Technote 5

Using effective milking techniques and routines to prevent mastitis

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1 Causes and characteristics of cow-associated mastitis bacteria

The bacteria generally responsible for 'contagious' or cow-associated mastitis are those which live on the teat skin or in the udder. Major pathogens (i.e. those responsible for clinical cases) include ***Staphylococcus aureus***, ***Streptococcus agalactiae*** and ***Strep. dysgalactiae***. Minor pathogens (i.e. those more responsible for subclinical infections) are **non-aureus staphylococci** (**NAS**, previously coagulase-negative staphylococci or CNS) and ***Corynebacterium bovis.***

Major pathogens are commonly associated with clinical cases, but can also be isolated from high SCC cows. Minor pathogen infections are more commonly associated with cows with an elevated SCC.

Spread occurs when infected milk contaminates the teat skin of clean quarters or other cows. This can be by milk on milkers' hands or teat cup liners, through splashes or aerosols of milk during stripping, and by cross flow of milk between teat cups (Phillips, 1982).

➜ See **Technote 8** for milking hygiene practices that help prevent mastitis, and **Technote 9** for the natural defence mechanisms at the teat end.

Staph. aureus may invade the udder tissue, forming micro-abscesses and scar tissue. As this makes it difficult to cure during lactation, prevention is therefore critical. By contrast, ***Strep. agalactiae*** resides in the ductal areas and responds well to penicillin, with high cure rates. It is rarely isolated in NZ herds. ***Strep. dysgalactiae*** can be isolated from sites on the animal but is often associated with teat end damage (Ericsson-Unnerstad *et al* 2009).

➜ **Technote 4.6** discusses the response to antibiotic treatment during lactation.

Non-aureus staphylococci (NAS; previously CNS) are a collection of pathogens that live on the skin and coat of the cow. They generally cause an elevated SCC but can be isolated from clinical cases. These pathogens share traits with environmental bacteria.

Corynebacterium bovis is a lipid-requiring bacteria that rarely causes clinical mastitis (Bramley *et al* 1976; Hillerton *et al* 1995). It is considered highly contagious and is often associated with poor teat disinfection. Its presence may increase the risk of *Streptococcus uberis* infection in unprotected quarters at dry off (Woolford *et al* 2001).

Streptococcus uberis has become the predominant mastitis pathogen in New Zealand. Although typically considered an environmental pathogen, it can spread contagiously (Williamson *et al* 2010), as can all infections caused by gram-negative, coliform pathogens.

➜ **Technote 1** describes characteristics of environmental pathogens and *Strep. dysgalactiae.*

Table 1. Characteristics of mastitis bacteria generally associated with infected udders

Characteristic	*Staphylococcus aureus*	*Streptococcus agalactiae*
Reservoir of infection	Milk from infected udders of cows. The surface of the teat skin, especially in cracks and sores.	Milk from infected udders of cows. Colonised teat canals, in the absence of gland infection, can be a significant reservoir.
Spread	Cow to cow at milking, via contaminated milk on liners and hands.	Cow to cow at milking, via contaminated milk on liners and hands. Spread is very rapid.
Risk of infection	All lactating cows are susceptible. Risk is increased if there is teat end damage, faulty milking equipment or poor teat disinfection.	All lactating cows are susceptible. Infection can occur in first-calf heifers before entering the farm dairy. Preventing cross-suckling may be helpful in herds with this pathogen.
Clinical signs	*Staph. aureus* is a common cause of subclinical and clinical mastitis. Signs of clinical mastitis can range from slight changes in the milk through to severe systemic illness. Occasionally gangrenous forms, with massive tissue damage and toxaemia, can occur (black mastitis).	Infection can cause high rates of clinical disease, with hard swollen quarters. Affected glands may experience recurrent acute episodes and eventually become uneven and firm with watery foremilk containing clots. Many infected quarters are subclinical with a very high SCC.
Duration of infection	Infections may become chronic. Bacteria are shed intermittently from subclinical quarters. If a single milk sample is taken from an infected quarter, there is about a 70% chance of isolating the bacteria.	Infections can be acute or develop into chronic subclinical infections. Very high numbers of bacteria are shed, especially in the early stages of infection when 100 million bacteria per mL of milk may be present.
Cow Somatic Cell Counts (SCC)	About 50% of infected cows have SCC >500,000 cells/ mL. Cell counts from infected cows rise and fall cyclically throughout lactation, typically in the range of 200,000 to over 1,000,000 cells/mL.	Most infected cows have SCC >500,000 cells/mL although SCC can fluctuate widely from below 200,000 to above 1,000,000 cells/mL.
Milk quality	Bacteria are shed in milk, but numbers in the bulk milk are low and rarely cause an elevation of the bacterial count in milk.	There is a potential for very high numbers of bacteria to be shed in bulk milk, occasionally enough to exceed bacterial count thresholds.
Management during outbreaks	Take cultures from at least 20 cases of clinical mastitis to confirm the identity of the bacteria. Correct milking machine and milking technique faults. Check teat disinfectant and application. It is essential to disinfect teats post milking and improve the health of teat skin. Because treatment in lactation may only cure a minority of infections, assign these cows to antibiotic Dry Cow Treatment (DCT) at dry off, or cull cows that have been chronic for months or years. Create a preferential culling list based on clinical history, cell count history, antibiotic DCT history, age, production, culture results and stage of lactation. See **Mastitis management – Staphylococcus aureus Factsheet** for more.	Take cultures from at least 20 cases to confirm identity of the bacteria. Cultures of bulk milk can help identify the cause. **This pathogen is rarely isolated from NZ herds**. It is highly contagious so outbreaks should be treated with urgency. Options include whole herd culture and treatment of infected cows or whole herd treatment (blitz treatment) with lactating cow antibiotics. Culture all treated cows before they re-enter the milking herd. The aim is to eradicate this infection so all factors contributing to its spread should be corrected, and affected cows treated or culled. Implement strict milking hygiene, segregate all infected cows, correct any milking machine or technique faults promptly, and ensure teat disinfection is optimised to improve teat skin health. Use Whole Herd antibiotic DCT and operate a closed-herd policy or culture milk from purchased cows.

