Maintaining low bacterial counts in milk-farm factors

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Why is Milk Quality so Important!

- **Ireland ~85% of dairy products exported, €2.1 billion, ~25% all food exports**
- **Higher value products - infant milk formula, Kerrygold Butter Cheddar Cheese**
- **Global market for infant formula ~ €4bn, Ireland produces ~10-15% of global exports.**
- **Important to the consumer in terms of taste, flavour and its impact on health**
- **Important to the processor as it impacts on product yields and consistency and market access**
- **Higher milk price to dairy farmers**

Bacteria growth in milk

- Milk is an excellent growth media for bacteria
- Bacteria population in milk can double in less than 20 minutes (in an average temperature of 90°F or 30°C)

- The rate of bacteria population growth in milk depends on:
  - Type of bacteria that contaminate milk
  - Initial amount of bacteria in milk
  - The temperature of milk

Milk quality parameters

- Milk quality issues that are important to the processor and that impact on milk price

  - Somatic cell counts
  - Total bacterial counts
  - Thermoduric bacteria
  - Antiobiotic residues
  - Other residues-QACs & TCM & iodine & DHHP

Milk quality parameters

Parameter	Threshold		Source
	Desired	EU Regulations	
Total bacteria count TBC	<30k	≤100k	Improper cooling Poor teat preparation Poorly cleaned machine Prolonged storage
Thermoduric count LPC -Bacillus Cereus	N/D	≤ 1k	Soil Cows teats Poorly cleaned machine Cracked old rubberware
Somatic cell count SCC	<200k	≤ 400k	Poor teat preparation and disinfection, Milking infected cows among healthy cows Malfunctioning machine Mastitis

Why are thermoduric bacteria a problem

- Contamination of milk with thermoduric bacteria can cause processing problems for the dairy industry- reduced prices for product – cheese
- Spores exist in form capable of surviving pasteurisation- can resist high temperature
- Thermoduric bacteria (Psychrotrophs) can multiply in milk on the supermarket shelf, which may reduce the shelf life of milk

Thermoduric bacteria (LPC)

- **Laboratory pasteurisation count (LPC) is used to assess the effectiveness of equipment cleaning procedures**
- **A high LPC count generally is a result of a chronic cleaning failure**
- **An LPC count<200cfu/ml is considered normal while a count <10 cfu/ml indicates excellent equipment hygiene**
- **Bacillus Cereus important spore - infant milk formula**

Penalties are imposed by processors in Ireland on LPC >500 cfu/ml

Types of Thermoduric Bacteria

- Generally, bacteria are classified according to their optimal growth temperature
  - **Mesophilic**
    - ✓ Grow well at warm temperatures (32°C)
    - ✓ Produce lactic acid
    - ✓ Coliforms
  - **Psychrophilic**
    - ✓ Grow well at cool temperatures (13°C)
    - ✓ Rancidity

Bacillus cereus

- ***Bacillus cereus*** **is one of the most common thermoduric species which can pose a significant food risk (nausea and diarrhoea)**
- **Spores exist in form capable of surviving pasteurisation**
- **Target in milk <10 cfu/ml**
- **High numbers of thermoduric spores exist in the farming environment- these will readily transfer to milk**

Sources of Thermoduric Bacteria

(thermoduric bacteria live in the environment)

- Soil (30-150 spores/100ml)

↓

- Silage (.05-50 spores/100ml)
- Faeces (2-100 spores/100ml),

↓

- bedding,

↓

- Teat Skin
- parlour hygiene

- With inadequate cleaning deposits build up on milking machine surfaces

-

The cow's environment

Soil – influenced by weather conditions (Christiansson et al, 1999)

Used bedding – Magnusson et al., 2007

Silage –via contaminated faeces (Aureli and Franciosa, 2002,Vissers et al., 2007)

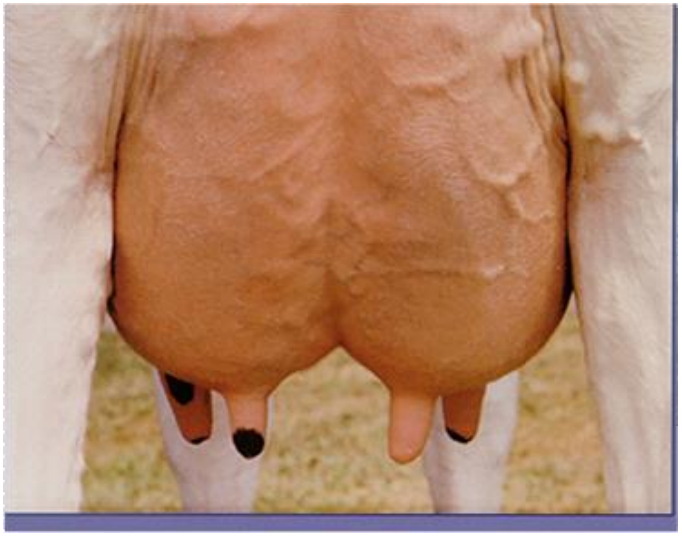
Sources of Thermoduric bacteria -Weather effect

