MASSEY UNIVERSITY
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UNIVERSITY OF NEW ZEALAND

NCDEA/Dairy Australia

Is your raw milk giving you a raw deal?

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THE ENGINE OF THE NEW NEW ZEALAND

The quality of raw milk determines the quality of dairy products

Outline of Webinar

- Why is milk quality important
- How to define quality milk
- Sources of contamination
- Tests for milk quality
- How to improve milk quality

Why is milk quality important?

- To meet customer specifications for microbial content
- To meet sensory requirements
- To meet functionality requirements
- To reduce costs of manufacture (eg. reduce fouling)
- Maximise return for product (eg. protein and fat content)

Definition of quality milk

- Antibiotic free
- Somatic cell limits (400,000/mL EU/750,000/mL US)
- Meets microbial specifications (Tetra Pak Guidelines)

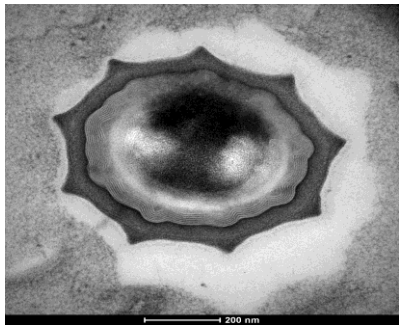
Total Bacteria Count	Outcome
≤ 300 000	Milk of good quality
300 000 – 1 million	Risk for organoleptic problems
1 million – 5 million	Risk for organoleptic problems &Shortened shelf life stability due to stability problems
>5 million	Not suitable for UHT processing. Product not stable

Other quality issues

- Feed taints
- Chemical residues
- Colostrum/blood
- Added water
- Foreign matter
- Mechanical damage

Quality Milk – key considerations

- Types of bacteria (sporeformers, enzyme producers)



- Stability of enzymes of microbial origin
  - Lipase
  - Phospholipase
  - Microbial rennet
  - Protease

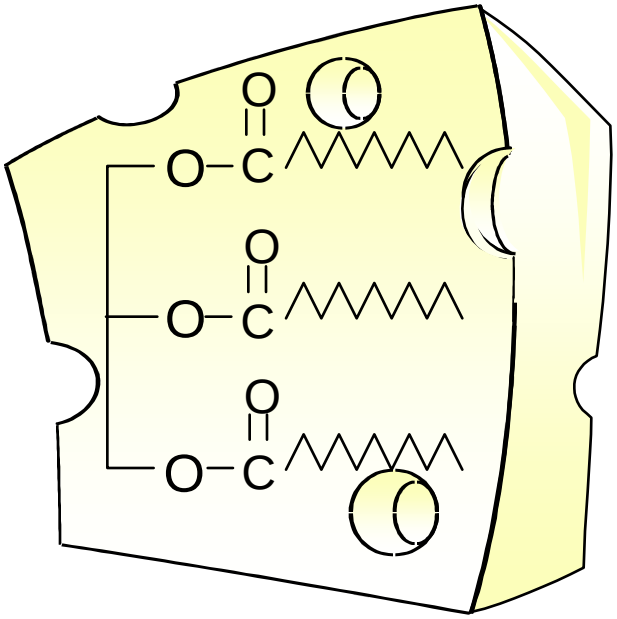
- Handling of milk (temperature/time)

Product defects resulting from poor quality milk

- Bitter flavours (proteases)
- Soapy flavours (lipases)
- Rancidity (lipases)
- Poor yields (fat and protein products)
- Dead vats (cheese)
- Excessive bacterial levels
- Product fouling