Table 2. Characteristics of mastitis bacteria generally associated with the skin of the cow

Characteristic	*Streptococcus dysgalactiae*	*Corynebacterium bovis*	Non-aureus staphylococci (NAS)
Reservoir of infection	Infected udders and teat lesions. The bacteria can also be isolated from the environment and sites on the animal such as mouth, udder and vagina.	Milk from other infected udders. This pathogen requires lipids to grow, so is only isolated from lactating glands, where milk fat is freely available.	Skin and coat of the cow, as well as other environmental sites and infected udders. These bacteria are a collection of different species, previously known as coagulase negative staphylococci (CNS).
Spread	Cow to cow at milking, via contaminated milk on liners or on hands. Contamination of teats can also occur between milkings, from bacteria in the cow's environment.	Highly contagious, this minor pathogen spreads at milking time via contaminated milk, especially if teat disinfection post milking is poor. It can easily spread to all quarters of an individual cow, and to a large proportion of the herd.	Contamination of teat skin builds up in absence of teat disinfection, so infections often develop when cows are dry or when teat disinfection is poor. Contagious spread may also occur via contaminated milk or milkers' hands.
Risk of infection	All lactating cows are susceptible, particularly those with sore or damaged teats. Heifers are also prone to infection in the last few weeks before calving, and during calving.	All lactating cows are susceptible. Although dry cows are not susceptible to infection, quarters infected at dry off may increase the risk of a cow developing *Strep. uberis* infection in the dry period if unprotected.	All cows are susceptible to infection. These bacteria are the most common isolates from heifers prior to calving.
Clinical signs	Most infections show mild clinical signs, without systemic signs. Infections can show acute signs, similar to *Strep. uberis*.	These infections are usually subclinical. On rare occasions, *C. bovis* may be the only pathogen isolated from a clinical case.	Infections are mostly subclinical but NAS can cause clinical mastitis. Some NAS species may be more virulent than others.
Duration of infection	Most infections are short-lived unless there is persistent teat end damage. Similar to other environmental streptococcal infections, high numbers of bacteria can be shed in the milk.	These infections develop into chronic infections that can last for the rest of lactation. Achieving complete bacterial cure during lactation is difficult using lactating intramammary antibiotics.	Chronic infections can be established and last for long periods (months). In other cows, infections may be short-lived and disappear within a few days.
Cow Somatic Cell Counts (SCC)	Similar to other streptococcal infections, most infected cows have SCC higher than 500,000 cells/mL.	Depending on the number of quarters infected within a cow, the cow SCC will vary from 150,000 and 300,000/mL.	Infections by NAS tend to have mild to moderate impacts on cow SCC, unless the infection develops into clinical mastitis.
Milk quality	Clinical cases have been rarely reported to contribute to bacterial count of the bulk milk.	This pathogen can be detected in bulk milk but is unlikely to contribute to bacterial count. Main impact is on bulk milk SCC.	These bacteria can be isolated from bulk milk but are unlikely to contribute to bacterial count of the bulk milk.
Management during outbreaks	Improve quality of post milking teat disinfection. Correct possible cause(s) of teat end damage e.g. milking machine faults or other management issues.	This pathogen is considered sensitive to intramammary antibiotic treatment, but the risk of re-infection is high. Prevent infection through good post-milking teat disinfection technique.	Prevent infection through good post-milking teat disinfection and appropriate use of antibiotic DCT and internal teat sealants at dry off – see **Technote 14**.