- **High water content of soil, dirty access alleys are considered the most important factors correlating with high spore concentrations in milk**
- **It is suggested that increased soil consumption occurs during wet weather due to increased levels of soil present on grazed grass**
- **Higher spore levels can aslo occur during periods of dry weather**
  - **Drought conditions, tight grazing-soil on teats**
  - **Vital have clean roadways and approach roads to the parlour**
  - **Clean collecting yards after each milking occasion**

Fluctuating thermoduric counts

- Weather conditions
- Pieces of milk film (which can contain vast numbers of thermodurics) breaking off and entering the bulk tank
- Important to wash plant with detergent after completing the descale wash

Present a clean cow for milking



- *Poor hygiene scores will increase the spore content in milk*
- *Pre-milking teat preparation and cluster cleaning will reduce bacterial numbers in milk*

Effect of cow udder hygiene treatments on bacterial counts (cfu/ml) in raw milk

(good hygiene indoors)

Treatment	TBC	Thermodurics
Full prep	3,800	10
Wash only	5,800	14
Dry Wipe	8,200	21
None	10,500	28
Significance	*	*

Murphy *et al.*, 2007

Effect of **pre-milking teat preparation treatment** in reducing *Staphylococcus* (STA), *Streptococcus* (STR) and Coliform (COL) bacteria counts on teats – outdoor (%)

Prep treatment	STA	STR	COL
'Iodine'	83	44	11
'Chlorhexidine' teat-foam	75	55	15
Wash & dry	60	45	15
No preparation	0	0	0
'Valient' teat-foam	85	95	15
'Byotrol' wipes	95	95	20

Gleeson *et al.*, 2009

Farm Management Practices on milk Quality Award nominee farms (%)

Milking Procedure	2013
Gloves worn	42
Stripping daily	79
Pre Spray/Dip Teat/wipe	53
Pre-milking teat preparation	100

Rubber as a source of bacteria

- ***As rubberware gets older it starts to pit and crack, allowing bacteria to survive, protected from hot water and chemicals***

- ***Exposure of rubber to chlorine for long periods will cause rubber to deteriorate more quickly--- hence the importance of using cleaning products the correct way***

- ***Shock treatment will destroy rubber***

Reducing bacterial numbers on LINERS with Automatic cluster flushing

Reduction in *Staphylococcal* counts on liners after cluster flushing (%)

Back-flush setting	Staph Reduction on liners	Liners % With 0 Staph. Count	Liners % With < 10 Staph. Count
No cluster flush	13	3	3
Cycle 1 (0.5 litres water)	67	3	43
Cycle 1 (0.5 litres water + Paracetic acid)	83	47	83
Cycle 2 (1.0 litres water)	69	28	59
Cycle 2 (1.0 litres water + Paracetic acid)	100	96	100

Milking equipment

- ***Poorly cleaned and maintained milking plants particularly where milkstone and perished rubber-ware are present have been identified as significant sources of thermoduric bacteria***
  - ***Thermoduric bacteria will grow on milkstone***
  - ***Acid wash vital***
  - ***Replace old rubberware***
  - ***Avoid washing clusters while attached to cows***
  - ***Avoid washing the cow standing while cows are present***

Summary

- *Teat skin contains infinite numbers of bacteria*
- *Reducing the numbers of bacteria on teats by good management practises, washing/drying, pre-spraying with disinfectant + DRYING will minimize the amount of bacteria entering the bulk milk tank*
- *Disinfection of clusters between individual milking's will minimize the possibilities of cross-infection and the amount of bacteria entering the bulk milk tank*

Soils that might occur in milking machines include

- **Organic residues (from milk)**

  - Lipids (fats), proteins, carbohydrates (sugars)

- **Mineral deposits (mainly from water)**

  - Calcium, magnesium, iron, others

- **Bacterial films**

  - Bacteria can form bio-films on organic substrates if allowed to incubate

- **Chemical residues**

  - Cleaning solutions, lubricants, teat dips, teat conditioners, teat sealants

Product types used for cleaning and disinfection of milking equipment

- **Detergent-powder or liquid**
  - Contains Sodium hydroxide (caustic soda) +surfactants/wetting agents
- **Detergent/sterilizer**
  - Contains sodium hydroxide + sodium hypochlorite (chlorine) + surfactants/wetting agents
- **Acid descaler**
  - Contains Phosphoric acid +
- **Peracetic acid**
  - Contains Acetic + hydrogen peroxide
- **Sodium hypochlorite-** Contains chlorine only