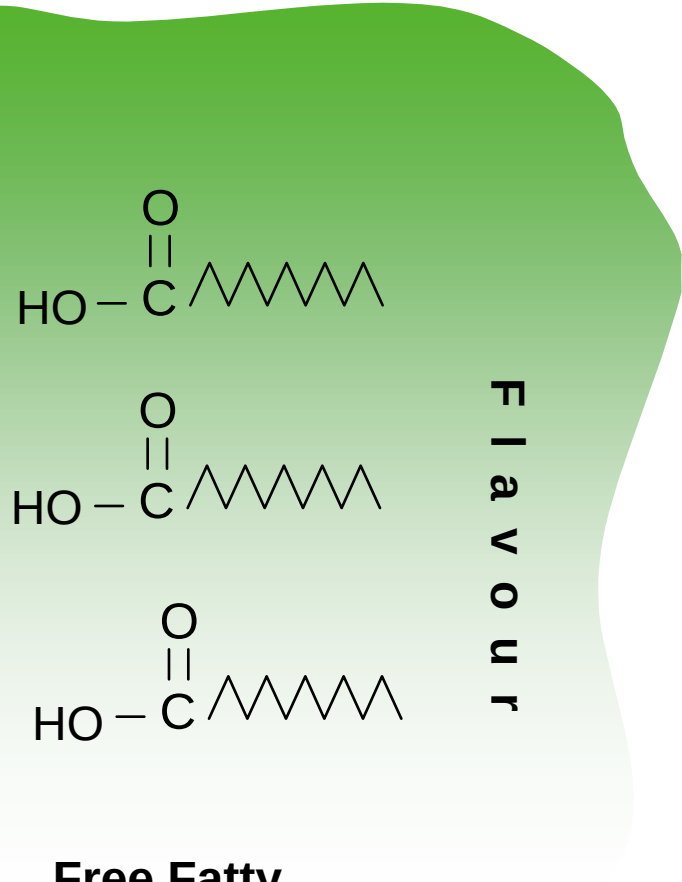
Lipase activity

33% fat



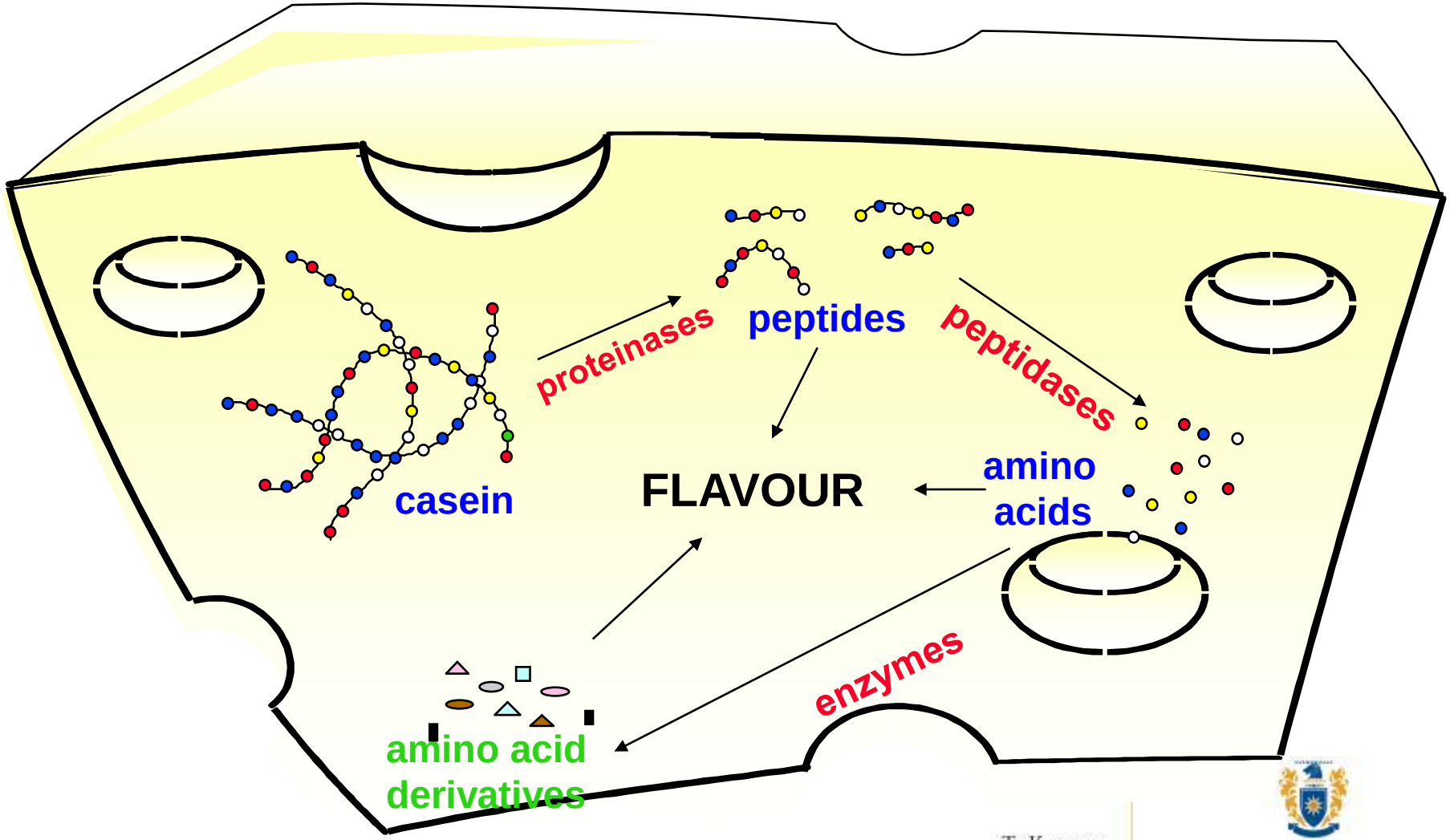
Triglyceride

Lipase



Free Fatty Acids

Proteolysis and flavour compounds

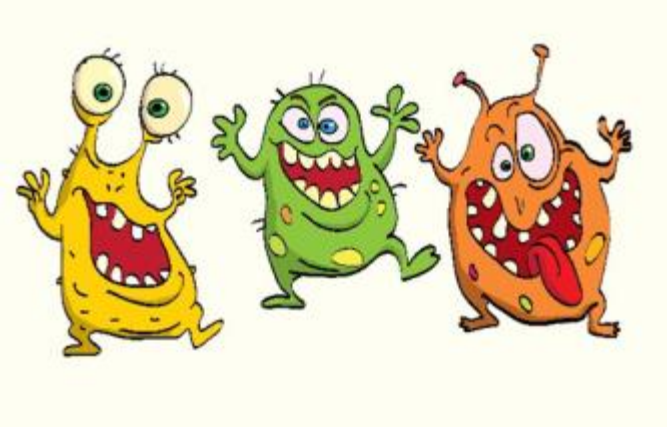


Types of microorganisms in milk

Microbial type	Outcome/concern
• Gram negative psychrotrophic bacteria	• *Enzyme producers – sensory/fouling/yield*
• Sporeforming bacteria	• *Product contamination*
• Thermoduric bacteria	• *Survive heat treatment*
• Pathogenic bacteria	• *Food Safety*
• Mastitis bacteria	• *Somatic cells*
• Lactic acid bacteria	• *Acid producers*
• Yeast and mould	• *Acid/sensory*

Raw milk survey *(de Vegt 2014)*

- Prevalent bacteria
  - *Mycobacteriaum*
  - *Lactobacillus*
  - *Lactococcus*
  - *Enterococcus*
  - *Chryseobacterium*

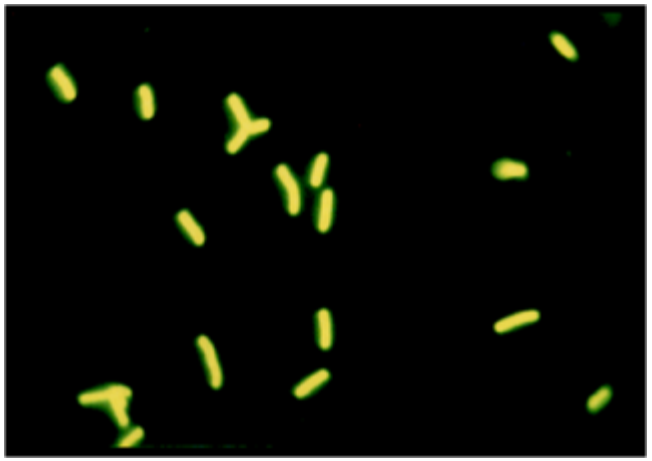


Raw milk survey *(de Vegt 2014)*

- Less prevalent bacteria
  - *Staphylococcus*
  - *Streptococcus*
  - *Pseudomonas*
  - *Corynebacterium*
  - *Acinetobacter*

Raw milk survey *(de Vegt 2014)*

- Occasionally detected bacteria
  - *Rhodococcus*
  - *Serratia*
  - *Enterobacter*
  - *Klebsiella*
  - *Micrococcus*
  - *Bacillus cereus*
  - *E. coli*



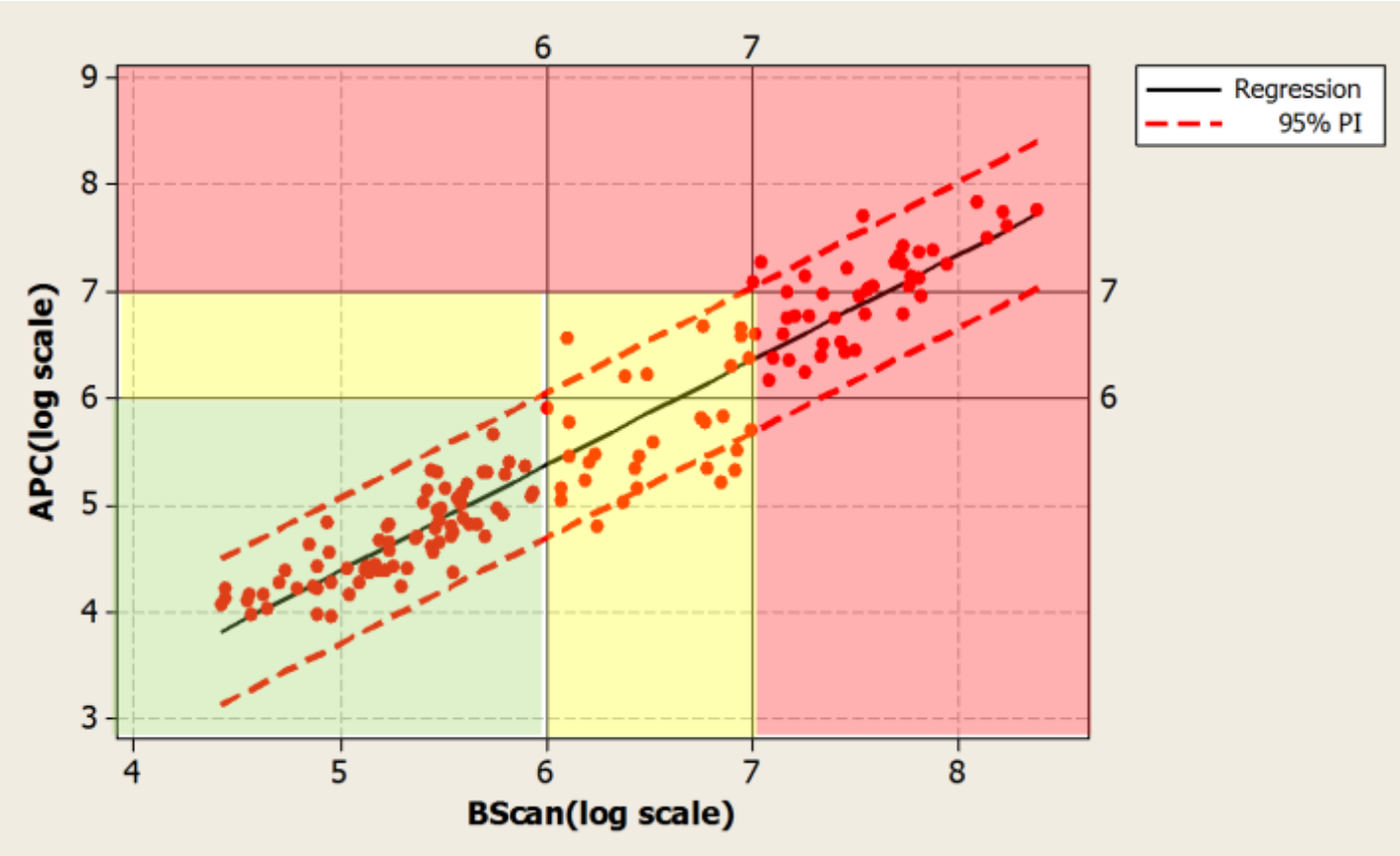
Sources of Contamination

- Udder infection
- External surface of udders
- Faecal Shedding
- Milking and storage equipment
- Farming Environment
- Transportation and silo storage

Tests for raw milk quality

- Antibiotic testing
- Total microbial load
  - APC
  - Bactofos
- Somatic cell counts

Raw Skim milk regression model that is divided into zones based on the production of heat resistant enzymes



Alternative microbial tests

- Methylene blue or Rezasurin reduction tests
- Total spore count
- Thermoduric count
- Psychrotrophic count