② Managing cow behaviour during milking

Human-animal interactions significantly influence the behaviour and productivity of dairy cows (Hemsworth 1997). Standardised milking routines can improve production outcomes (Hemsworth 2002). Successful machine milking relies on the cow's cooperation throughout the process. Stressful handling when being brought in from the paddock, handled in the yard or encouraged into the bail, can cause a cow to become nervous or frightened. This triggers an adrenaline release which blocks the oxytocin release and prevents the milk ejection reflex. This block can last for up to 30 minutes and prevents milk let-down.

A calm, consistent milking environment improves milk yield, shortens milking time, reduces stripping volumes, and lowers the frequency of urination and defecation. Seabrook (1994) demonstrated that cows exposed to 'pleasant handling' entered the dairy more quickly and dunged less frequently than those exposed to 'aversive handling'.

Cow behaviour during milking can be assessed by the frequency of kicks and steps (the 'KiSt response'), although interpretation must account for environmental factors such as flies, or machine/operator interactions (Mein 1997; Meyer *et al* 2021). Highly fearful cows may not show overt behaviours, instead entering a 'tonic', immobility phase.

➜ **Technote 6.2** provides more on 'KiSt response' to assess cow behaviour.

Australian research shows that frequent negative interactions (e.g., hitting with plastic pipes) increase cow fear, while positive interactions (e.g., patting, talking and slow deliberate movements) reduce it (Hemsworth *et al* 2000). Elevated fear of humans correlates with reduced milk yield (Hemsworth *et al* 2002) and lower conception rate to first insemination (Hemsworth *et al* 2000).

When handling cows, positive behaviours should be encouraged and negative behaviours actively discouraged – it is important to recognise that even moderate slaps and hits, used repeatedly, will result in cows becoming fearful. Where cow flow is an issue, a review of facilities and milker routines should be undertaken to identify contributing factors. When a cow is behaving as required, positive reinforcement should be used where possible.

Introducing heifers to the milking shed early, either before they calve, or by calving them early, before the older cows, can ease their transition. Early familiarisation is recommended to reduce fear and improve milking outcomes (Bremner 1997).

➜ See **Technote 2.3** for guidance on training heifers in the milking area, and the DairyNZ **MilkSmart** programme for practical tips on managing cow flow.

③ Foremilk strip cows to detect abnormal milk

Foremilk stripping is a practical tool for detecting clinical mastitis. It is most valuable at the start of lactation when infection rates are highest and cows are being conditioned to the milking routine. Early detection and prompt treatment of new intramammary infections improves cure rates (Milner *et al* 1997).

Stripping involves the removal of 2-4 squirts of milk from each quarter before milking, and checking for abnormalities such as clots, wateriness, or discolouration. Changes that persist for more than three squirts suggest clinical mastitis and are considered eligible for treatment. Quarters with a few flecks should be monitored and rechecked at the next milking.

➜ **Technote 4.1** defines the signs that a cow has clinical mastitis and should be treated.

Effective technique involves rolling the thumb down while holding the top of the teat closed, and stripping onto a black surface (e.g., strip cup or dark paddle) to aid visual detection (see the DairyNZ **Healthy Udder Guide**).

Foremilk stripping also helps identify blood in milk or milk unsuitable for the vat. Cows that received internal teat sealant at the end of the previous lactation may still show small residues in the first days after calving (Swinkel *et al* 2024). Foremilk stripping of 10-12 strips at their first milking after calving may mitigate this.

NMAC (National Milk-Quality Advisory Committee) strongly recommends foremilk stripping of all quarters of all cows in the colostrum mob at least once a day.

Routine stripping of freshly calved cows is increasingly adopted in NZ, particularly in the first few weeks of the lactation. A survey of 40 herds found the majority stripped once daily, although only 22% stripped every cow at every milking in the colostrum mob (Compton & McDougall, 2008, unpublished).

The benefits of stripping increases during high-risk periods, such as calving, when *Strep. uberis* infections are more common, as early detection improves treatment outcomes.

Routine foremilk stripping is recommended when:

- clinical new infection rates are high,
- bulk milk SCC is approaching penalty thresholds, or
- clots are found on the milk filter.

