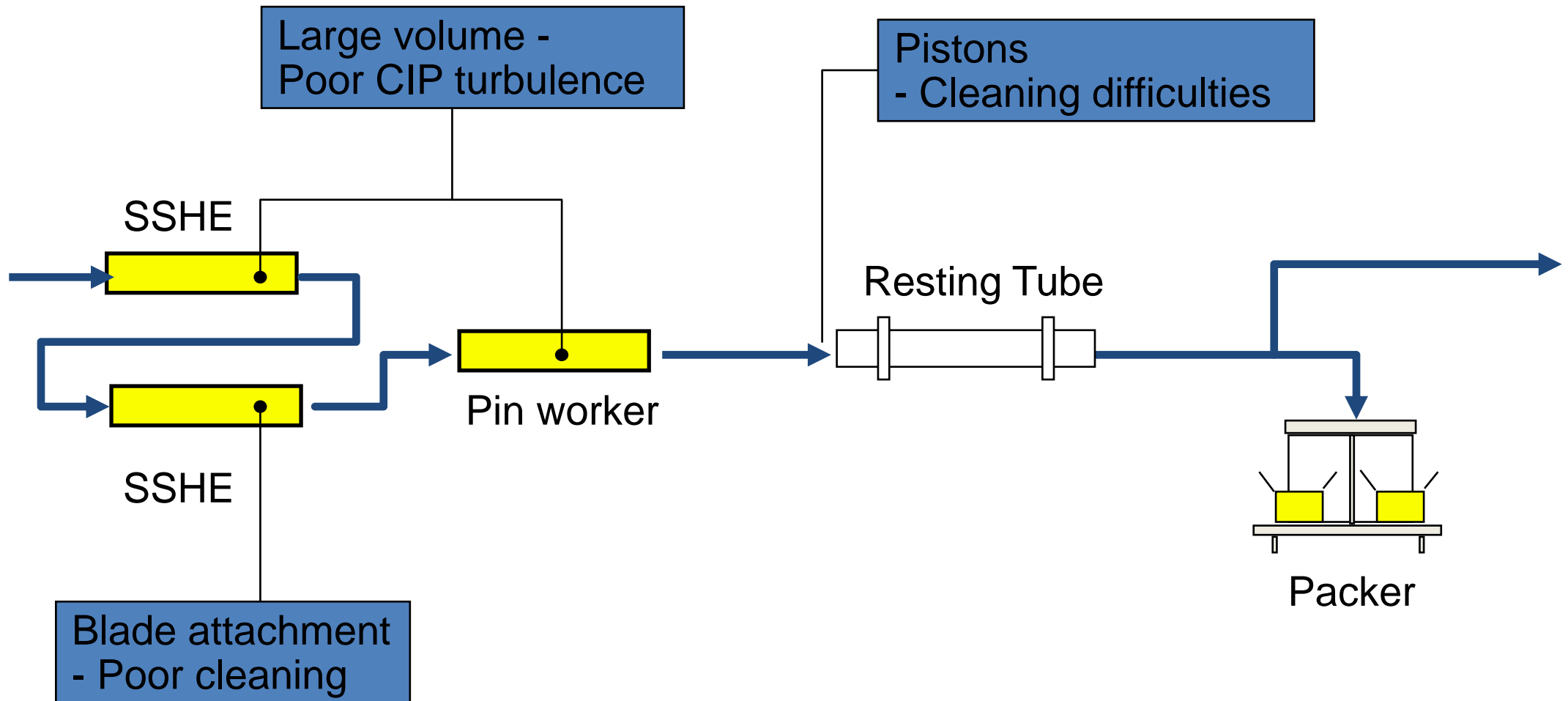
SSHE, Pin Worker & Resting Tube



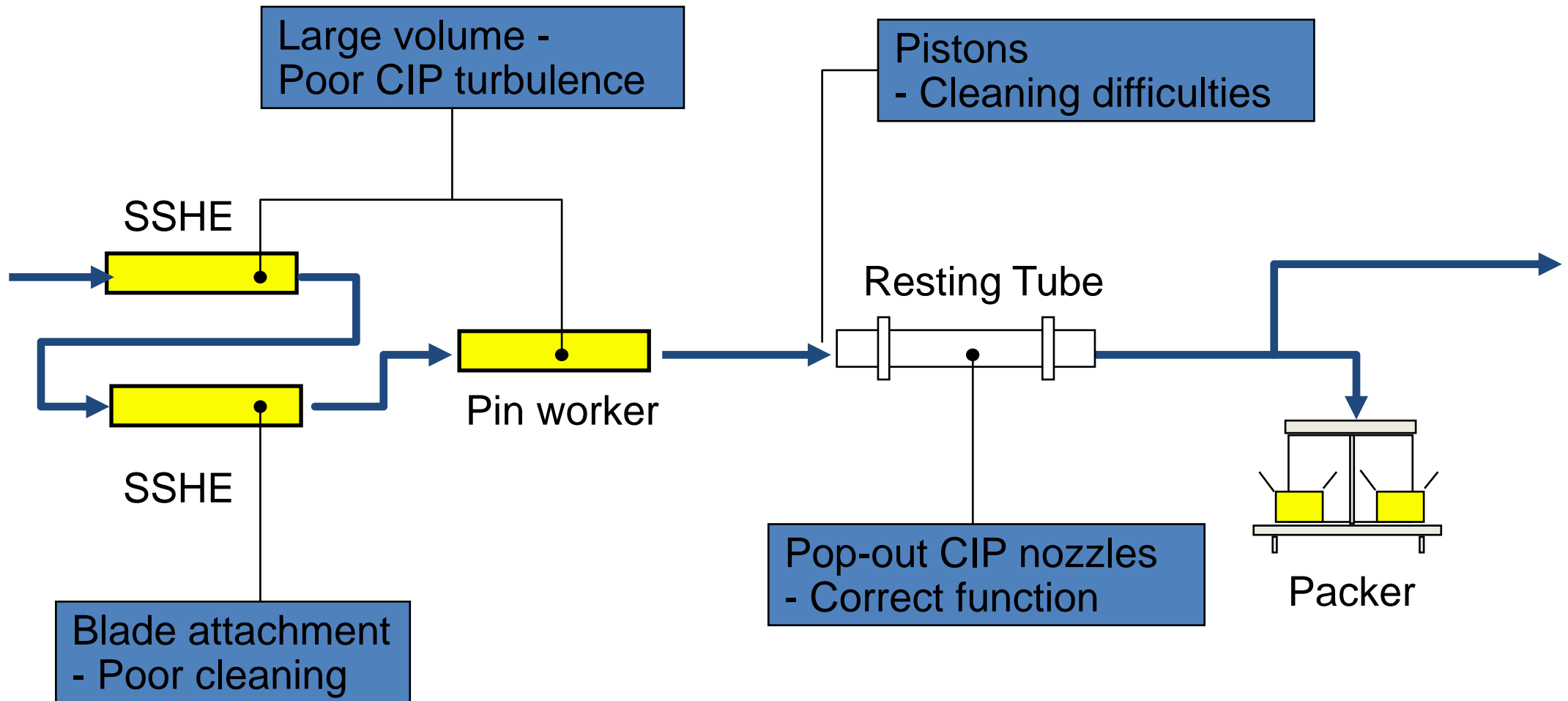