Other testing – Chemical/Physical

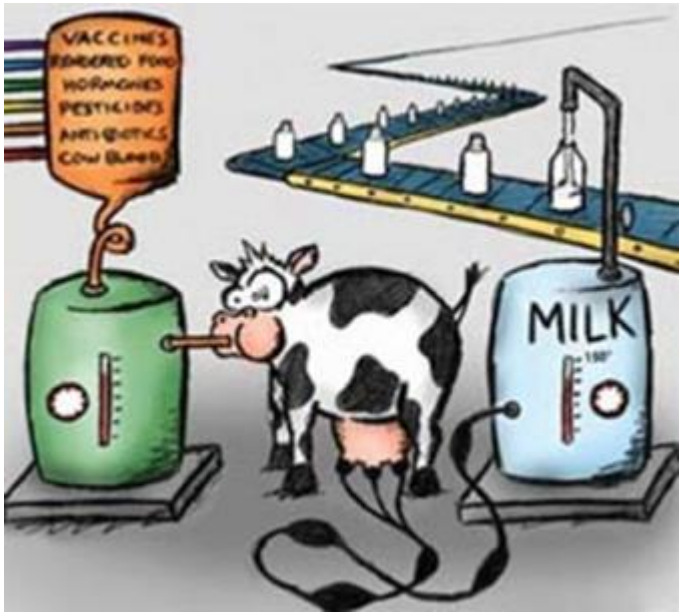
- pH
- Total acidity
- Alcohol precipitation (protein stability)
- Freezing point
- Density (solid content)

Comparison between APC and TA results

APC (CFU/mL) (log scale)	TA (%m/v)
10^4	0.1
10^5	0.10-0.13
10^6	0.15
$>10^7$	0.17

Current Raw Milk Requirements

- Australia – Varies from state to state but generally requires milk to be chilled to 4° C.



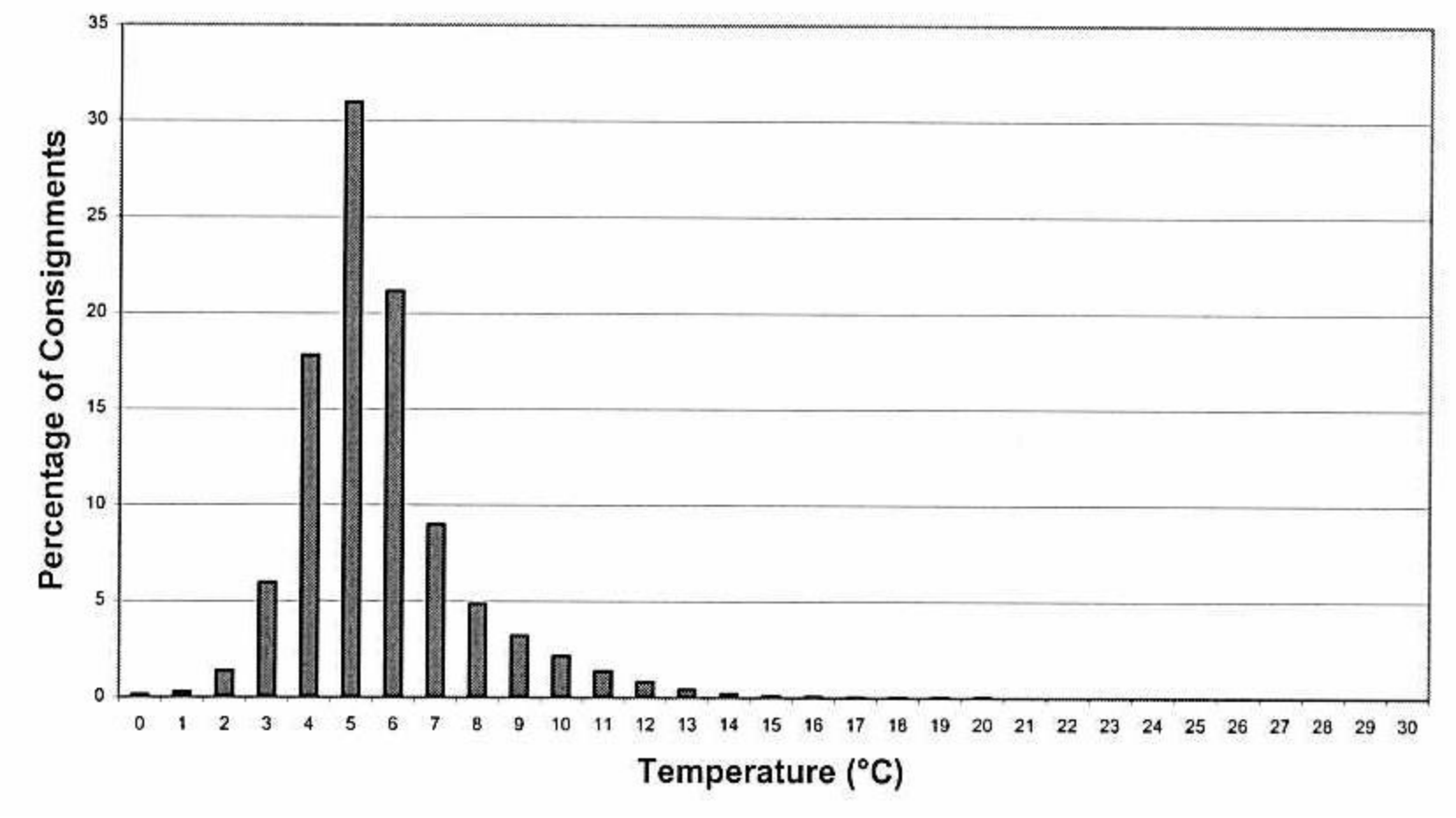
International Regulations

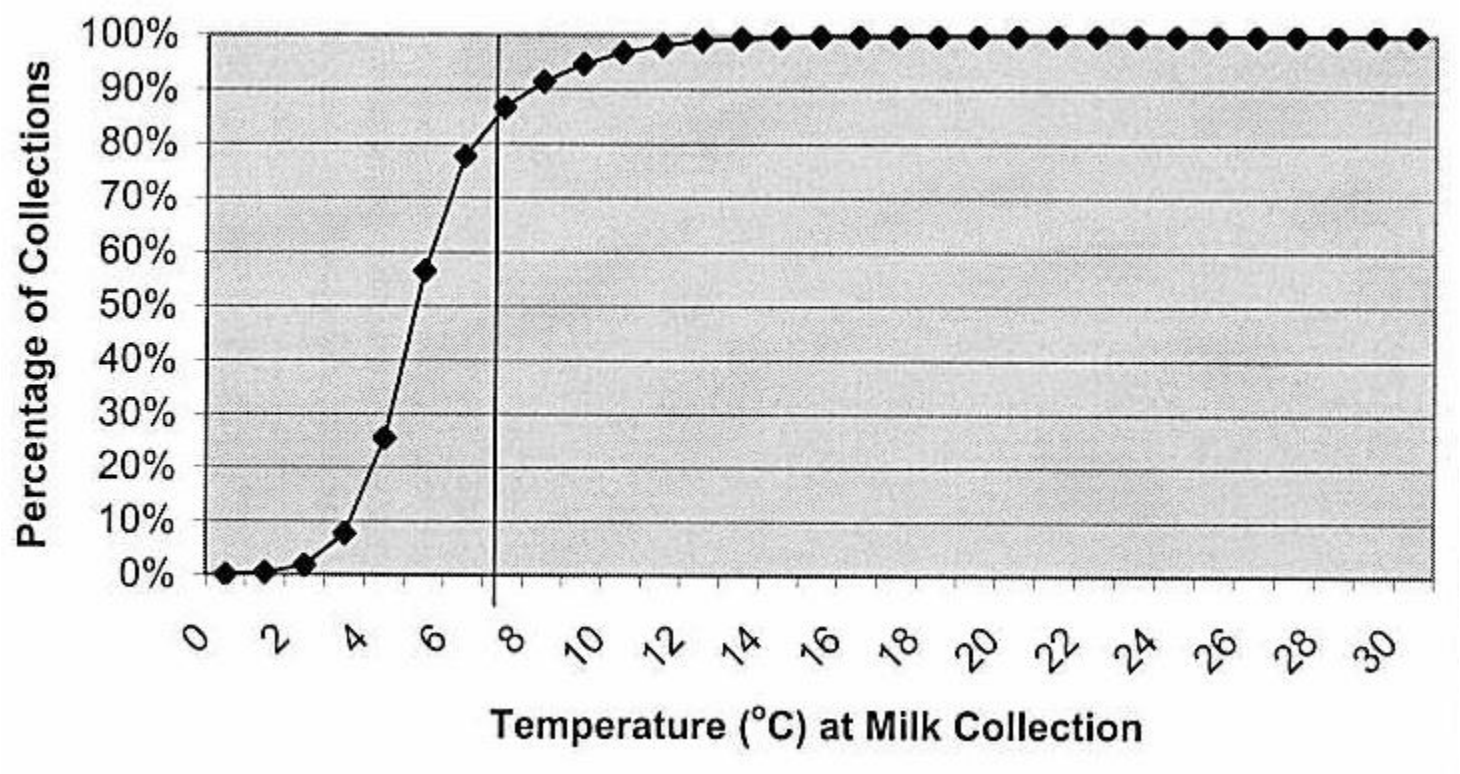
- New Zealand - 7 ºC within 3 hours from the completion of milking. Revised to be 6˚ C within 6 h of milking.