When clots are found on the filterand the cause is not established, every quarter of every cow should be checked before machine milking. For large herds, this can be spread over multiple milkings to ensure a thorough inspection (see Table 3). Farmers should consider systems to allow continuation of regular foremilk stripping all season.

Table 3. Routines for implementing foremilk stripping of the whole herd

System	Description	Comment
Strip all 4 quarters prior to every milking.	All four quarters foremilk stripped prior to every milking.	Very effective when clinical incidence rate is high. When low, this method is time consuming and labour intensive.
Strip all 4 quarters once a week.	All four quarters foremilk stripped prior to milking, at one morning milking per week.	Can be unsettling as cows tend not to become accustomed to having teats touched. Requires additional labour and/or prolonged milking time.
Strip 2 quarters at two milkings each week.	Two quarters foremilk stripped at one milking and the other two at the next milking, once a week (e.g. both fronts at morning milking, both backs at evening milking).	Milkers should be able to handle this method without extra labour but milking routine will be slowed on that day.
Strip 1 quarter at four milkings each week.	One quarter foremilk stripped at a milking. All quarters stripped over 4 milkings, in rotation. Can be done either across two days at morning and evening milkings, or across 4 milkings (usually morning).	This system requires no extra labour and has least impact on milking routine. Tends to be less unsettling to cows as teats are being touched more regularly. Sensitivity of detection will be less accurate than stripping all 4 quarters but method is more practical when clinical incidence is low to moderate.

Role of SCC and other tests for detecting mastitis

The **Rapid Mastitis Test** and **individual cow somatic cell counts (ICSCC)** are useful tools for identifying problem cows (i.e. glands or cows with high SCC). They can be used alongside foremilk stripping to confirm clinical signs.

Current knowledge does not support general treatment of subclinical mastitis i.e. those with no visual signs, with lactating cow antibiotic therapy. These tests were designed to detect subclinical mastitis, and not all test-positive cows need to be managed as clinical cases. These tests help identify suspicious quarters for closer visual examination for clinical signs, and can assist in decisions around excluding cows from factory supply during milk quality grading investigations.

Hand-held conductivity meters, which detect ionic changes in milk, may help identify suspect glands but are less useful for SCC-related decisions, as they do not measure somatic cells.

Point-of-care (POC) tests enable identification of the likely pathogen associated with subclinical or clinical cases. They offer rapid, on-farm diagnostic support and complement existing tools for mastitis detection and management. Their integration into routine herd health protocols can enhance decision-making, particularly in high-risk or grading situations.

➜ **Technote 4.4** provides more information on POC diagnostic tests.

In-line filter systems, fitted in the long milk tube between clawpiece and milkline in a position where they can be easily read, are designed to trap clots and aid in mastitis detection. However, their effectiveness depends on consistent checking after every cow and the passing of clots in the milk, rather than watery milk (Blowey & Edmondson 1995). Filters must be cleaned regularly to maintain visibility and function.

Automated mastitis detection systems are improving, especially when integrated with cow ID and data processing (Mein 2010; McDougall *et al* 2024). These systems should be able to support three key tasks:

- early detection of clinical cases (especially in early lactation)
- identification of 'millionaire' cows (ICSCC >1 million cells/mL) to manage BMSCC
- selection of cows for antibiotic dry cow therapy based on late-lactation SCC.

While no system is 100% accurate, they can help narrow down suspect cows and reduce false positives.

④ Pre-milking teat preparation and hygiene

Mastitis risk is closely linked to bacterial load at the teat end. Keeping teat ends clean and dry is essential to reduce new infection rates. An udder hygiene scoring system developed by Dr. Pamela Ruegg (Schreiner & Ruegg 2003) offers a practical, validated method for assessing udder cleanliness and has shown strong correlations with bulk milk SCC and mastitis rates in US herds.

Despite climatic differences, the tool is valuable for NZ herds, providing a quick (≤20 min) and quantitative way to evaluate cow environment and management strategies. Ward *et al* (2002) found a strong link between cow cleanliness and mastitis due to environmental pathogens like *E. coli* and *Strep. uberis* in British herds.

In NZ, increasing levels of milk production per cow and greater stocking intensity of cows within herds, elevates the risk of faecal contamination of teats, and therefore, environmental mastitis. NZ research (Lacy-Hulbert *et al* 2002) found high rates of clinical and subclinical mastitis in zero-grazing systems with total mixed rations. The combination of a high starch content in the diet, coupled with high faecal contamination in the environment, led to heavy bacterial loads on teats. This necessitated thorough washing and drying of teats before each milking, especially in wet weather, to prevent new infections.

➜ **Technote 1.6** describes how to fix areas that make udders muddy.