Teagasc Detergent lists

- **85% of products are registered (23 % in 2010) with DAFF**

- Moorepark website-PDF format

  http://www.agresearch.teagasc.ie/moorepark/milkquality

or

Research & innovation

Dairy

Milk quality

- **Separate table for**
  - **Detergent/sterilizer**
  - **liquid caustic only products**
  - **Powder products**
  - **Sodium hypochlorite**

- **Registered products only are listed-PCS**

Detergent list used in UK by dairy farmers

Chemical analyses of detergents

- **Liquid Caustic range:**
  - **< 1 to 28 %**
  - **45% of products with caustic levels below 10%**

- **Chlorine range:**
  - **<1 to 9.5%**
  - **32% above 4.5%**

- **Powder products have a high concentration of sodium hydroxide/carbonate -76%**

Important points in relation to detergent sterilizers

- **A minimum of 950 ppm in the working solution is suggested for detergent sterilizers where the product is recycled and when used with both hot and cold water**
  (e.g. 12.5% caustic @ 340mls/45 litres = 944 w.s. approx)

- **Detergents with a lower working solution (>300ppm) may give satisfactory cleaning when used with hot water daily and not recycled**

- **Increasing the usage rate of products to achieve higher caustic levels may result in non-acceptable levels of chlorine in the working solution.**

- **Acceptable chlorine levels in the working solution may range between 150 and 320 ppm depending on the temp of water (e.g. 3.5% chlorine@ 340mls/45litres =264 w.s. approx**

Detergent (non-chlorine products evaluated)

Treatment	TBC (average)	Thermodurics (average)	Tank TBC (24hr) (average)	Tank Thermodurics (average)
MIPCIP/cold	2,181	92	14,247	161
MIPCIP/hot/ch	2,166	67	12,814	69
MIPCIP/acid	1,252	39	6,856	59
Hydral/hot	2,173	112	8,165	140
Liquid Gold/hot	2,010	90	5,864	86
Multisan CF/cold/p	1,956	104	11,437	252
Parlosan NC/cold/p	2,019	123	13,635	205

Problems with use of detergent products

- **Some products with no recommendations on usage rate or manufacturer details**
- **Measurement equipment not always supplied**
- **Expiry date- 6 months from manufacture –group buying**
- **Extra chlorine added at farm level to main wash to compensate for poor product**
- **Wrong product used for task**
- **New products used on farm, but usage rate remain the same - possible double in quantity**
- **Confusion with regard to correct washing procedure**

Calculating the correct level of detergent required per day

milkstone remover) and follow the instructions for usag
Liquid Gold for washing as given below:

1. Wash the jetters and the outside of the clusters. Then attach the clusters to the jetters.
2. Rinse plant with 13.6 ltrs (3 gal) cold water or 9 ltrs (2 gal) warm water per cluster.
3. Add required volume of water to wash trough allowing 9 ltrs (2 gal) water per cluster.
4. For cold circulation cleaning add Liquid Gold at the rate of 375 ml per 45 ltrs (13 fl oz per 10 gal) w
5. For hot circulation cleaning add Liquid Gold at the rate of 312ml per 45 ltrs (11 fl oz per 10 gal) w
6. Circulate the solution for 10 minutes.
7. Rinse plant with 13.6 ltrs (3 gal) water per cluster

Calculating the quantity of detergent required per day

- **Liquid gold**
- **Usage rate for COLD water= 375 mls per 45 litres of water**
- **9 litres water per unit x 20 units =180 litres p/wash**
- **180/45 = 4 x 375mls = 1.5 litres per wash**
- **2 washes a day = 3litres a day of detergent required**

Problems with use of detergent products

- ***Some products with no recommendations on usage rate or manufacturer details***
- ***Measurement equipment not always supplied***
- ***Expiry date- 6 months from manufacture –group buying***
- ***Extra chlorine added at farm level to main wash to compensate for poor product***
- ***Wrong product used for task-high chlorine product***
- ***New products used on farm, but usage rate remain the same - possible double in quantity***
- ***Confusion with regard to correct washing procedure with products***

Correct use of products

- ***Detergent-sterilizer products (containing chlorine) should be rinsed from the milking system with clean water immediately after the main wash cycle to prevent the chlorine from damaging the rubberware***

- ***Detergent-sterilizer products or detergent powder products may be re-used on one occasion where recommended by the manufacturer***

- ***When using detergent-only products (powder or liquid caustic with no chlorine), for effective cleaning the stain of the solution should be left in the plant or bulk tank and then rinsed just prior to the next milking***

Choosing a wash routine

- **The wash routines outlined (A, B, C, and D) represent the most commonly used routines in Ireland**
- **Routines which incorporate the use of more regular acid cleaning (C, D) are highly effective in maintaining low bacterial numbers on any size milking system; however this system is more suited to plants with automatic wash systems in place due to the extra safety precautions necessary with the use of acid**
- **Liquid products are more suitable than powder products where automatic cleaning is in place**
- **Cold wash systems (B, C) which may contain liquid or powder products require a higher working solution of sodium hydroxide and require increased contact time to be effective as they do not contain chlorine**
- **If milk meters are in place, daily cleaning with hot water is required**
- **Details of the washing systems are available on the Teagasc website**