- USA - 2 ºC within 2 h of milking

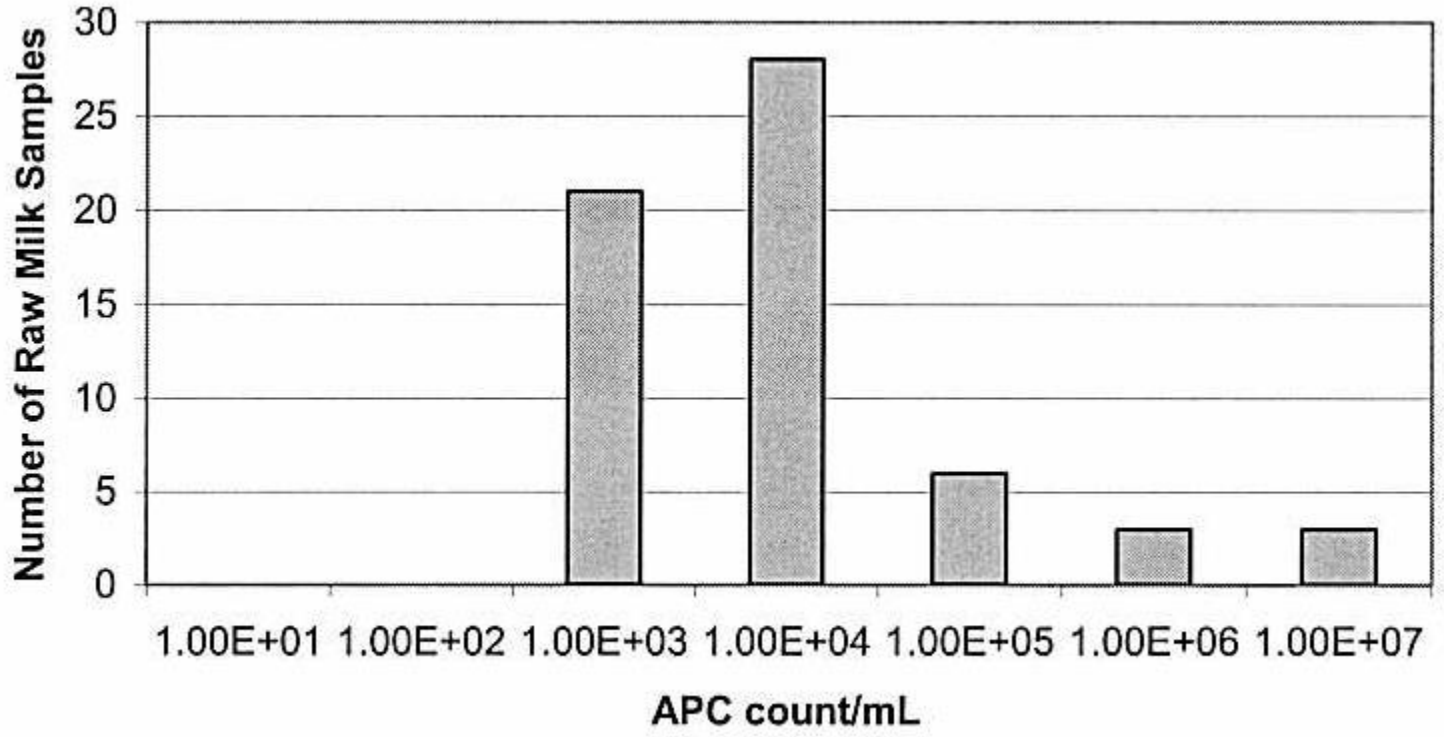
- EU - 8 ºC within 2 h of milking

Milk temperature on farm at the point of collection

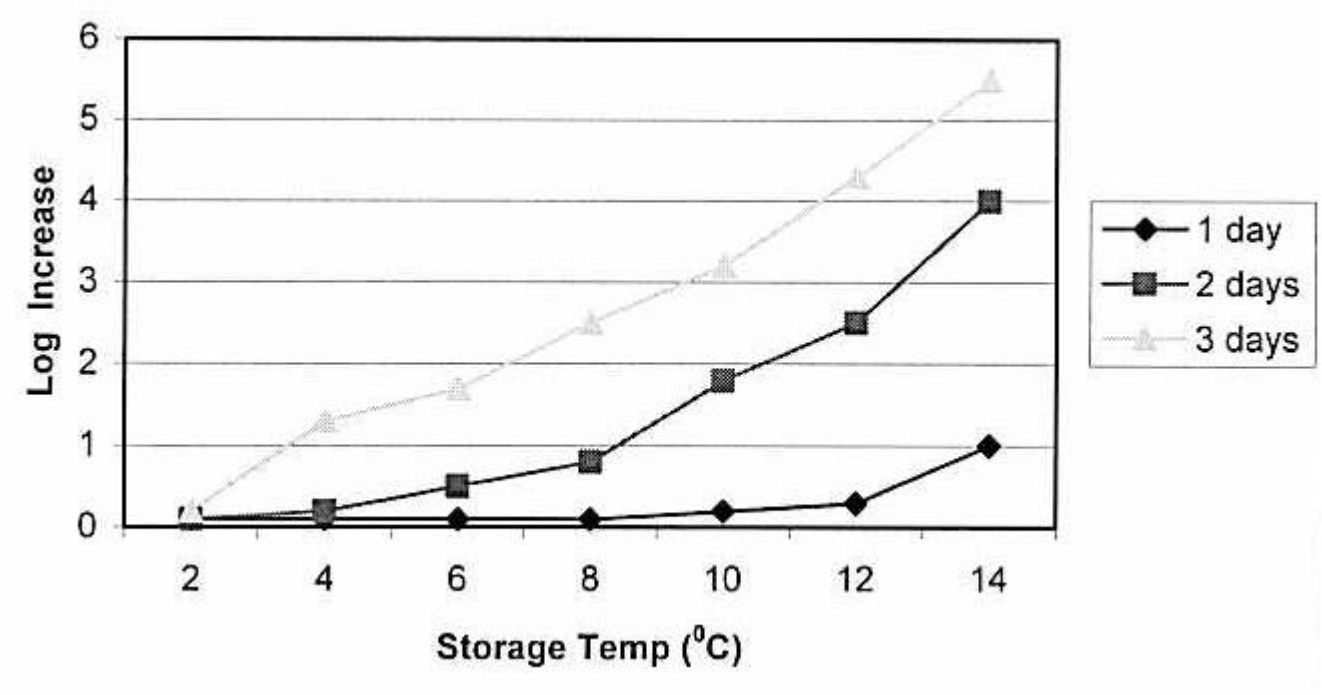



Percentage of Collections
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Temperature (°C) at Milk Collection