SSHE, Pin Worker & Resting Tube



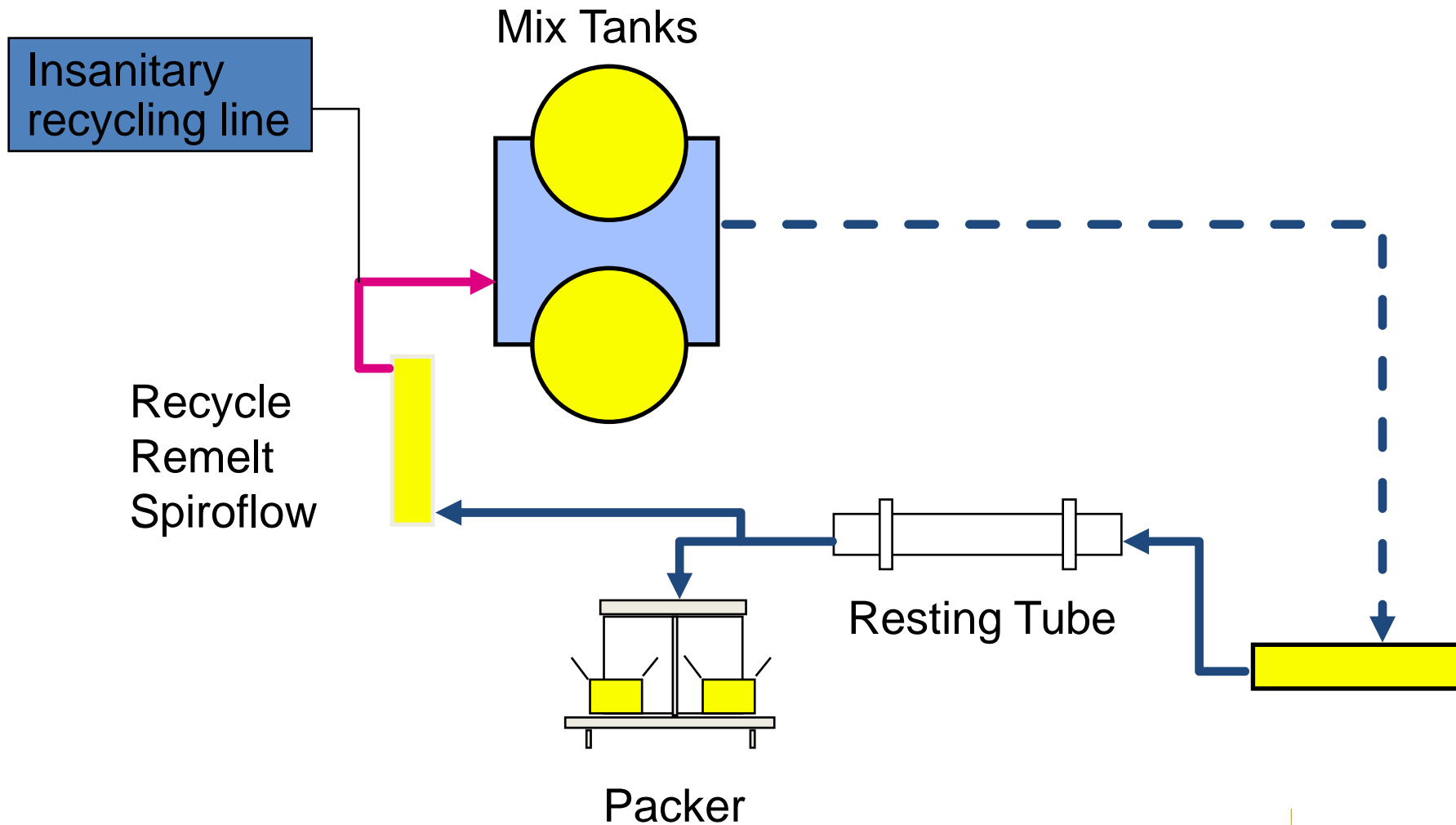
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