Routine A: Hot Detergent-steriliser cleaning

Detergent-steriliser (Sodium Hydroxide and Sodium Hypochlorite

Wash outside of clusters, attach jetters and remove milk filter

1. Rinse plant with 14 litres (3gls) of water per unit (cold or warm)
3. Add **liquid detergent-steriliser** at the manufacturers recommended usage rate to hot water (65-75°C), allowing 9 litres (2gls) per unit
4. Circulate the hot solution for 8-10 min, allowing first 5 litres to run to waste, the solution may be retained for the 2nd daily wash (if retained; discard solution after the second daily wash)
5. Rinse the plant immediately after the main wash cycle with 14 litres (3gls) of cold water per unit
6. Ensure the system is drained before the next milking

- ***Once weekly**:* After step 2, add an acid descaler (**milkstone remover**) at the manufacturers recommended usage rate to hot or cold water, allowing 9 litres (2gls) of water per unit
- Circulate the solution for 8-10 min and discard
- Rinse plant with 14 litres (3gls) of cold water per unit
- Continue with steps 3, 4, 5 and 6

- **Optional extra**: After step 5 is complete, **Peracetic acid** may be added as a sterilizer, at the manufacturer recommended usage rate to **an additional** rinse water cycle

Routine B: Cold cleaning

Detergent powder (sodium hydroxide, chlorine free)

1. Wash outside of clusters, attach jetters and remove milk filter
2. Rinse plant with 14 litres (3gls) of cold water per unit
3. **Add the detergent powder** at the manufacturer recommended usage rate to cold water, allowing 9 litres (2gls) per unit
4. Circulate the solution for 8-10 min; allowing first 5 litres to run to waste. Solution may be retained for the second daily wash. **Leave the stain of the solution in the milking plant until just before the next milking**
5. Just before the next milking, rinse with 14 litres (3gls) of cold water per unit
6. Ensure the system is drained before milking

- **Once weekly:** After step 2, add an Acid descaler (**milkstone remover**) at the manufacturers recommended usage rate to hot water
  - **Circulate the solution for 8-10 min and then discard**
    - **Rinse plant with 14 litres (3gls) of cold water per unit**
      - **Continue with steps 3, 4, 5 and 6**

- **Once weekly**: At step 3, add Sodium hypochlorite (**chlorine**) to the detergent powder solution at the manufacturer recommended rate in **hot water** (65-75°C). (A combined detergent-sterilizer product may be used as an alternative to using these two individual products). Continue with steps 4, 5 and 6

- **Optional extra**: After step 5 is complete, **Peracetic acid** may be added as a sterilizer, to **an additional** rinse water cycle

Routine C: Non-chlorine cleaning

Detergent /acid cleaner
(Sodium hydroxide and phosphoric acid)

1. Wash jetters and outside of clusters and remove milk filter
2. Rinse plant with 14 litres (3gls) of water per unit (cold or warm)
3. After the morning milking, **add liquid detergent (non-chlorine)** at the manufacturer recommended usage rate to hot (65-75°C) or cold water, allowing 9 litres (2gls) per unit
4. Circulate the solution for 8-10 min; allowing the first 5 litres to run to waste. When circulation is complete, discard the solution. **Leave the stain of the solution in the milking plant until just before the next milking**
5. Just before the next milking, rinse with 14 litres (3gls) of cold water per unit
6. Ensure the system is drained before milking

- A**fter each evening** milking replace the liquid detergent (non-chlorine) product with a **Liquid Acidic cleane**r added at the manufacturer recommended usage rate to cold or **hot water** (65-75°C), allowing 9 litres (2gls) per unit
- Circulate for 8-10 min; allowing the first 5 litres to run to waste and then discard. Follow immediately with a rinse

Routine D: Hot Detergent-steriliser/acid cleaning

(Sodium hydroxide-Sodium Hypochlorite and phosphoric/nitric acid)

1. Wash jetters and outside of clusters and remove milk filter
2. Rinse plant with 14 litres (3gls) of water per unit (cold or warm)
3. After the **morning milking**, **add liquid detergent-steriliser** or powder product containing sterilizer at the manufacturer recommended usage rate to hot water (65-75°C), allowing 9 litres (2gls) per unit
4. Circulate the solution for 8-10 min, allowing the first 5 litres to run to waste, and discard when circulation is complete
5. Rinse the plant immediately with 14 litres (3gls) per unit of cold water
6. Ensure the system is drained before the next milking