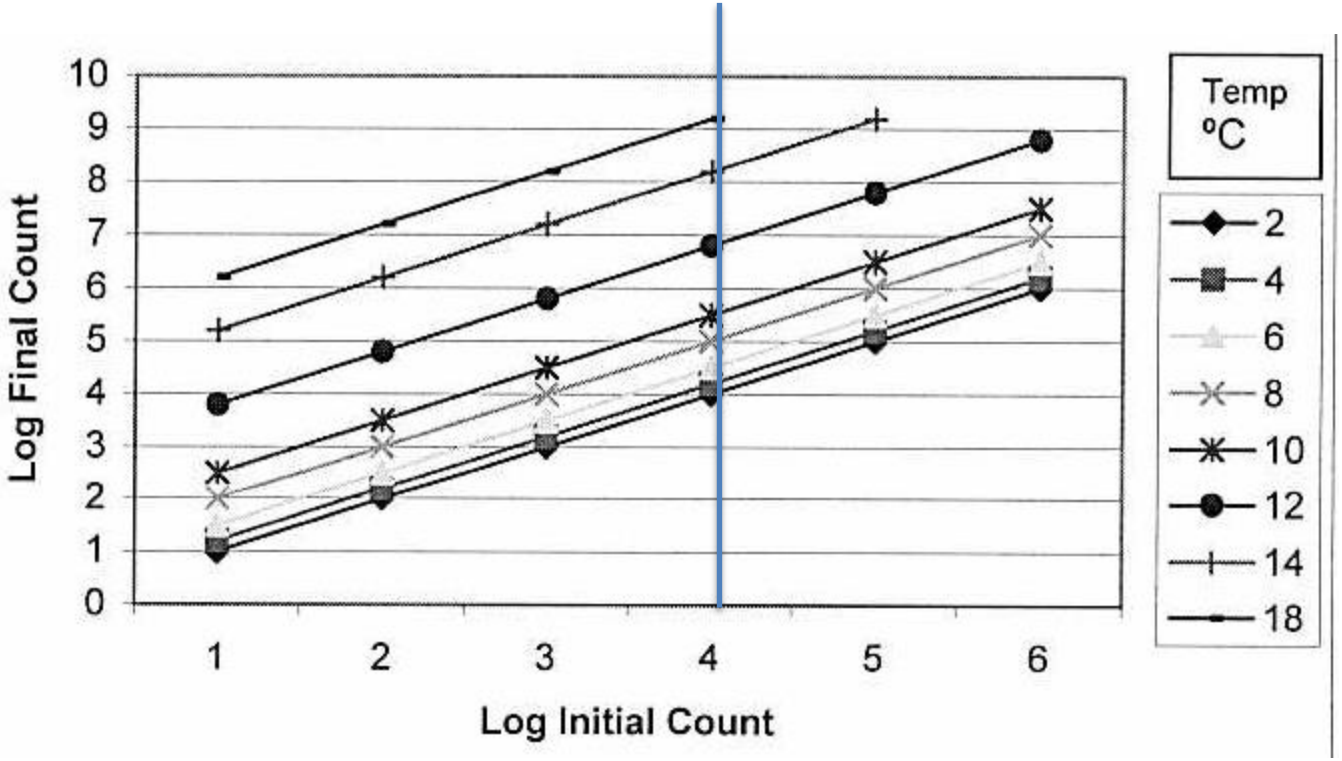
APC counts in milk – case study on one manufacturing site



Effect of storage time on APC growth in milk



Relationship between initial count and average final counts in milk stored for 48 h

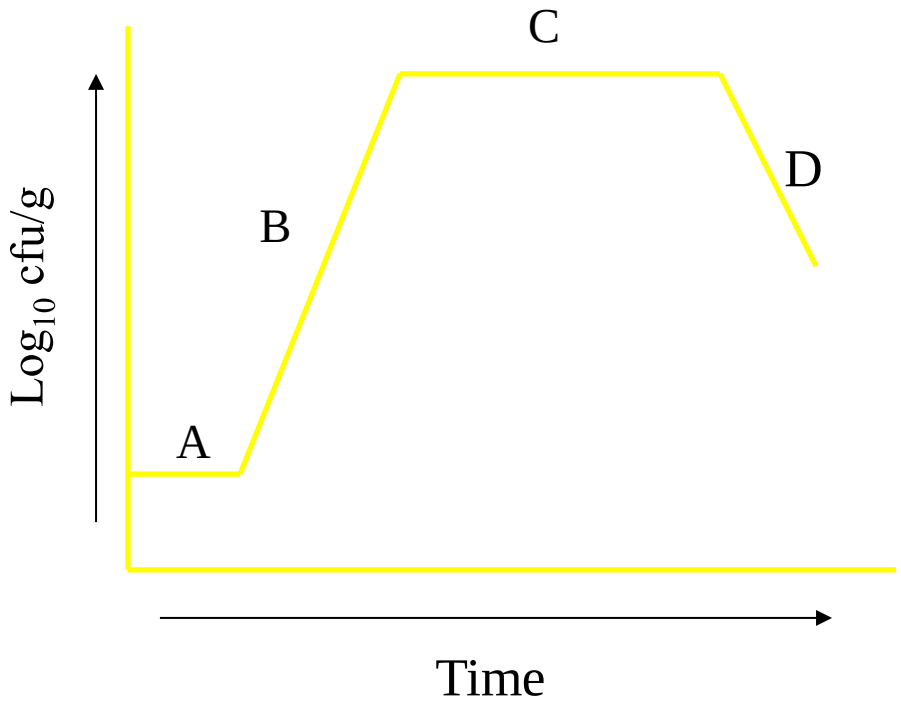


Effect of delayed cooling on bacterial growth in raw milk

Delay in Cooling to 12.8°C (h)	Total Plate Counts/mL after (h)		
	0	24	48
0	2.5×10^2	3.0×10^3 (12)*	2.0×10^6 (8000)
2	2.0×10^2	1.5×10^4 (70)	2.7×10^6 (13500)
4	2.3×10^2	2.5×10^4 (110)	1.5×10^7 (75000)
8	1.9×10^2	9.3×10^4 (480)	4.4×10^7 (230000)
16	1.6×10^2	1.4×10^7 (87000)	4.0×10^7 (250000)

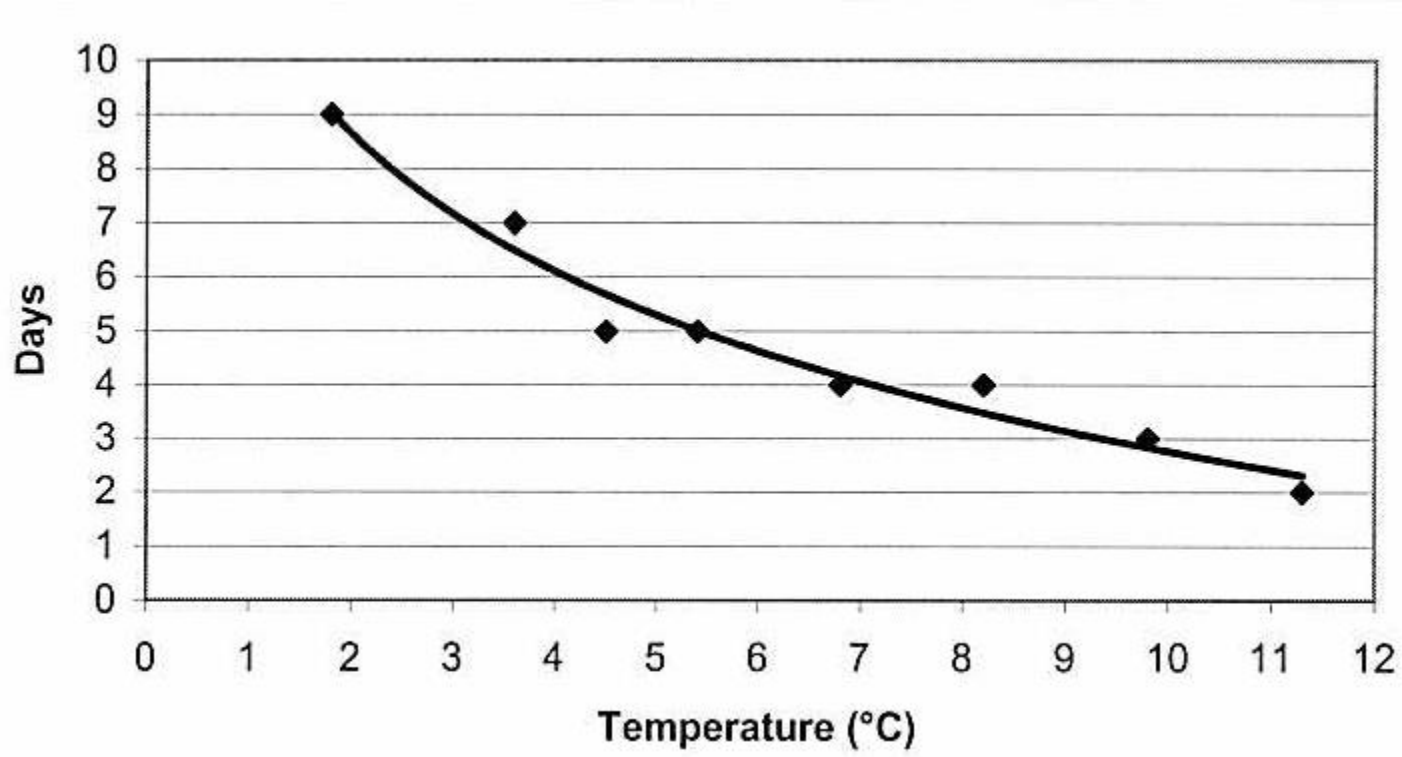
* The figure in parentheses gives the number of fold increase over the initial count.