Teat cleaning before milking

Milking wet, dirty udders can increase the risk of mastitis and milk quality issues. Research in the US and UK (Galton *et al* 1986; McKinnon *et al* 1983) found that wetting any portion of the udder above the teats without subsequent drying will result in dirty, bacteria-contaminated water draining into the top of the teat cup liner during milking. This in turn reduced milk quality, through increasing bacterial counts, and increased mastitis risk, especially from environmental pathogens such as coliforms and *Strep. uberis* (Smith & Hogan 1997).

However, research in Australia with pastured cows (Hubble & Mein 1986) reported little benefit of washing and drying all teats, compared to tactical washing of dirty teats alone. No issues arose when the teat washing phase was suspended for cows milked in automated systems (Davis *et al* 2008).

In NZ, the risk management programmes operated by most dairy processors requires milk to be harvested in accordance with the NZ Animal Products Notice: Production, Supply and Processing (MPI, 2025) and NZ Code of Practice (NZCP1; MPI, 2024).

A practical guide to comply with these codes is:

- if it's clean, cup it,
- if it's dry/dusty, wipe it
- if it's wet and dirty, wash and dry it.

Relatively clean, but dusty teats can be cleaned without water, using a gloved hand or a single, disposable cloth per cow.

Wet and dirty teats should be washed using a low-pressure water supply, combined with manual cleaning and drying by the operator. This results in much less water ending up in unwanted places on the cow (udder, legs, underside and flanks). High pressure hoses **should not** be used for udder washing.

Tactical washing is recommended in high-risk environments (e.g., housed systems or heavy faecal contamination). All contaminated teats should be washed and dried prior to cup attachment until the environmental source of contamination is controlled.

Wearing gloves improves milker comfort and hygiene, as gloved hands are easier to clean and less likely to transfer bacteria (Olde Riekerink *et al* 2008). Gloves should be rinsed regularly under running water to maintain cleanliness during milking.

➜ **Technote 8** describes the importance of hygiene at milking time and the benefits of wearing gloves.

Pre-milking teat disinfection

Pre-milking teat disinfection in NZ is encouraged for cows in the colostrum mob but is generally prohibited for cows once they join the milking herd.

It is widely practiced overseas where environmental mastitis is more prevalent. The typical protocol involves:

1. **Pre-clean** teats as necessary.
2. **Strip** – Foremilk strip to check for clinical signs
3. **Dip** – Apply registered pre-dip and allow contact time.
4. **Dry** – Wipe off teat dip with single-use towels or cloths.
5. **Apply** – Attach teat cups.

Pre-milking teat disinfection has three recognised effects:

1. Milk quality

Pre-milking udder preparation can reduce bacterial counts and sediment in milk if performed properly (Galton *et al* 1984, 1986). However, poor wiping with iodine-based disinfectants can lead to significant iodine residues in milk. Effectiveness of pre-milking disinfection is also reduced if cows' teats are wet and dirty. These should be washed and wiped before the pre-milking disinfectant is applied.

2. Udder health

Evidence for reducing mastitis risk is mixed. Some studies show reduced mastitis risk from environmental pathogens (Pankey *et al* 1987; Galton *et al* 1988), while others found no reduced risk (Hillerton *et al* 1993).

NZ research found no added benefit of pre-milking disinfection alongside post-milking teat spraying for controlling *Strep. uberis* infections in early lactation (Williamson & Lacy-Hulbert, 2013). Only approved products should be used, and manufacturer instructions followed to avoid milk contamination.

3. Milk let-down

The role of udder preparation in stimulating milk let-down response is not well understood in NZ. Research shows minimal benefits of foremilk stripping prior to applying the cups, for shortening milking duration (Edwards *et al* 2013a).

Dairy water quality

Good quality water must be used in dairies for teat preparation, making up teat disinfectants and cleaning the plant and equipment. NZ dairies must meet the water quality standards for Farm Dairy Water set out in the MPI Animal Products Notice: Production, Supply and Processing (MPI, 2025). This requires that all water that may come into contact with raw milk intended for manufacture of dairy products must meet the following criteria:

- does not result in microbiological, chemical and physical contamination of the raw milk;
- has *E. coli* absent in 100ml; and
- turbidity of maximum 5 NTU (Nephelometric Turbidity Unit) or clarity that is equivalent to 5 NTUs when tested.

➜ **Technote 7.5** discusses water quality for teat disinfectant solutions.

Udder and tail clipping

A major source of bacteria and organic matter that enters the bulk milk is from the teat, udder and tail switch. Hair is a good base for organic matter to collect and accumulate. Clipping the tail switch helps reduce contamination on the udder.