- After each **evening milking:** replace the detergent-sterilizer product with a **Liquid Acidic cleaner** at the manufacturer recommended usage rate to **hot water** (65-75°C), allowing 9 litres (2gls) per unit
- Circulate the solution for 8-10 min allowing the first 5 litres to run to waste and discard when circulation is complete
- Continue with rinse and drain

Milk-stone removal

- ***Descale (acid) wash should be carried out weekly to both machine and bulk milk tank to remove mineral deposits from water***
- ***High 'water hardness' levels will effect the cleaning ability of detergents and allow the build up of Bio-films on stainless steel surfaces which will accommodate the growth of thermoduric bacteria***
- ***Where peracetic acid is used daily, the descale acid wash may be carried out less frequently***
- ***Under no circumstances should acid (milkstone remover or peractic acid) come into contact with detergent – rinsing required between* each product**

Peracetic acid

- ***Peracetic acid may be used to sterilize a milking plant pre-milking or for the disinfection of clusters between individual cows (as a replacement for chlorine)***
- ***The use of peracetic acid in the final rinse water is beneficial where the microbial quality of the water supply may be considered an issue***
- ***If peracetic acid is to be used in the final rinse water (pre-milking disinfection) then two post-wash rinse cycles are necessary; the first rinse with water only is required to remove traces of the detergent and the second rinse containing the peracetic acid added to the water***
- ***When used at the rates recommended, further rinsing with water to remove stains is not considered necessary***

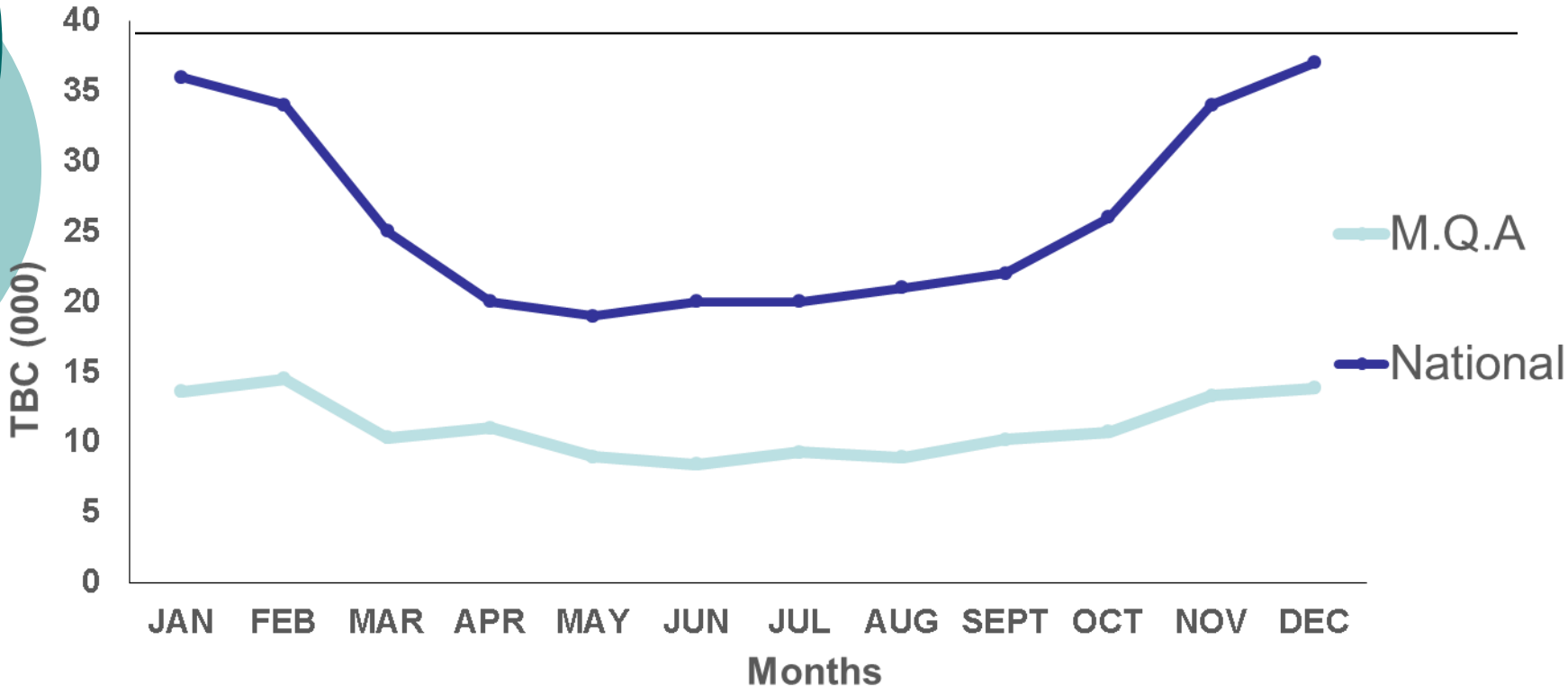
Milk quality Award Nominees
Farm Management Practices (%)