Microbial Growth Phases



A=Lag Phase
B=Log/Exponential Phase
C= Stationary Phase
D= Death Phase

Lag phase for APC in raw milk at different temperatures



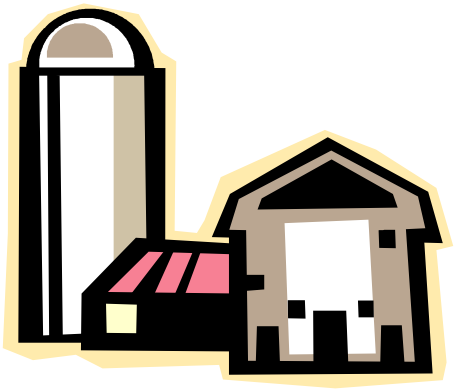
Effect on speed and temperature of cooling on lag phase

Storage Temperature (°C)	Slow/Rapid Cooling	Trial 1 – Lag (h)		Trial 2 – Lag (h)	
		Mean	SD	Mean	SD
2	Rapid (40 s)	12.6	0.5	14.9	0.5
2	Slow (2 h)	11.6	0.8	15.8	0.2
7	Rapid (40 s)	12.9	0.7	15.2	0.5
7	Slow (2 h)	12.2	0.9	14.5	0.3

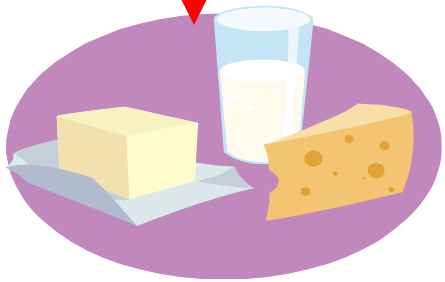
Dairy farm

Spoilage enzymes

Milk tanker



Dairy processing plant



Dairy products

Dairy related spoilage bacterial enzymes

- **Two major bacterial enzymes in milk:-**
  - **Protease (Bitterness)**
  - **Lipase (Rancidity)**
- **Activity in final product**

Proteolysis in raw milk

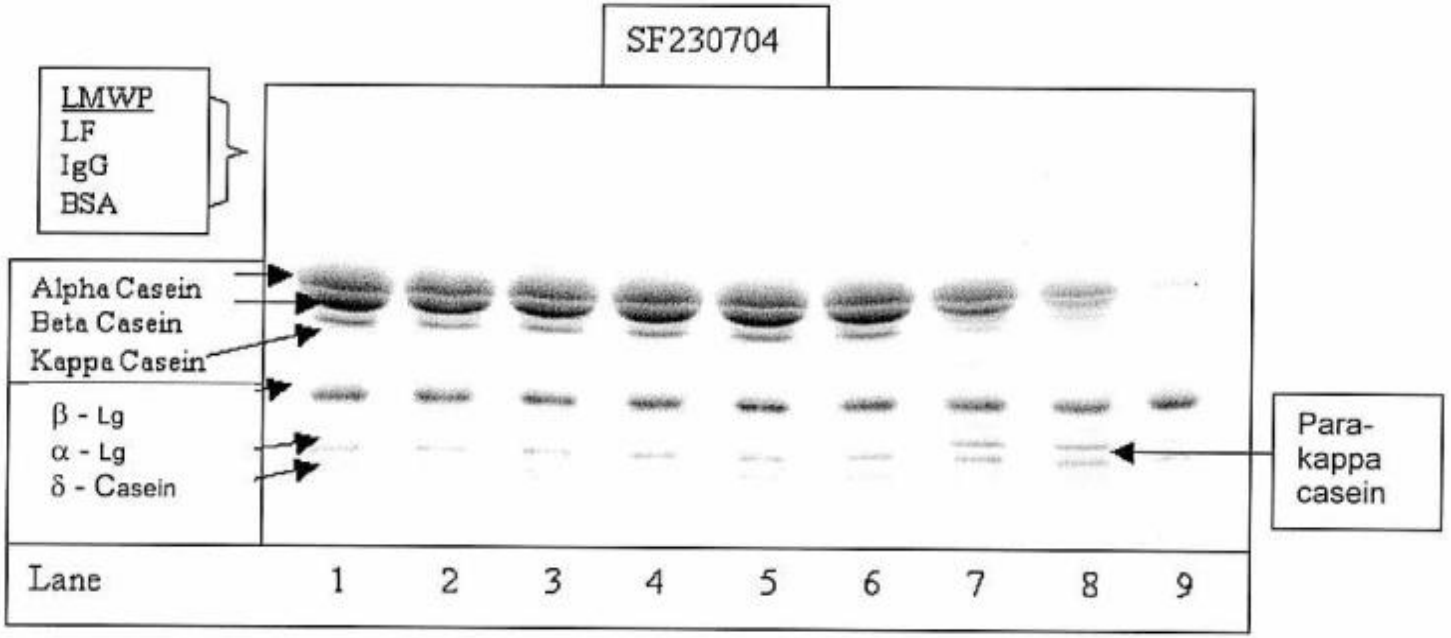
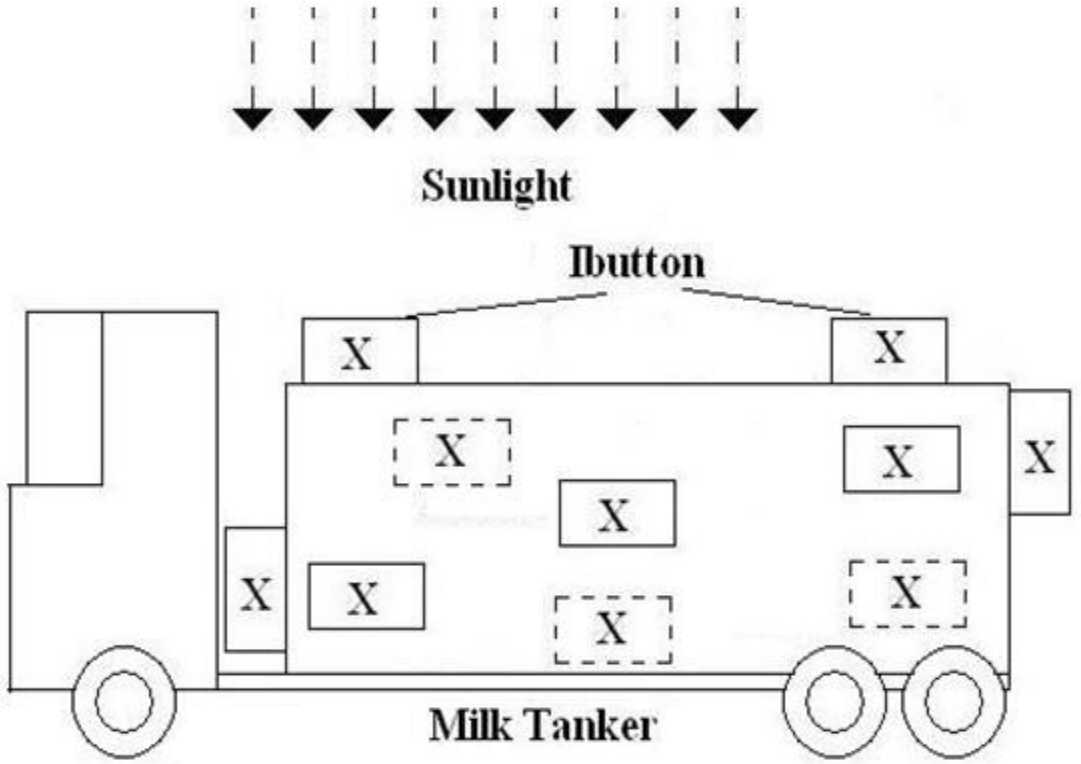


Figure 10. SDS PAGE analysis of proteins from raw milk stored at various temperatures for 48 h (1. Skim milk control; 2. Test control; 3. 1.9°C; 4. 4.9°C; 5. 7.1°C; 6. 10.2°C; 7. 15.4°C; 8. 19.2°C; 9. 25.0°C).