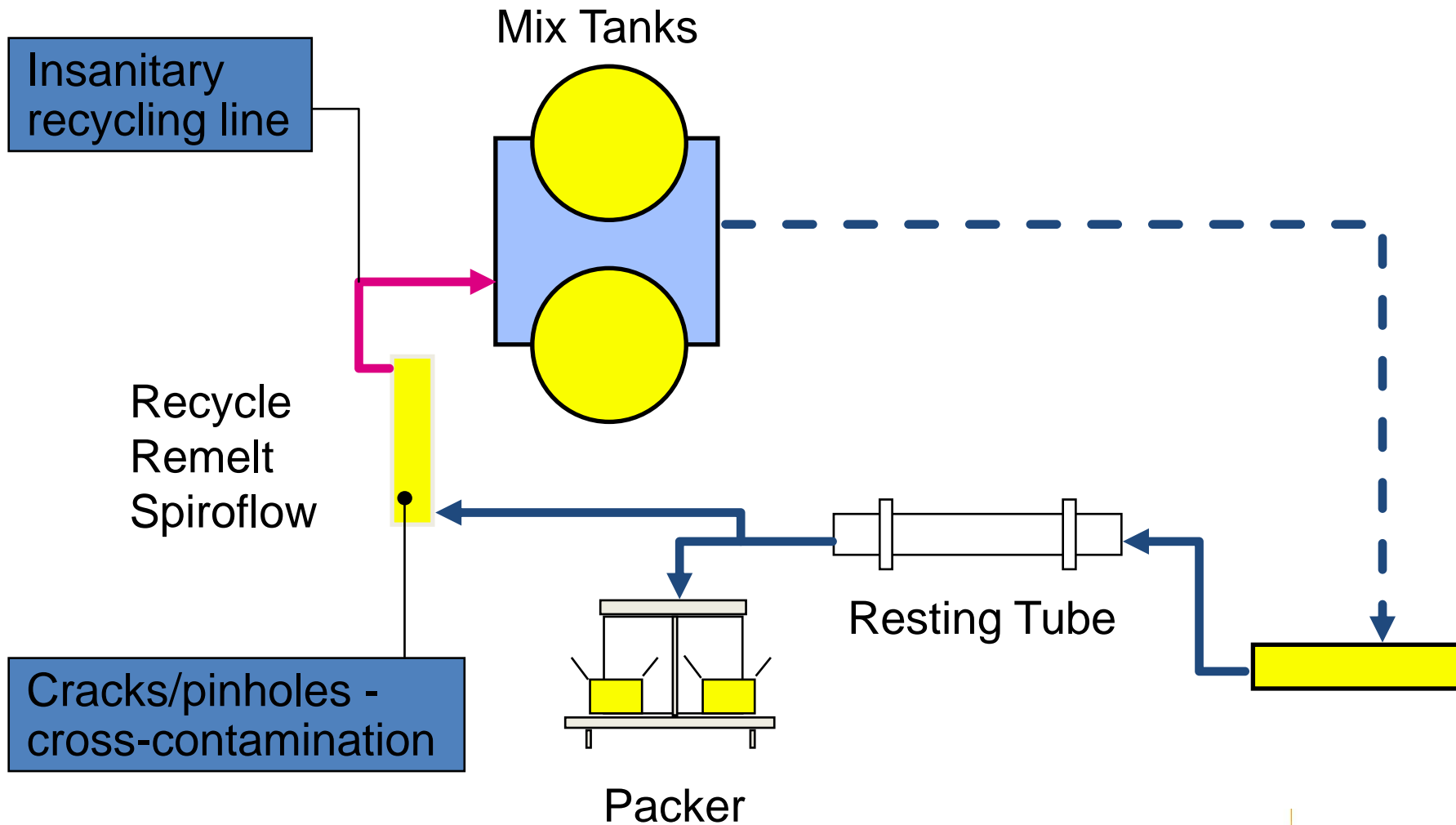
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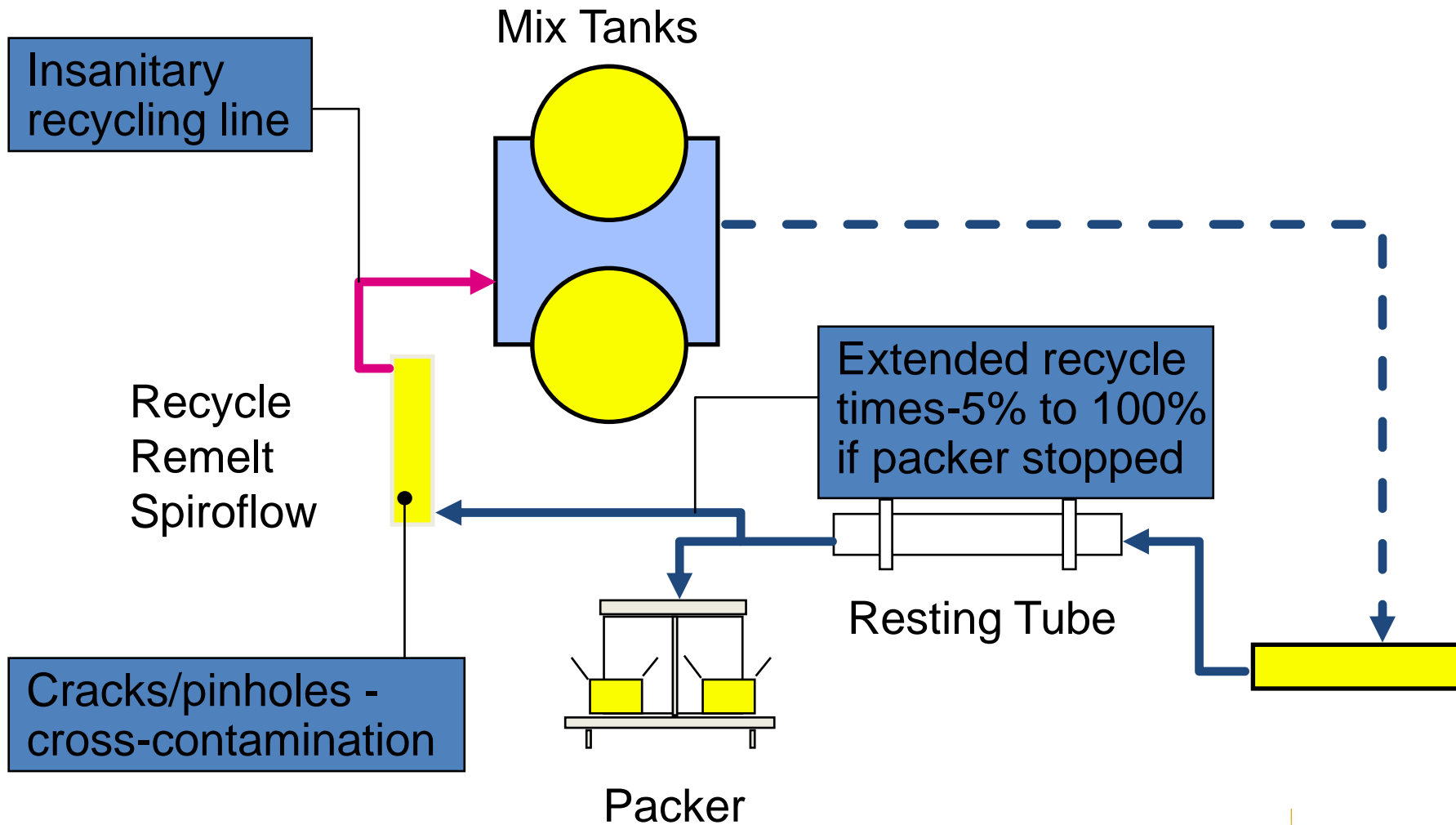
Recycling



