

# Dairy Thermodynamics

## Module 3: Controlling Thermodynamics in Dairy Farms

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# Content

- Cross contamination of raw milk with thermodurics
- Control of Thermodurics in dairy farms



# Factors influencing thermoduric counts in raw milk



# Raw milk contamination

- Milk is virtually sterile when secreted in the alveoli in the udder
- Bacterial contamination thus can possibly occur from the following three sources
  1. Within the udder
  2. Outside the udder
  3. Cross contamination during milking, handling, and storage

*(Carlin, 2011; Hong et al, 2009; Giffel, 2002; Foltys, 2007; Novak et al, 2005)*



# Understanding contamination from within the udder

- ▶ A fact to remember:
  - ▶ In healthy cows, the bacteria present in teat canal do not significantly increase the total bacterial load of raw milk, which generally remains less than 1,000 colony forming units (cfu)/ milliliter (mL)
  - ▶ Much of this constitutes the micrococci and streptococci
  - ▶ Some of these could be thermoduric (Refer to Module 1 for types)
- ▶ What then causes the bacterial numbers to go up?
  - ▶ Mastitis has the potential to increase the total bacterial counts in excess of 10 million cfu/mL
  - ▶ Generally constituting *Streptococcus agalactiae*, *S. uberis*, *Staphylococcus aureus*, and coliforms, which do not influence lab pasteurization counts (LPC)
  - ▶ Occasionally, sporeforms such as *Bacillus cereus*

(Slaghuis, 1996; Faile et al., 2001, Wallace, 2009)

# Understanding contamination from outside the udder

- ▶ The exterior of udder can contribute organisms from two sources
  - ▶ Naturally associated with the outside of normal skin: Are mostly in small numbers and are not good competitors
  - ▶ From environmental sources: May originate from soiled teats due to manure, mud, bedding material, and feed. Can easily exceed a billion cfu/mL
  - ▶ The outside of udder thus has the potential to contribute thermoduric spore formers to raw milk, in addition to streptococci, staphylococci, coliforms, and other gram negative bacteria
  - ▶ Dirty udders may have the potential to significantly increase the raw milk counts over 10,000 cfu/mL, with many of those being Thermodurics

*(Fredsted et al., 1996, Wallace, 2009)*



# Understanding the cross contamination at dairy farms

- ▶ Milking machines and equipment are equally important sources of cross contamination of raw milk
- ▶ In comparison to the mastitis bacteria, the bacteria from manure and bedding material are more likely to grow and multiply on the soiled milk contact surfaces
- ▶ Any milk residues left after inadequate cleaning and sanitation are more likely to serve as colonization spots for these bacteria and also support their growth, thereby leading to emergence of predominant species
- ▶ Several of these persisters are thermotolerant, and the biofilms formed by them are the likely cause of raw milk cross contamination
- ▶ This will eventually get carried over and result in high Lab Pasteurization Counts (LPC), indicating thermally resistant microflora in milk
- ▶ Many of these are psychrotrophic in nature, and result in limiting the shelf life of refrigerated milk

# Understanding the relationship of Standard Plate Counts with Thermodurics

- ▶ SPC: Standard Plate Counts are indicative of the total aerobic bacteria present in raw milk
  - ▶ A count of less than 1,000 cfu/mL is considered as good farming conditions, while counts under 10,000 cfu/mL is in general achievable
  - ▶ Several factors including environmental cross contamination, inadequate cleaning, milk residues, failure to rapidly cool and hold milk under 5°C/ 41°F can lead to high SPC
- ▶ LPC: Lab Pasteurization Counts indicate the level of thermoduric bacteria (surviving 62.8°C/ 145°F for 30 min)
  - ▶ They are lower than SPC and in general an LPC count greater than 300 cfu/mL is considered high
  - ▶ In addition to raw milk, persisters in biofilms result in cross contamination of milk with thermodurics from inadequately clean contact surfaces

*(Wallace, 2009)*





# Understanding relationship of SPC with Preliminary Incubation Counts

- ▶ PI: Preliminary Incubation Counts are mainly indicative of milk production practices and farm conditions
- ▶ Milk is held at 12.8°C/ 55°F for 18h prior to plating for obtaining PI. This encourages rapid growth of psychrotolerant bacteria, which have the ability to grow at refrigeration temperatures, and are mainly responsible for limiting the shelf life of refrigerated milk
- ▶ These counts are generally higher than SPC. Any increase greater than 3-4 folds is considered significant or PI Counts higher than 50,000/mL are reflective of either mastitic animals or inadequate cooling of milk prior to holding

*(Wallace, 2009)*



# Control of Thermomodurics in Dairy Farms



# Clean cows

- ▶ It is easier to maintain a clean milking environment if the cows start off clean
  - ▶ Routinely check pastures for accumulation of water and mud in high traffic areas
  - ▶ Make sure the water tank is on cement to reduce the mud
  - ▶ Proper drainage in the main walkways
  - ▶ Clean bedding and routinely remove excess manure
- ▶ Teats directly contact the cluster – potentially contaminating all of the milk
- ▶ Teats should be thoroughly cleaned before each milking
  - ▶ With dry paper towels for 10 seconds per cow can reduce spores in milk by 45 to 50%.
  - ▶ With moist towels can reduce spores in milk by 50 to 74%.
  - ▶ With moist towels followed by dry towels for 20 seconds per cow can reduce 96% spores in