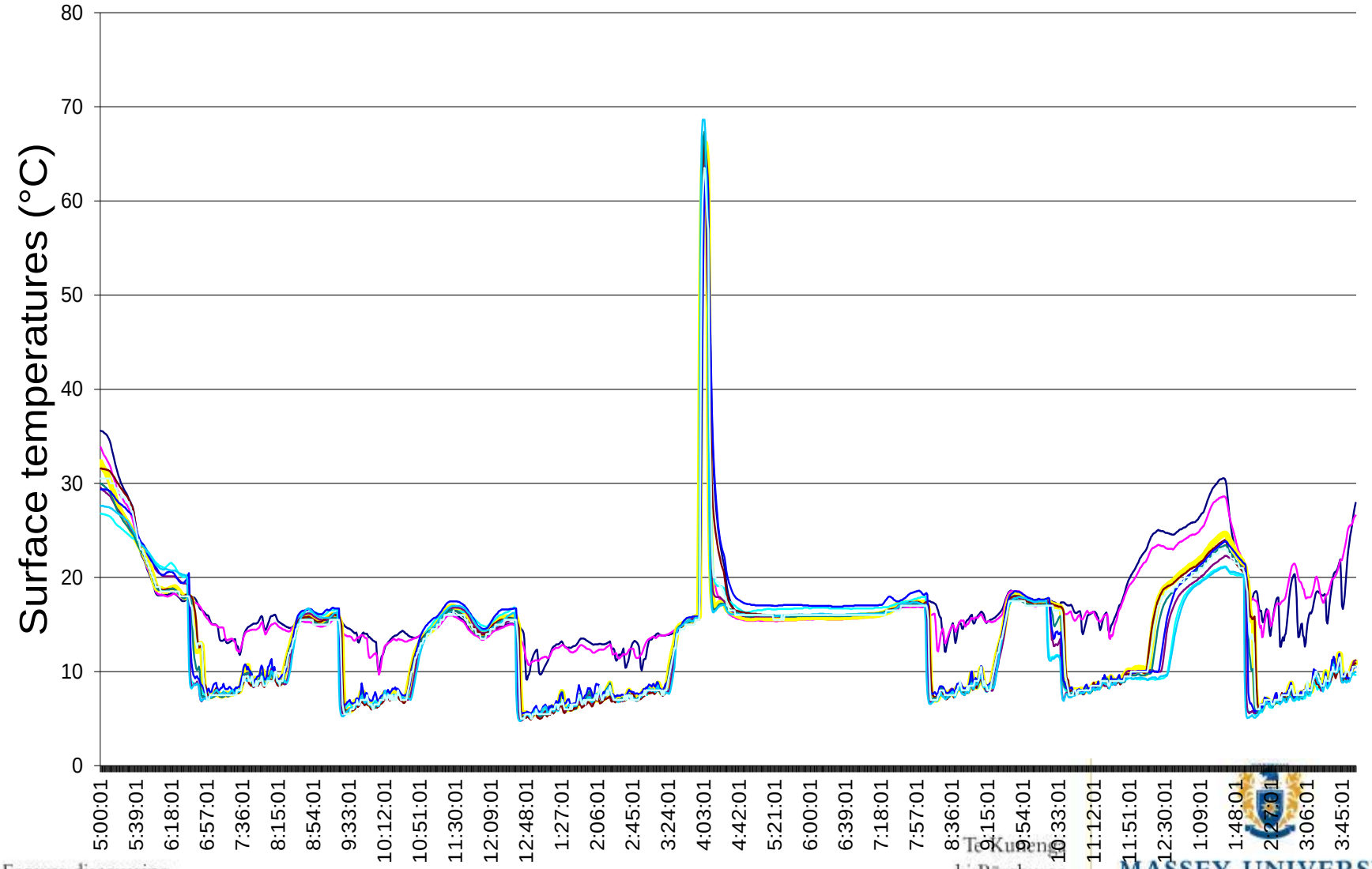
General background

- **Biofilm**
  - **Reservoirs of bacterial enzymes**
  - **Entrapment or secretion**
  - **Milk tanker surfaces suitable for biofilm growth**

Temperature Monitoring



Temperature monitoring



Enzymes produced by biofilm cells

- **Isolates from milk tanker surfaces**
  - **153 isolates**
  - **52 biofilm and enzyme producers**

  - 12 typed (16S DNA) for further study
- **Dairy bacteria can produce proteases and lipases within biofilms - in greater amounts than planktonic cells**

Material and methods

- **A cocktail of bacterial strains**
  - ***P. fluorescens* C224, *S. liquefaciens* DC, *S. aureus* SF01**
- **Three different level of contamination**
  - **Slightly, Moderately and Heavily**
- **Initial inoculum**
  - **10^3, 10^5, 10^7 cfu/mL**