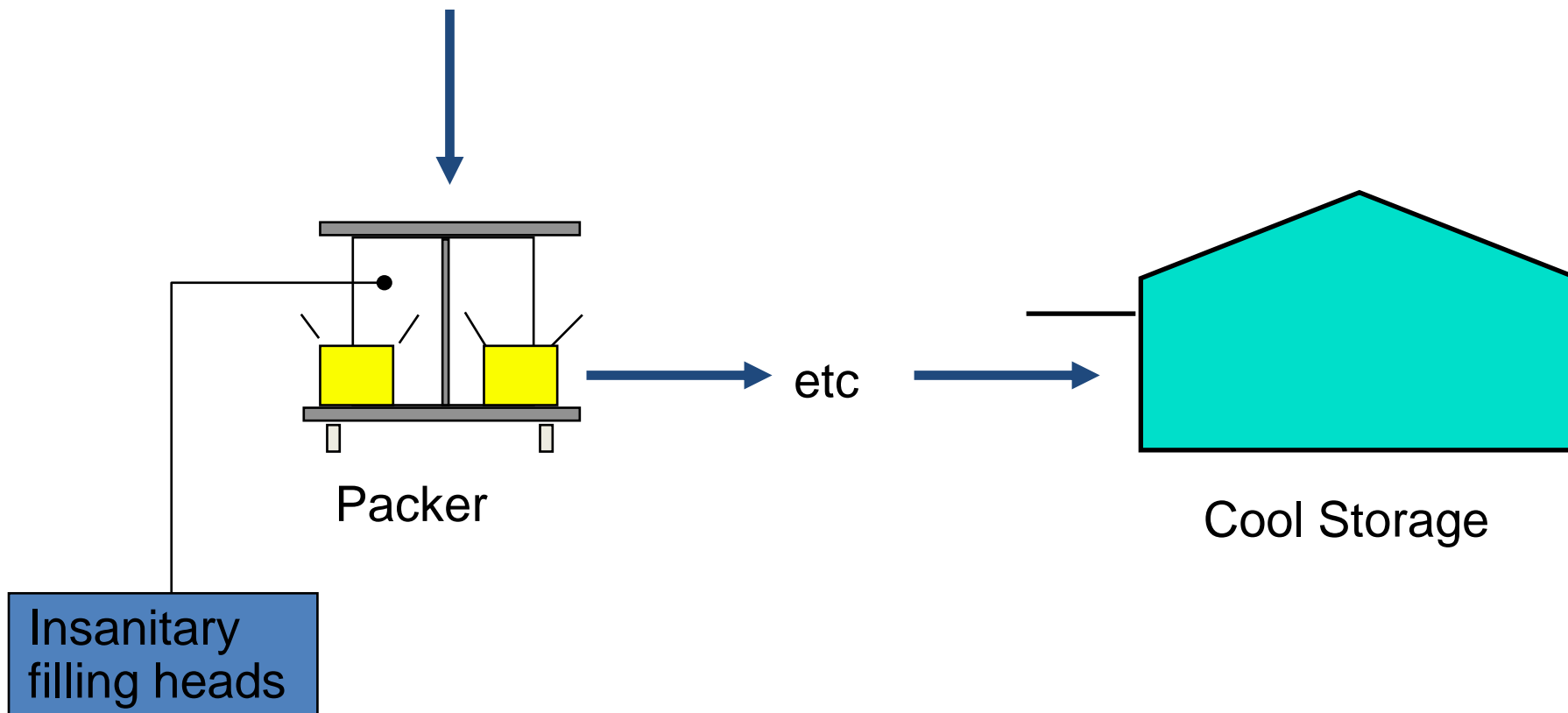
Recycling



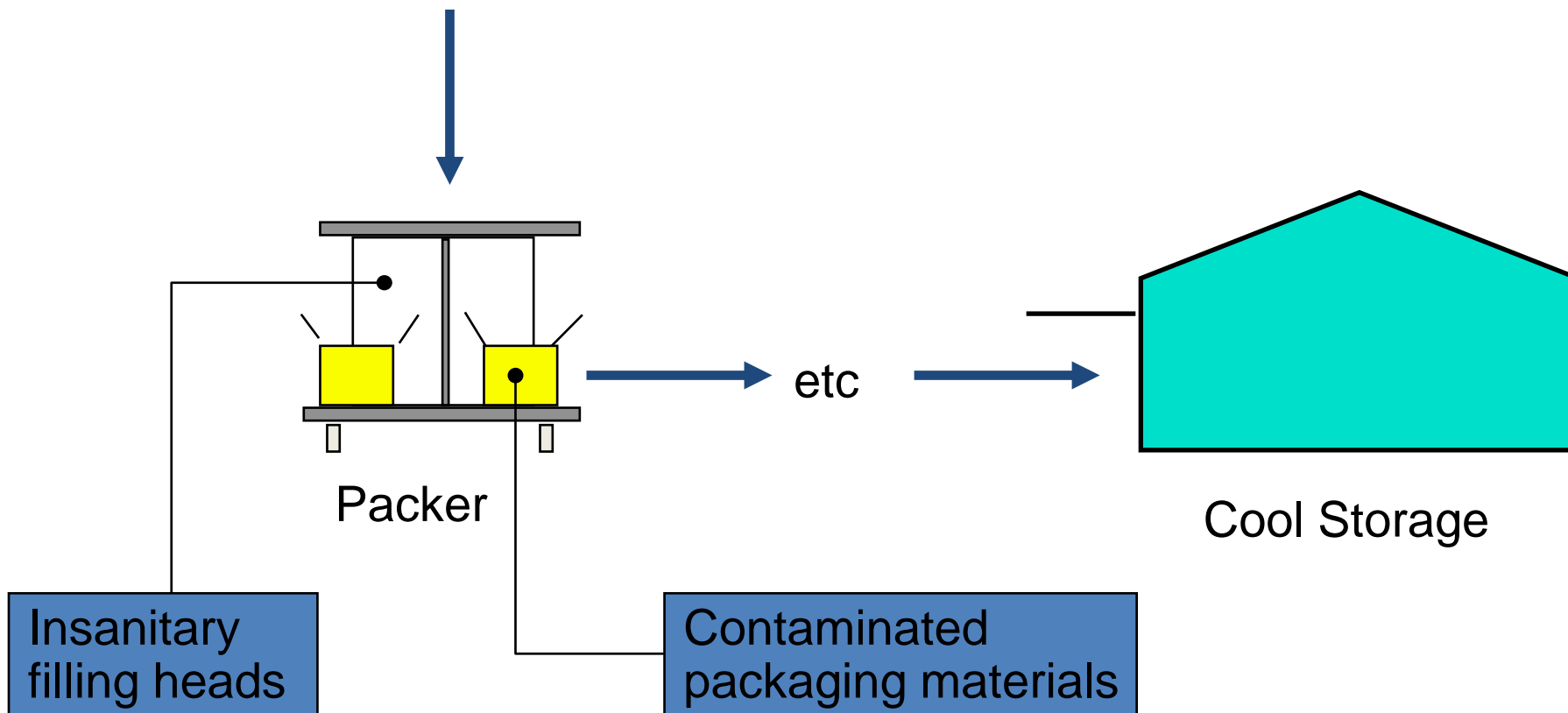