Equip. cleaning procedure	2013
Hot water daily	47
Hot water 2/3 per week	42
Cold Water daily	11
Detergent reuse-ONCE	47
Auto Wash	44
Descale Weekly	74
Water Temp ≥70	94
Milk Storage Temp.	2.7 ^{o} C

Key cleaning checks to avoid milk TCM residues & achieve low TBC

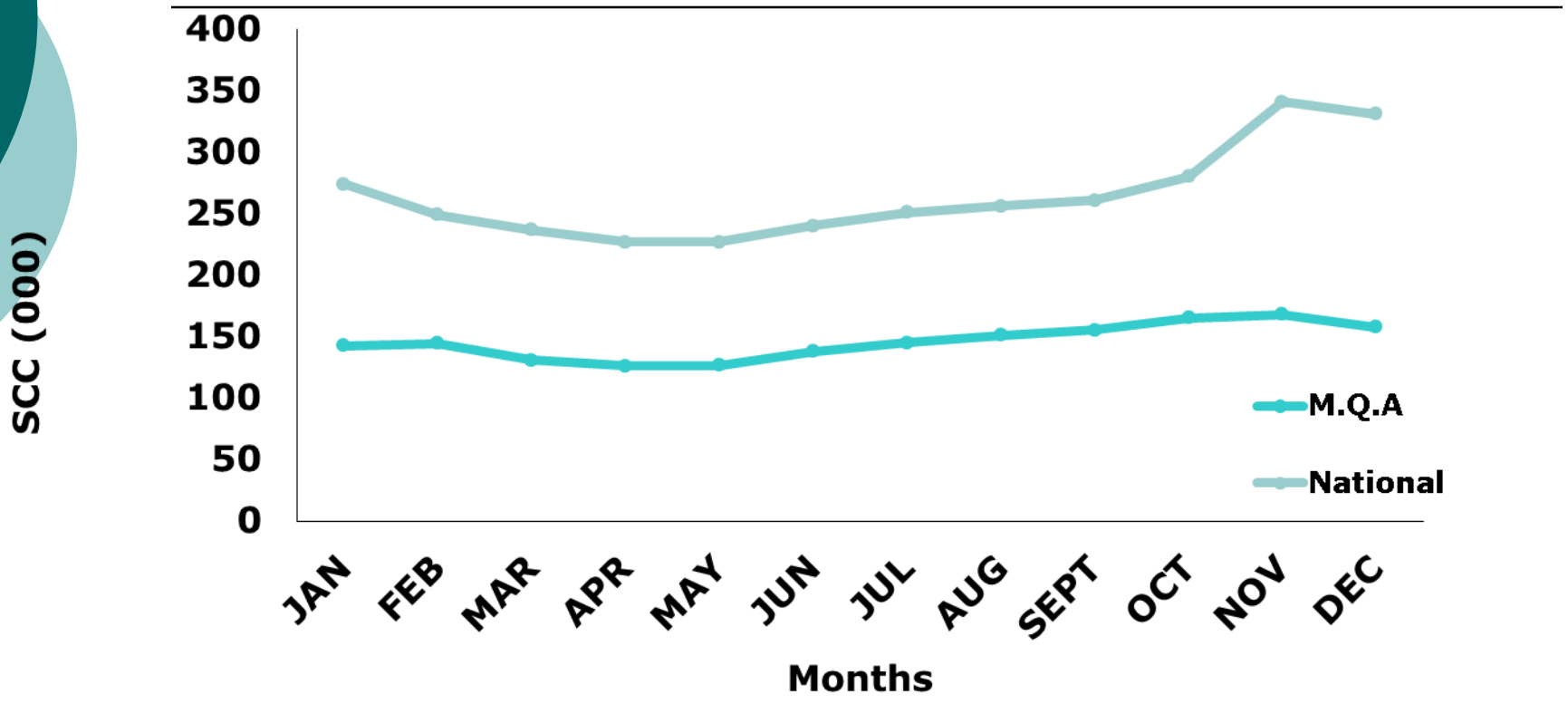
- **Re-using rinse water-never**
- **Re-using detergent solution –once only**
- **Quantity of rinse water used – 14l/unit (check pH)**
- **Low chlorine product used for daily wash-read label (<3.6%)**
- **Correct levels of chemical used-check**
- **Avoid adding chlorine product to detergent/steriliser solvent**
- **Washing procedure used correctly-website**
- **Increase rinse cycle times in bulk tank (check PH)**
- **Dipping clusters in chlorine -avoid**
- **Rinsing plant with chlorine avoid**