Materials and Methods

20° C for 24 h

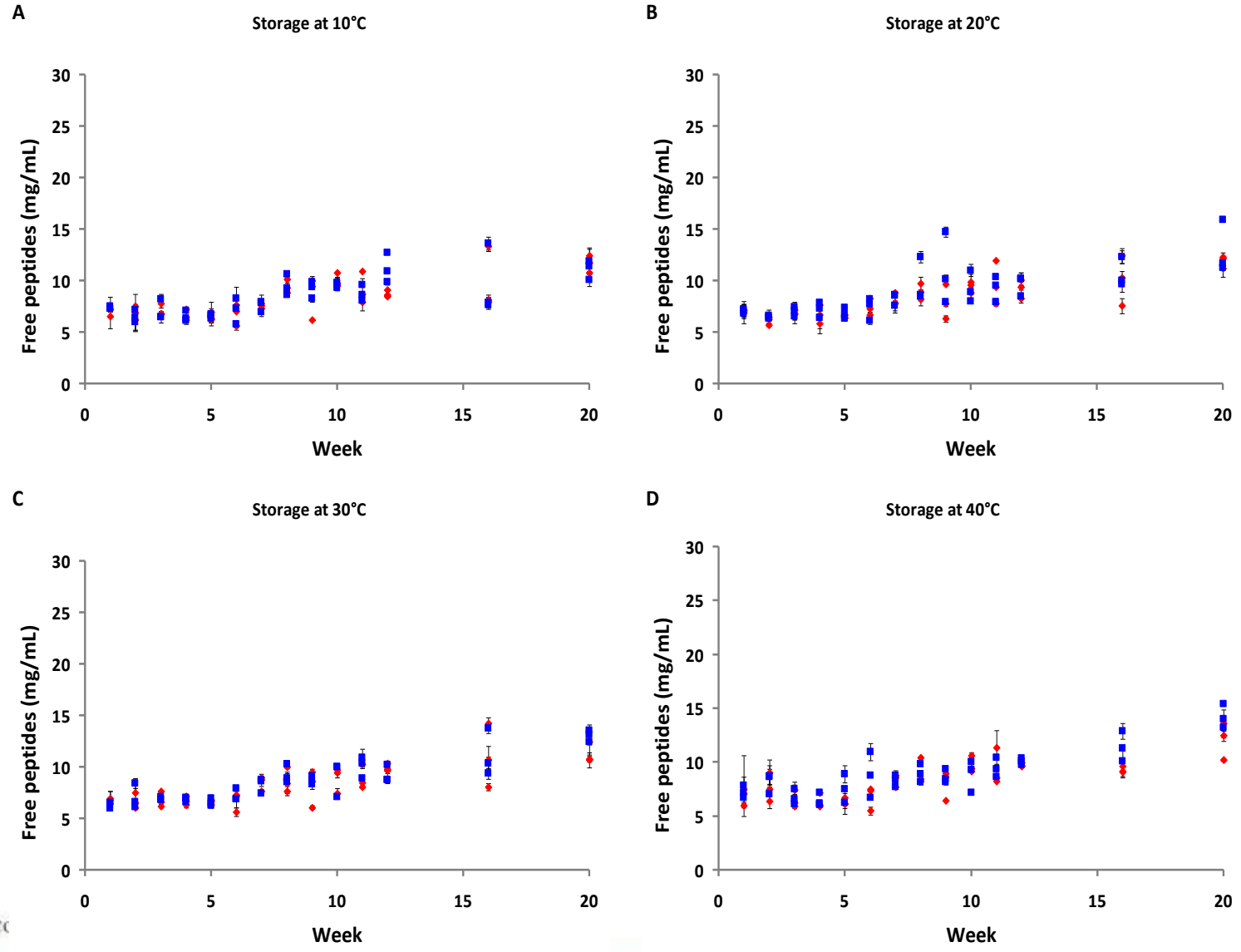
20° C for 10 h

141° C for 5 s

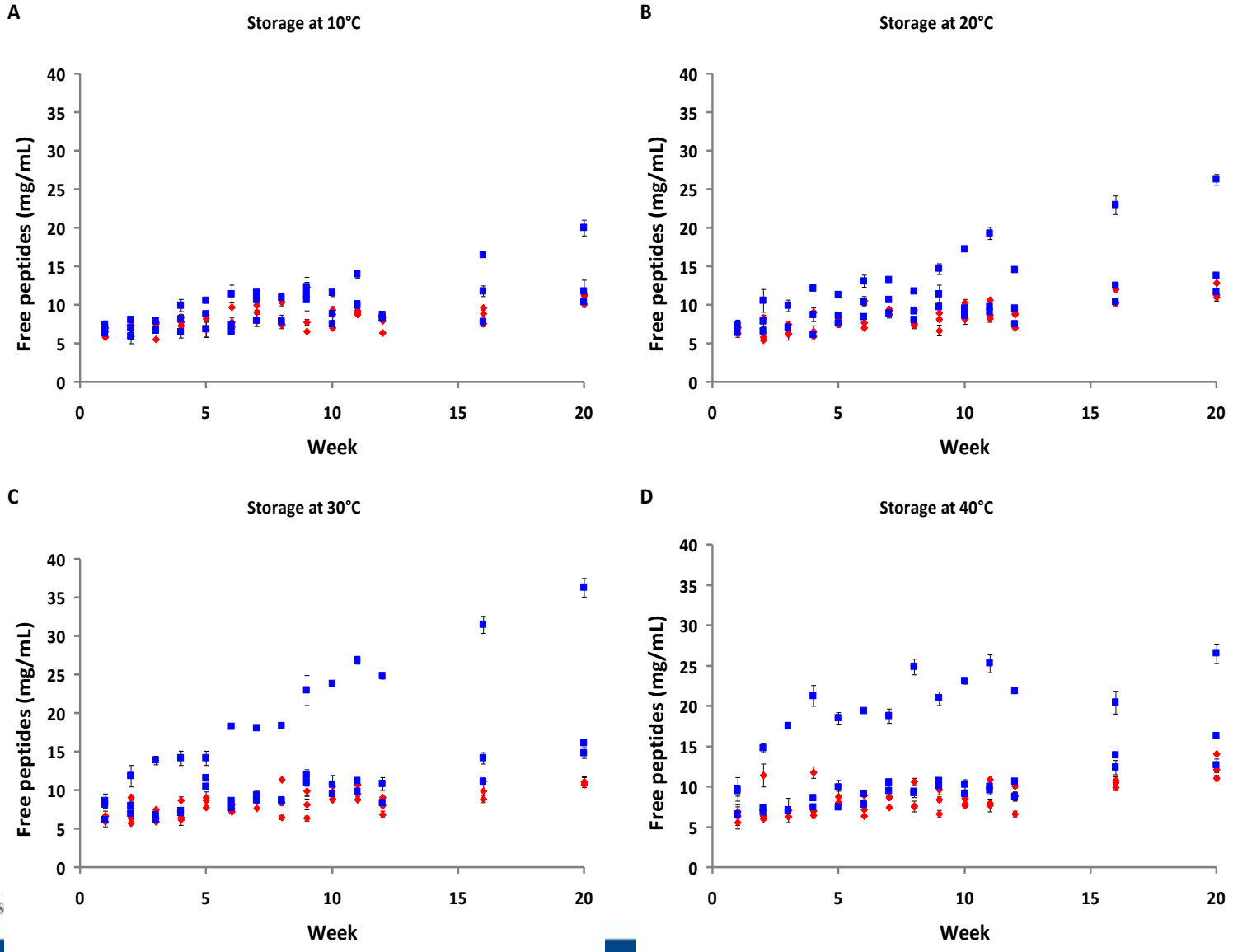
10, 20, 30, 40° C

	Bacterial cell counts on the surfaces (log CFU cm^{-2})	Bacterial cell count in the milk (log CFU mL^{-1})
Heavily contaminated trial*		
Treated vessels	8.84	7.96
Control vessels	< 1	< 1
Moderately contaminated trials		
Treated vessels	7.41 ± 0.62[a]	6.47 ± 0.04
Control vessels	< 1	< 1
Slightly contaminated trials		
Treated vessels	5.61 ± 0.21[b]	6.13 ± 0.34
Control vessels	< 1	< 1

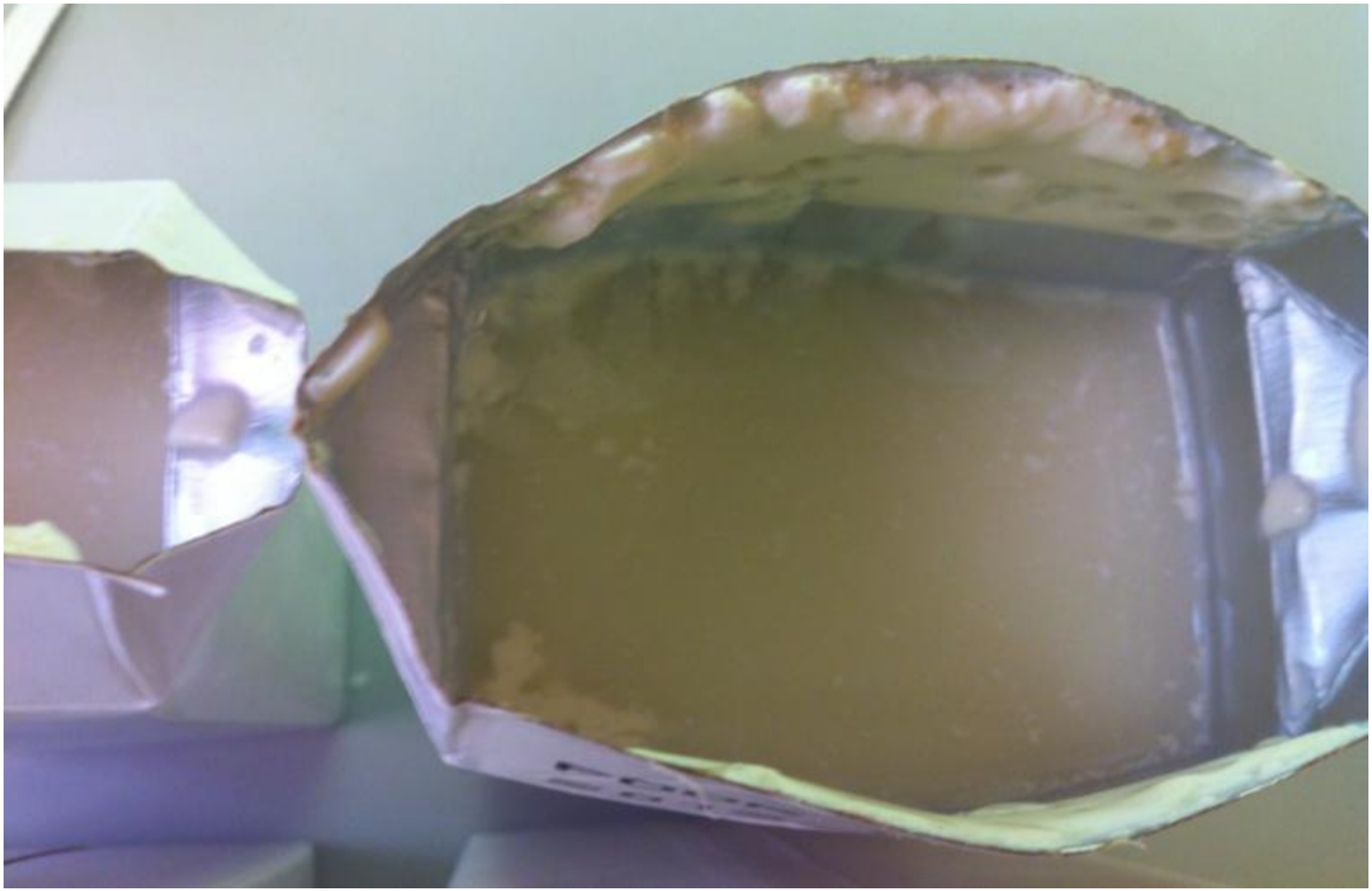
Results – Slightly Contaminated



Results – Moderately Contaminated



UHT milk following enzymatic damage




2012/04/12

Conclusions

- **Raw milk quality affects product quality**
- **Microbial enzymes are the main concern with poor quality milk**
- **Maintaining the cold chain from farm to factory is the best control measure.**

Reference

- Tetra Pak Handbook – The role of raw milk quality in UHT production

http://www.tetrapak.com/about-tetra-pak/cases/how-milk-quality-affects-your-uht-dairy-products?disableMobile=1&utm_source=foodqualitynews&utm_medium=mailshotrawmilkquality&utm_campaign=processing

Questions