Recycling



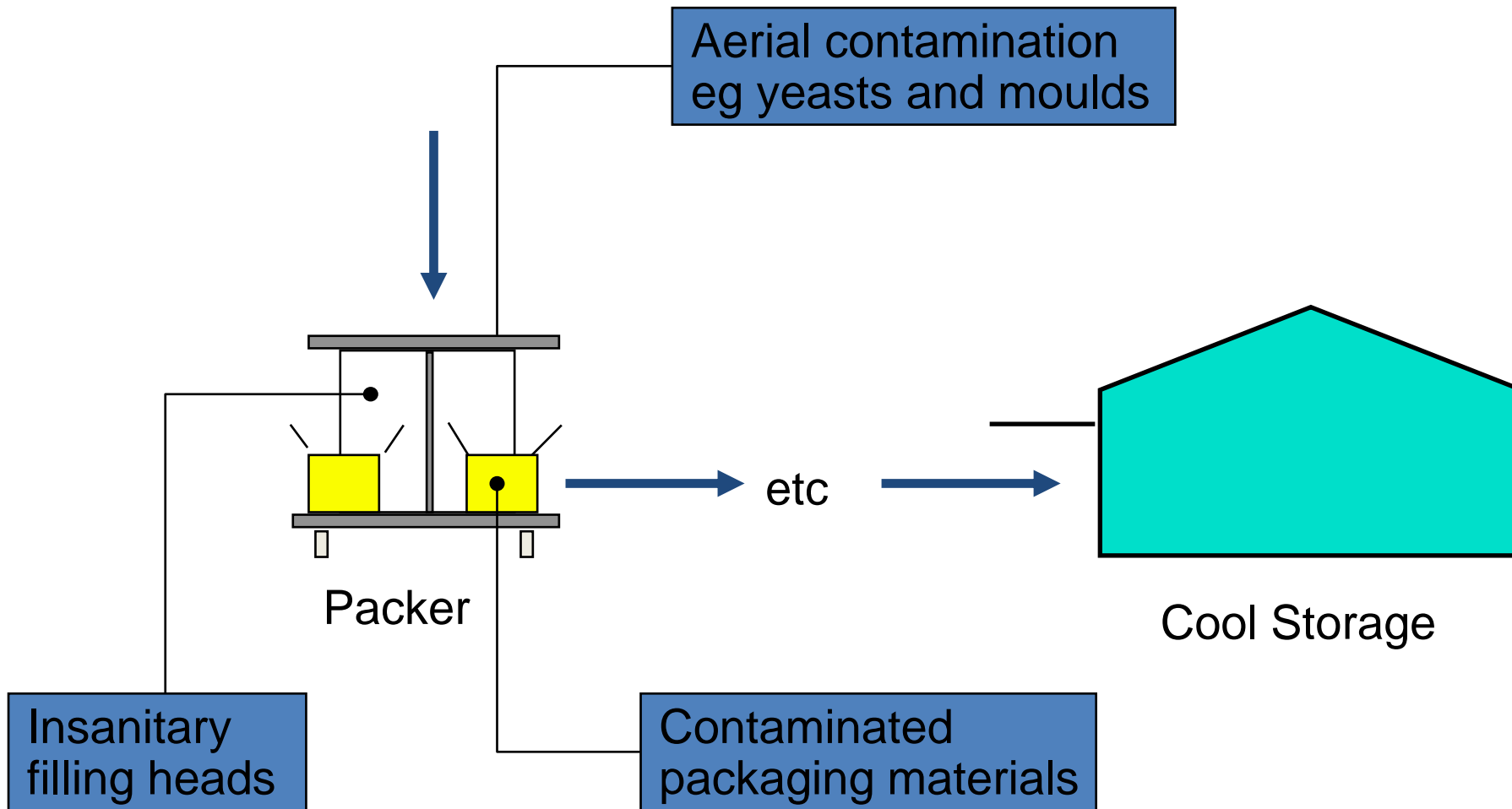
Packing & Storage