A hairless udder also collects less manure and dirt and is easier to clean. Significantly more water accumulates on a hairy udder than on a smooth one. Udders are easier to clean, and keep clean, if udder hair is kept short by clipping.

⑤ Teat cup attachment technique and timing

Cows respond well to consistent routines. Visual and auditory cues in the dairy can trigger milk let-down, especially in early lactation. Consistency and gentle handling are key to cow comfort and milker safety. The golden rule is to choose a set of procedures that support each milker to be consistent at every milking.

Overseas research has debated the timing of cup attachment to support more efficient milking, better teat condition, and potentially higher milk yields per cow (Hamann & Dodd 1992; Reneau *et al* 1994). The optimal window is considered to be 60-90 seconds after initial teat stimulation (Reneau *et al* 1994), and the main purpose is to prevent teat cup crawl during the first minute of milking. This is where cups crawl up the teat before full milk ejection has occurred and potentially restrict milk flow once peak milk flow has finished.

However, the impact under NZ conditions remains unproven. NZ research on pre-milking preparation found that delaying cup attachment by up to 45 seconds did not affect yield or milking time, and foremilk stripping reduced milking time by only 18 seconds (Edwards *et al* 2013a, 2013b).

The first touch by the milker (the signal to trigger milk ejection) can be one of the following:

- foremilk stripping;
- pre-wiping teats;
- brief manual palpation of each quarter (to feel for hot or hard quarters); or
- brief rub-down of each teat to remove loose dirt.

Identifying early cup attachment

As a simple check, watch the claw bowls during the first minute of milking. When teat cups are applied too soon, milk flow into the claw bowl typically slows or stops after about 15-20 seconds of initial flow, then full flow does not start (or restart) until about one minute after cups on.

Cup attachment technique

Minimising air admission during cup attachment helps maintain vacuum stability and prevents cluster slip. Sudden air inrushes can create milk slugs, reducing milkline carrying capacity and causing vacuum fluctuations. These irregular vacuum fluctuations may be severe enough to cause other clusters to slip or fall. The sizing of milklines has changed to improve the effective carrying capacity of the milkline, thereby improving stability of the milking vacuum during cup attachment. The relationship between air admission and the carrying capacity of milklines is acknowledged in international guideline tables for sizing milklines (ISO, 2007).

➜ DairyNZ **MilkSmart** describes different cupping techniques and procedures.

6 Machine stripping and its effect on udder health

Machine stripping refers to the practice of applying weight to the milking cluster at the end of milking to reopen the connection between the udder cistern and teat sinus, potentially removing residual milk.

The relationship between completeness of milking and mastitis risk is debated. Older publications reviewed by O'Shea (1987) suggested increased mastitis when machine stripping was omitted, while more recent research found no increase in infection rates when small amounts of milk were left in the udder (Rasmussen 1993; Burke & Jago 2010), and in some cases, higher SCC counts were associated with machine stripping (Clarke *et al* 2008). This may be due to sudden air admission during vigorous machine stripping, which can destabilise the vacuum and increase cluster slip, leading to impacts and elevated mastitis risk.

Additional weight on the claw can unbalance the cluster, increasing the likelihood of cup slippage and vacuum fluctuations. New Zealand studies (Jago *et al* 2010b; Edwards *et al* 2022) show that truncating milking time of the slowest milking cows does not adversely affect milk yield or mastitis incidence, suggesting that complete milk removal may not be necessary for udder health (see section 8).

7 Correct teat cup removal

For optimal cow comfort the recommended method for manual removal, as outlined in the **Healthy Udder Guide**, involves:

1. **breaking the vacuum** by kinking the long milk tube or closing the clamp near the cluster,
2. **waiting a couple of seconds** for the vacuum to break and
3. **gently twisting the cluster** to ensure all four teat cups release simultaneously.

Automatic cup removers (ACRs) can also provide a consistent and gentle detachment process.

The technique used when removing teat cups is often more important for mastitis risk than the timing of removal.

⑧ Selecting an appropriate end-of-milking time

There are many misconceptions about the timing of cup removal and how this may affect mastitis risk. The main goal of efficient milking is to find a balance between removing milk from the majority of glands in a time-efficient manner whilst minimising production losses through leaving too much milk behind.

Shorter milking times can be achieved by increasing the milk flow rate threshold at which the automatic cluster removers (ACR) cups are activated and/or by using a time-based approach, by applying a preset maximum machine-on time, to truncate the milking of a proportion of the slower milking cows.