TBC- National (8000 herds- 5 years) V Milk Quality Nominees (81 herds) – 5 years



Milk quality nominees consistently produce low TBC across all months

SCC- National v Milk quality Nominees



Milk quality nominees produced consistently lower SCC milk than national

Cleaning milking equipment

- **Milk cooling and storage**
- **Cleaning products**
- **Wash routines**

Bacteria increase rapidly in numbers if milk is cooled slowly or inadequately

- Milk should be cooled within 30 min of milking to 4°C or below
- Use of plate coolers– 32 to 15°C
- Adequate agitation during storage
- Blend temperature
- Collection days

Three identical milk tanks

Objective: To establish the effect of milk storage duration (5 days) and storage temperature (2, 4 & 6 ^{0}C) on the microbial quality of bulk tank milk

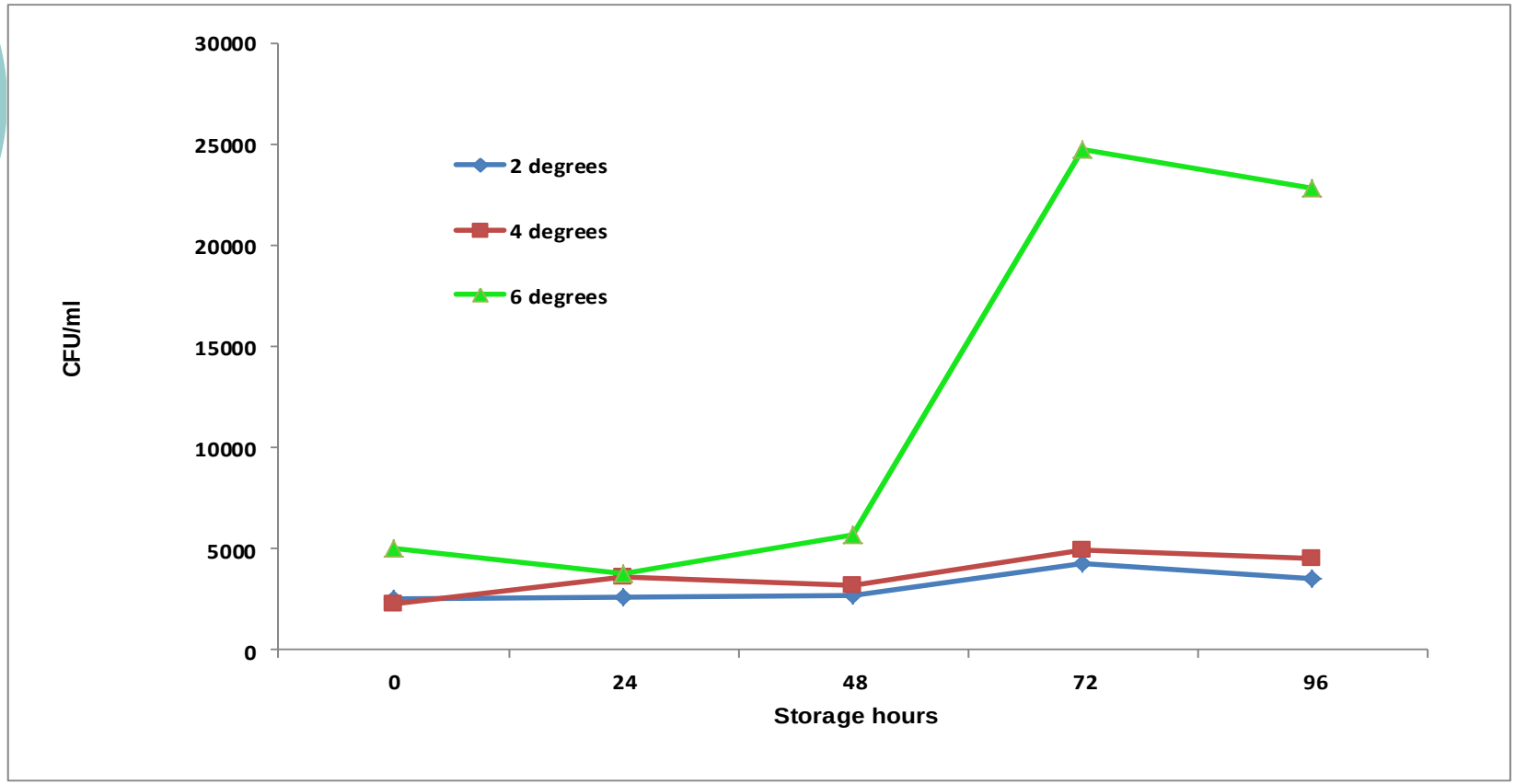
Bulk Tank Specification

- **3 x Dairymaster SwiftCool Milk tanks – 4000litre**
  - **20% Thicker insulation and thicker steel!**
  - **Soft start mode if low milk level in tank**
  - **Milk volume display**
  - **Alert messages to mobile**