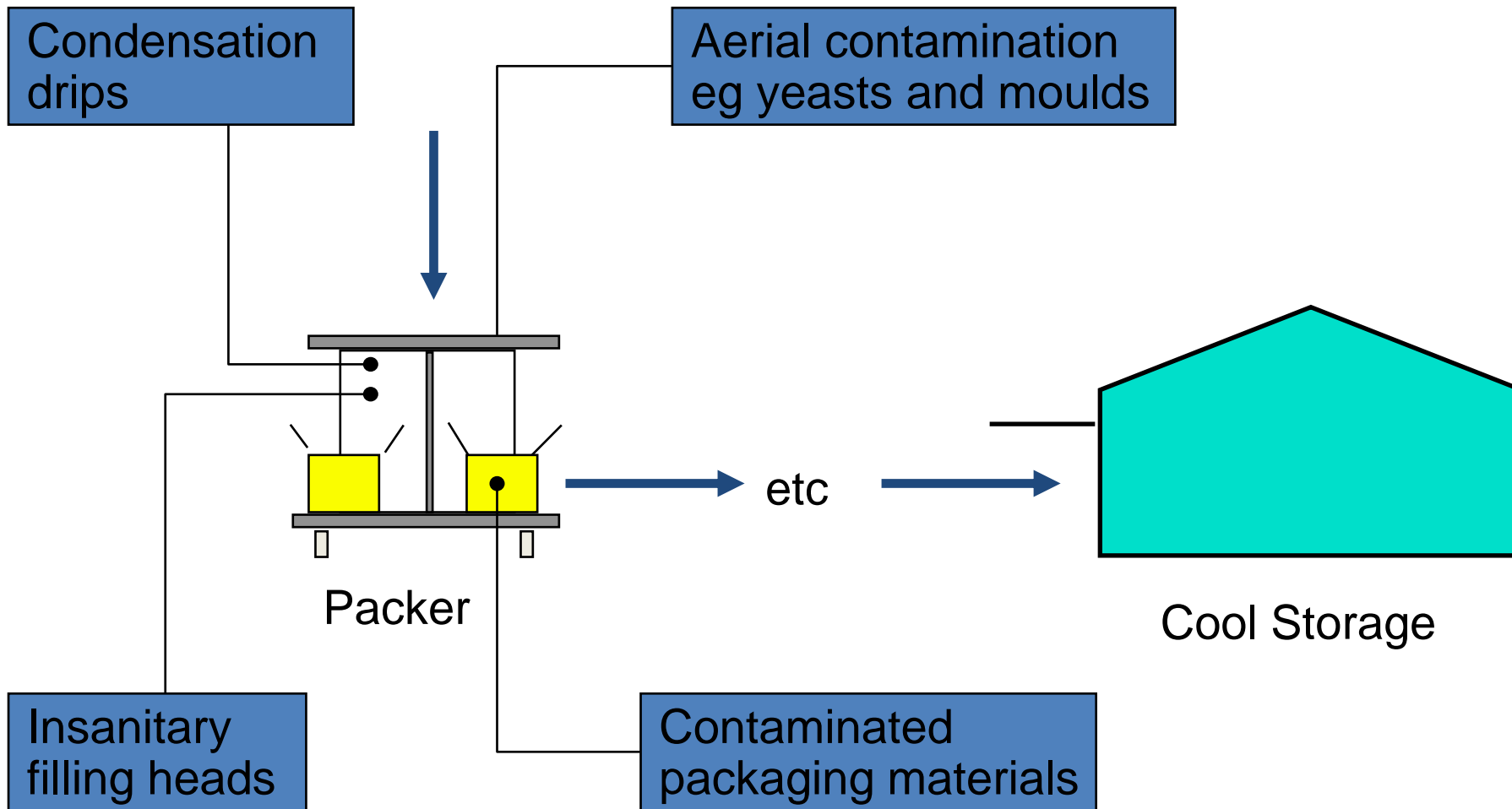
Packing & Storage



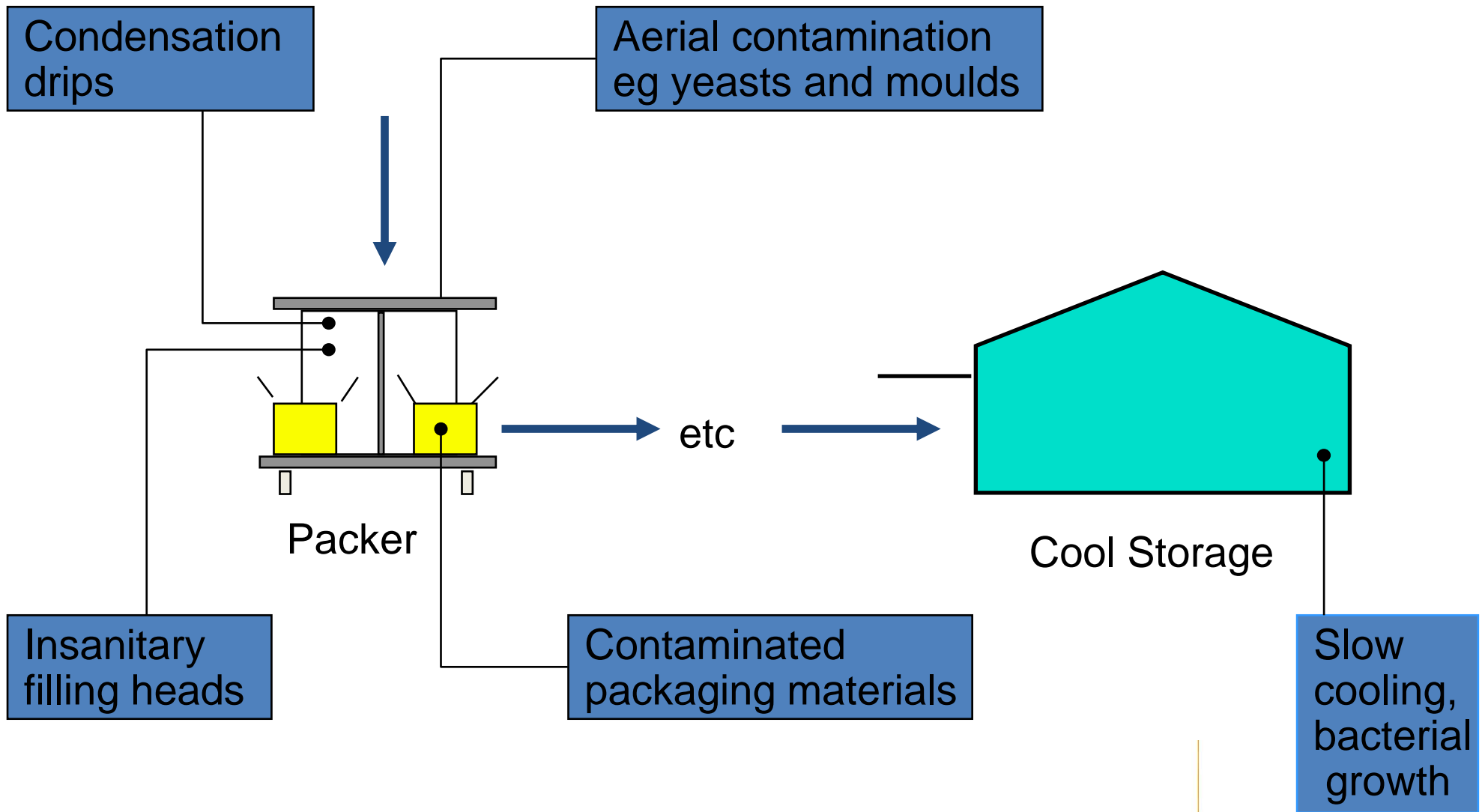
Packing & Storage



Packing & Storage



Packing & Storage



Sampling

What to Sample?