Both methods reduce the duration of cups-on time, especially when teats are likely to be exposed to the full milking vacuum, with minimal milk flow. This process contributes to 'overmilking', which can lead to teat end congestion and damage if applied for more than 2 minutes (Edwards *et al* 2013c). Severe teat end damage and hyperkeratosis can increase the risk of new infections (Neijenhuis *et al* 2001; Pantoja *et al* 2020) but the degree to which incomplete milking increases mastitis risk has not been proven.

➜ **Technote 6** details how to monitor and maintain milking machine function during lactation.

Milk in a time-efficient manner

Milking in a time-efficient manner helps reduce cups-on time for individual cows, as well as overall milking time. Studies that altered ACR threshold settings reported no difference in milk yield, mastitis or SCC when flow-rate thresholds were raised:

- from 200 to 400 mL/min in short-term studies in Denmark (Rasmussen 1993)
- from 200 to 400 mL/min for a whole lactation study in NZ (Jago *et al* 2010a)
- from 300 to 800 mL/min to achieve incomplete milking in cows with sub-clinically infected quarters in Australia (Clarke *et al* 2008)
- from 0.2 kg/min to 0.8 kg/min in short-term studies in NZ cows (Edwards *et al* 2013a, 2013b).

Studies using a pre-set maximum milking time to achieve shorter milking times also achieved similar results (Jago *et al* 2010b), whereby the maximum milking time was set at the 70th percentile of a group of cows, ordered from shortest to longest milking time.

Minimise losses in milk production

Under milking (i.e. incomplete milking) means that an unacceptable amount of milk is left in the udder after teat cups are removed, in the majority of glands. Milk left in the ducts or udder cisterns is referred to as 'available milk' or 'strippings' and can be removed through hand stripping after the teat cups are removed, or by reattaching the milking machine. Milk left in the clusters of secretory cells (alveoli) is referred to as 'residual milk' and requires an intramuscular injection of oxytocin to allow collection, by machine stripping or by hand-stripping. This milk typically represents 1-3 kg or about 10-20% of total milk in the udder.

Completeness of milking can be assessed by visual assessment of the udder shape, by measuring the volume of milk that can be machine-stripped from the udder after re-attaching the milking machine, or by hand-stripping individual quarters and measuring the volume, or counting the number of 'easy' strips that can be removed in 1 minute (Meyer *et al* 2019).

➜ **Technote 6.2** gives guidelines for assessing completeness of milking of individual cows, including definitions of good, poor and uneven milk out.

Published evidence on the relationship between completeness of milking and production losses has evolved. Early work indicated a reduction in lactational milk production of about 3% when 0.5 kg of milk was left in the udder after milking (Dodd & Griffin1979). This compared to an estimated <0.25 kg strippings per cow to remain if clusters are correctly designed, maintained and applied (Mein & Reid 1996).

Increasing strip yields to 530 mL from 300 mL per milking did not affect SCC or milk production for cows with infected or uninfected quarters (Clarke *et al* 2008). In fact, higher stripping volumes tended to be associated with higher SCC quarters, rather than be a cause of high SCC quarters.

Applying substantial levels of incomplete milking (i.e. 25% of the quarter yield) from 5 days in milk was sufficient to prevent the rise in milk volume typically observed as cows approach peak production (Penry *et al* 2017), in a split udder experiment. Changes in milk composition from quarters that were incompletely milked were indicative of changes induced by switching to once daily milking, and not necessarily an increase in mastitis.

Identifying herds where under milking is problematic cannot rely solely on assessment of strip yields in individual cows. Incomplete milking may be a symptom of a poorly operating milking system, rather than a direct cause of a mastitis problem. Conducting a full milking time investigation is the preferred approach for identifying herds with problematic under milking.

➜ **Technote 13** and the **Mastitis Investigation Kit** provide a systematic approach for conducting a full milking investigation.

With the large amount of research conducted on adoption of shorter milking times, the completeness of milking has become less relevant, although gross or unbalanced milking between the different glands within the udder should be noted.

Minimise over-milking and risk of mastitis

Milking in a more time-efficient manner helps to reduce the degree of over-milking experienced by some or all cows in a herd. Over-milking can lead to increased risk of teat end damage, which in turn, can lead to an increased risk of new infections.

Over-milking occurs when teat cups remain attached to the teats after milk flow has fallen below an arbitrary 'end-point of milking', (commonly 200 mL/min in NZ, or a 'dribble in the bowl'). Some over-milking is inevitable because individual quarters milk out at different times. Both field experience and research studies indicate that:

- A moderate amount of over-milking (say 1 or 2 minutes) has minor effects if the milking system is functioning correctly.
- Over-milking for 5 minutes per cow induced marked changes in the firmness of teats after milking (Hillerton *et al* 2002) and an increase in mastitis risk when applied in conjunction with pulsation failure (Mein *et al* 1986).
- Regular over-milking can lead to thickening of skin at the external teat orifice and increased teat congestion and oedema (Hamann 1987, Hamann *et al* 1994, Olney & Mitchell 1983).
- Higher ACR thresholds of ≥400 mL/min led to improved teat condition and cow behaviour for high-producing herds in the US (Rasmussen 1993). Fewer cows developed clinical mastitis in the early detachment group.