# Udder cleaning and counts (cfu/ mL)

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

*(Murphy et al., 1997)*

# Clean equipment

- ▶ Milking Machines; Another potential sources of thermotolerant bacteria
  - ▶ Cracked rubber seals
    - ▶ Cracks compromise the vacuum seal, thereby allowing outside air into the milk
    - ▶ Cracks allow attachment sites for bacteria
    - ▶ Several of those could be thermotolerant spore former species
  - ▶ Inadequate cleaning practices
  - ▶ Soil and organic buildup on milking equipment
  - ▶ Failure to sanitize between cows
- ▶ Controlling organic buildup
  - ▶ Any soiling, dirt, or residues (lipids, proteins or carbohydrates) that collect after cleaning can help attach and grow bacteria
  - ▶ Routine cleaning and equipment replacement decreases organic buildup leading to lower bacterial counts

# Clean parlor

- Milking parlor environment, like any other work environment, is prone to bacterial contamination
- Dirty cows and fecal material are a good sources of thermoduric bacteria in the parlor
- It is important to keep the walk ways clean to prevent cross contamination of animals, as well as, equipment milking surfaces
- Standard of hygiene is a major factor influencing the microbial quality of milk produced at farms

*(Craven and Macauley, 1992)*

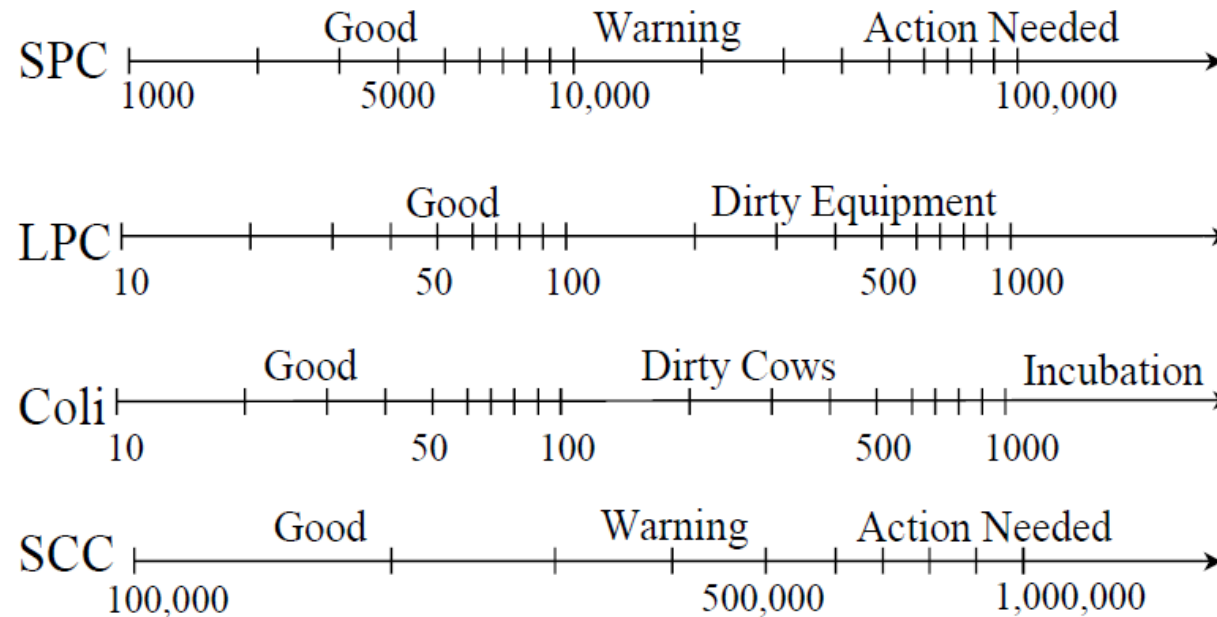
# Possible reasons for elevated raw milk counts

Counts	Natural Flora	Mastitis	Dirty cows	Dirty equipment	Poor cooling
TBC > 10,000		√	√	√	√
TBC > 100,000		√		√√	√√
High PIC >50,000 or >3X TBC			√	√√	√√
High LPC > 300			√	√√	
Coliforms > 100		√	√	√	

(√ = possible; √√ = likely)

(Murphy, 1997; Wallace, 2009; Greg and Ahmed 2011)

# Troubleshoot high bulk milk counts



**Figure 1. Diagnostic Chart for Bulk Tank Bacteria Counts.**

*(Reinemann, 2011)*



# Keeping thermodurics low at farms; Faster cooling

- ▶ Rapid cooling of milk helps to control multiplication of psychrotrophic bacteria that invariably contaminate the milk during production
- ▶ Faster cooling is also helpful in keeping the thermoduric counts low
  - ▶ Milk leaves the cow at ~98°F and should be cooled to at least 7°C/ 45°F within 2 hours of milking completion
  - ▶ Prolonging the cooling time allows bacteria to grow and multiply
  - ▶ Periodic checks of the refrigerated milk is necessary to ensure the cooling system is functioning



# Keeping thermodurics low at farms; Low holding temperature

- ▶ Storage at 2°C/ 35.6°F can be more effective as compared to 4°C/39.2°F in extending the shelf life raw milk
- ▶ It must, however, be remembered that this effect is limited by the level of initial contamination

*(Griffiths et al., 1988; Champagne et al., 1994; Muir, 1996; Haryani et al, 2003)*

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