- Raw Materials
- Combined Ingredients
- Survivors After Heating
- Known Process Hazards



Sampling

Sampling Technique

- Document Methods to IANZ standard
- Train Samplers
- Use Clean Sterile Sampling Equipment
- Leave No Chemical Residues
- Do Not Contaminate Sample or Equipment
- Discard if Contaminated
- Label Samples Correctly



Sampling

Sample Storage

- Short Time (<1 Day) at Refrigeration Temps
- Minimise Micro. Changes
- Represent the Process / Product
- In-Process Testing in Manufacture?
- What Micro Failures can be Tested?
- Can Lab Supply Materials?



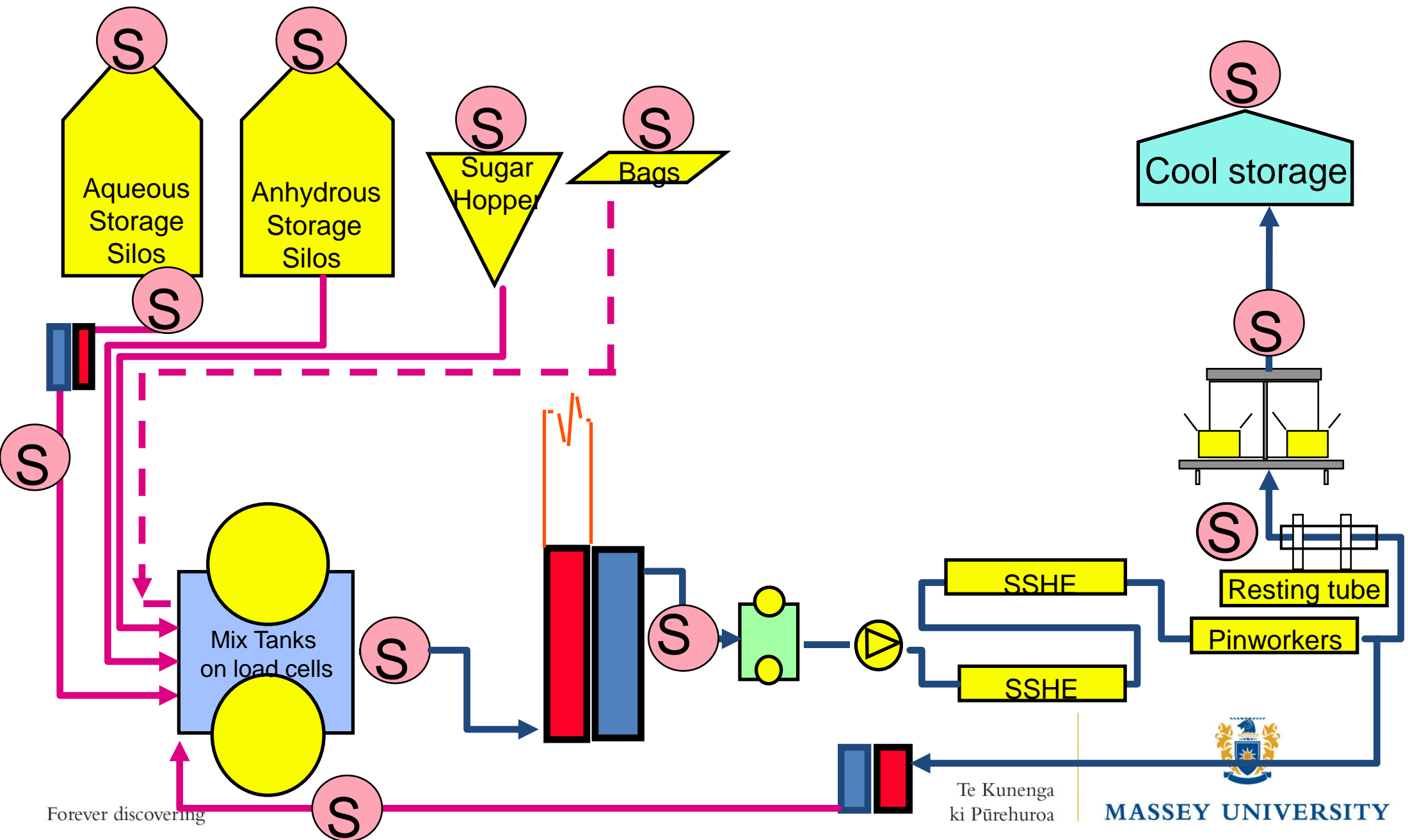
Sampling

Analyses

- To Reflect the Process e.g.
 - APC30
 - Coliforms
 - Thermophiles
 - Surface Spoilers, eg Yeasts, Acinetobacter
 - *B cereus*



Sampling Points S



Key factors affecting the micro quality of butter

- Cream handling
- Fat recycling
- Water/buttermilk quality
- Cooling



Questions