Situations most at risk of excessive over-milking are those with large numbers of bails per operator and no ACRs. These can be solved through:

1. **changing milking routines** (see **dairynz.co.nz** for MilkSmart tips on cupping procedures that reduce over-milking) or
2. **changing machine and/or ACR settings** (see an NZMPTA-registered milking machine consultant for assistance).

➜ **Technote 9.2** describes the changes to teats associated with over-milking.

Shorter milking times

Research in Australia and New Zealand arising from Rasmussen's research has identified no adverse effects when setting a maximum time limit for milking slow cows, with marked reductions in the time required to milk herds. The initial goal, set for Australian conditions, was to remove clusters from about 80% of cows at a flow-rate threshold of 0.4 kg/min while truncating the milking time of the slowest 20% of cows, thereby inducing some under milking in these cows.

The Australian studies reported:

- Up to 35% of normal milking time of slow milking cows could be saved when maximum milking durations were applied, with no adverse effect on daily milk yield, milk composition, teat condition or cow behaviour (Clarke *et al* 2004).
- No effects on clinical mastitis incidence or SCC for healthy quarters or those sub-clinically infected with *Staph. aureus* or *Strep. uberis* when early termination of milking was applied (Clarke *et al* 2008).

Subsequent studies in New Zealand confirmed and extended these results:

- Truncating the milking of slow cows could be started before cows reached peak lactation (Jago *et al* 2010a)
- More aggressive application of shorter milking times, by truncating the milking time of 30% of cows, had no detrimental effects (Burke & Jago 2011; Jago *et al* 2010b)
- Increasing flow rate thresholds from 0.2 to 0.8 kg/min shortened milking duration of affected cows by 18-25% and increased strip yields but had no detrimental effects on SCC or milk production (Edwards *et al* 2013a, 2013b)

A herd's Maximum Milk-Out Time (MaxT) depends on the average milk production per cow per milking.

- For example, 80% of cows in a typical herd, where cows are producing an average of 10 L at a single milking, will be milked in 6.3 minutes.
- If MaxT is applied at the suggested target of 80%, then the slowest 20% of cows in that herd will have their milkings truncated when clusters are removed after 6.3 minutes (6 minutes, 15 secs).

The following guidelines can be used for setting MaxT for herds at different production levels (see Table 4).

Table 4. Guidelines for milking times for cows of different production levels

Average milk yield at a single milking	Time in which 80% of cows should have completed milking (min:sec)
10 L/milking	6.3 minutes (06:15)
12 L/milking	7.2 minutes (07:10)
14 L/milking	8.0 minutes (08:00)
16 L/milking	8.7 minutes (08:45)
18 L/milking	9.5 minutes (09:30)
20 L/milking	10.2 minutes (10:10)

Practical guidelines for setting MaxT

Fixed time cluster removal can sometimes feel hard to implement in the farm dairy so training posters are available to help apply MaxT. In a herringbone dairy, set cluster removal at a Fixed Time that allows about 80% of the cows to finish milking. Follow routines such as:

- Not waiting for all the cows to row up before cupping
- Cupping cows in batches of 5-10 cows, working from exit to entry, teat spraying as you go
- Being brave and letting the row go once beyond the half-way point in the row.

In rotaries, select a platform rotation time and apply a strict policy of no 'free riders' - no cow goes around twice unless there is a specific reason (e.g., the cluster had been kicked off).

In summary, guidelines to avoid under and over-milking, and shorten herd milking times include:

1. Aim to milk **most** cows as completely as possible, within a reasonable time, at every milking. This assumes a minimum ACR threshold setting of 400 mL/ min for herds milked once or twice daily.
2. Aim to milk **all** cows out as evenly as possible. This is important as uneven milk-out contributes to uneven distribution of milk yield between quarters, leading to less uniform udder conformation, which reduces the ease and efficiency of machine milking.
3. Don't wait around for slow cows to finish milking. Instead, remove clusters from slow-milking cows based on the herd's expected MaxT, or remove clusters from the last 10-15% of cows milking in any one batch.

➜ Posters for the farm dairy are available at **dairynz.co.nz** to support farms applying MaxT for more efficient milking.

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