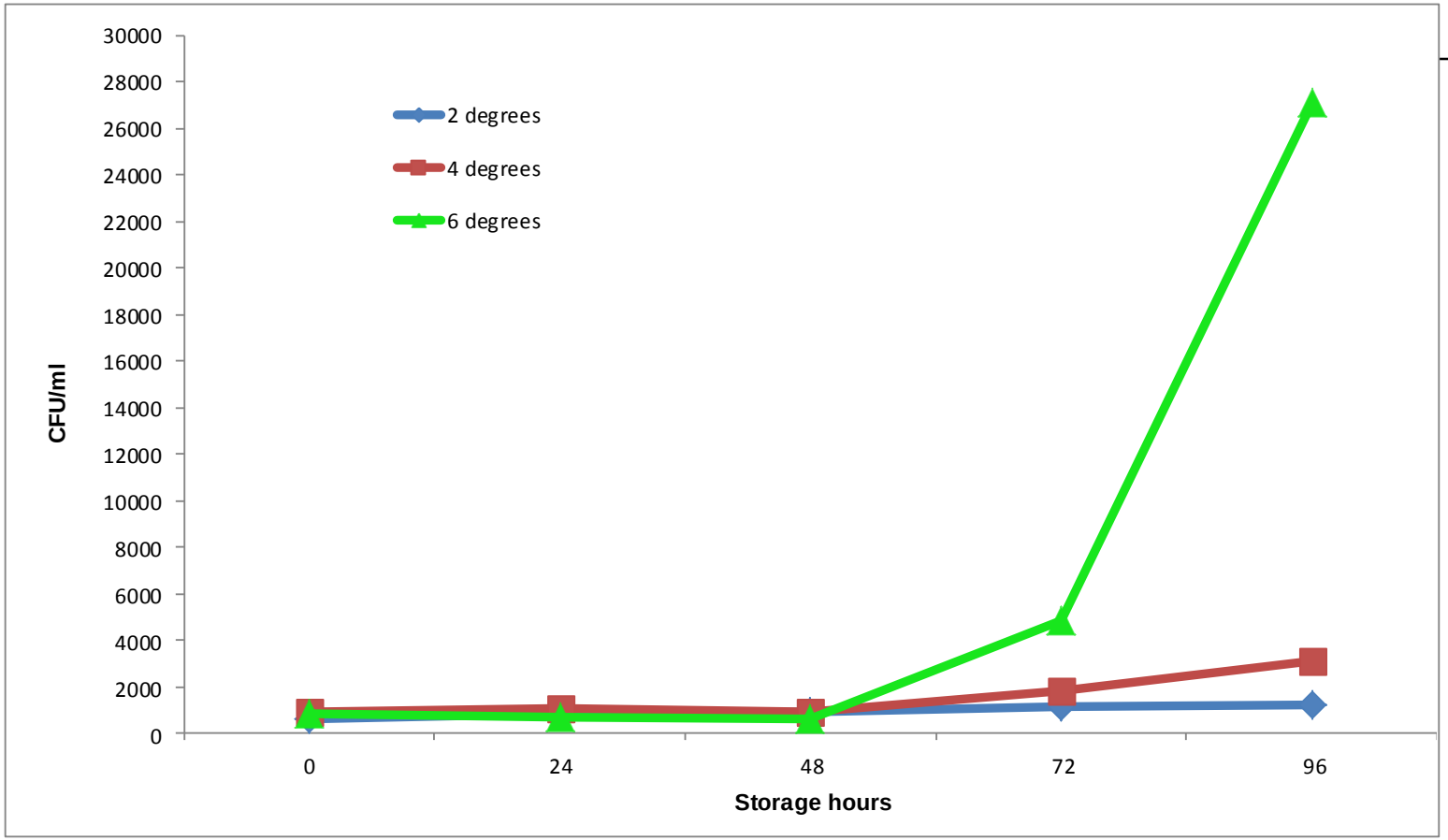
- **Condensing unit -5.5hp**

- **3 x Single stage coolers- 37 plates- milk cooled to 14.5^{0}C -before entering tank**

Effect of storage temperature and time on TBC



Effect of storage temperature & time on psychrotrophic bacteria



Summary-Microbiological tests

TBC

- **Initial milk quality excellent --3,000 CFU/ml**
- **Low TBC levels maintained in milk stored for 4 days when cooled at 2 or 4°C**

  TBC increased to high levels from 3 days when stored at 6°C
- **Starting with low TBC essential**

Psychrotrophic counts

- **Higher psychrotrophic counts at 3 days even at 6°C**

- **Thermoduric**
  - **No change in low thermoduric counts with storage temperature**

Actions implemented at Moorepark to improve the quality of milk on Irish dairy farms

- **Milk Quality booklet**
- **DVD-training purposes/website**
- **Training of milk quality advisors**
- **Washing procedures defined and available to all farmers-website**
- **Chemical analysis conducted on all cleaning products used on Irish farms-website**
- **http://www.agresearch.teagasc.ie/moorepark/milkquality/**


Thank you for your time