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LACTATION

TECHNOTE 5

Use good milking technique and a consistent routine

The main mechanism of transmission of contagious (or ‘cow-associated’) mastitis is the spread of pathogens from cow to cow, mostly at milking.

The bacteria generally responsible for contagious mastitis are *Staph. aureus* and *Strep. agalactiae*. These bacteria live on the teat skin or in the udder. 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 (see Table below).

Staph. aureus invade udder tissue and can form pockets of infection (micro-abscesses) and scar tissue. The infection is difficult to cure, especially during lactation, so prevention is essential. In contrast, *Strep. agalactiae* tends to be located in the duct areas of the udder where antibiotics are effective. It is very sensitive to penicillin, so treatment has a relatively high cure rate.

Strep. uberis has become the major cause of mastitis in New Zealand. Although it usually behaves as an environmental pathogen, sometimes *Strep. uberis* can spread contagiously. *Strep. dysgalactiae* is another major pathogen that can be isolated from sites on the animal and can spread contagiously. Teat end damage is a risk factor for mastitis caused by *Strep. dysgalactiae* (Ericsson-Unnerstad *et al* 2009).

Coagulase negative staphylococci (CNS) are minor pathogens that can cause clinical mastitis but are generally associated with subclinical mastitis. These pathogens share characteristics with cow-associated, contagious bacteria and environmental bacteria (see Table below).

Corynebacterium bovis is a minor pathogen that causes subclinical mastitis, and rarely causes clinical mastitis. It is usually associated with poor teat disinfection, and is considered highly contagious. Both CNS and *C. bovis* are generally associated with the skin of the cow.

The spread of contagious mastitis can be minimised by good hygiene, keeping teat ends healthy, using milking equipment that is operating well, and disinfecting teat skin after milking.

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

Technote 4.7 discusses the response to antibiotic treatment during lactation.

Technote 8 describes good milking hygiene that helps prevent mastitis.

Technote 9 describes the natural defence mechanisms at the teat end.

Coagulase-positive *Staph. aureus* is a major pathogen that often infects older cows. Coagulase-negative staphylococci are minor pathogens that are commonly isolated from heifers.

Characteristics of cow-associated or contagious mastitis bacteria

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 and 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 have 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 are typically 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 passed 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 cures a minority of infections, culling is an important part of a control program. Create a preferential culling list based on clinical history, cell count history, antibiotic Dry Cow Treatment (DCT) history, age, production and stage of lactation. Consider Whole Herd antibiotic DCT.	Take cultures from at least 20 cases to confirm identity of the bacteria. Cultures of bulk milk can help identify the cause. These bacteria are 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 treated cows before they re-enter the milking herd. The aim is to eradicate this infection from the herd. All factors contributing to its spread should be corrected and existing infections treated or affected cows removed. Strict milking hygiene should be implemented, and milking machine and milking technique faults corrected. It is essential to disinfect teats post milking and improve health of teat skin. Segregate all infected cows. Use Whole Herd antibiotic DCT. Use a closed-herd policy or culture milk from purchased cows.

Characteristics of mastitis bacteria generally associated with the skin of the cow

Characteristic	*Streptococcus dysgalactiae*	*Corynebacterium bovis*	Coagulase negative staphylococci (CNS)
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.
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 can increase the risk of a cow developing *Strep. uberis* infection five-fold, if not treated with antibiotic DCT.	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 CNS can cause clinical mastitis. Some CNS 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 CNS 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. Use Whole Herd long-acting antibiotic DCT at the next dry period to prevent new infections.	This pathogen is considered sensitive to intramammary antibiotic treatment, especially intramammary antibiotic DCT but the risk of re-infection is high in the following lactation. Prevention of infection is by good post-milking teat disinfection technique.	It is generally accepted that prevention of infection is best achieved through good post-milking teat disinfection and the use of Whole Herd antibiotic DCT.

5.1

Ensure that cows enter the farm dairy willingly by use of good stockmanship.

Human-animal interactions have marked effects on the behaviour and productivity of farm animals, including dairy cows (Hemsworth 1997). Introduction of standard operating procedures for milking routines can result in increases in production (Hemsworth 2002).

The success of machine milking depends on the willing co-operation of an animal throughout the whole milk harvesting process. The way in which the cows are brought in from the paddock, handled in the yard, and encouraged to enter the bail area, can all impact on milk let-down. If cows are nervous or frightened the milk ejection reflex is blocked by the release of adrenaline and this block can last for up to 30 minutes.

If the milk ejection hormone (oxytocin) doesn't reach the udder, then milk let-down doesn't occur. Milk yield is higher, milking time per cow is shorter, stripping yields are reduced, and cows dung and urinate less frequently when the milking environment is pleasant, consistent and predictable for the cows. For example, Seabrook (1994) found that cows entered the farm dairy more quickly (10 seconds versus 16 seconds per cow), and there was less dunging on the cow platform (3 versus 18 times per hour of milking), when cows were milked with 'pleasant handling' compared with 'aversive handling'.

Behavioural responses of the cow to milking can be assessed by the frequency of kicks and steps (the 'KiSt response') although careful observation and analysis is required to separate environmental effects (e.g. flies) from machine effects and operator/machine interactions (Mein 1997). Also, cows that are highly fearful may exhibit a "tonic phase", and may not show kicking or stepping behaviours.

Research on commercial dairy cows in Australia has shown that high fear levels occur if stock people use a high percentage of negative interactions, such as slaps or hits with a poly-pipe, when handling their cows (Hemsworth *et al* 2000). In contrast, fear of humans is low in situations where stock people use a high percentage of positive interactions such as patting, talking and slow deliberate movement. Lower milk production (Hemsworth *et al* 2002) and lower conception rate to first insemination (Hemsworth *et al* 2000) were associated with farms in which cows showed a greater fear of humans.

Some farmers calve their heifers before the rest of the herd so that they can spend additional time familiarising them with the milking shed and milking routine. Other people calve their heifers with the herd so that cows accustomed to the milking routine 'lead the way' for heifers. Both methods are valid strategies for introducing new cows to the farm dairy. Whichever calving pattern is employed, it is preferable that heifers and new cows are familiarised with the farm dairy before calving (Bremner 1997).

Confidence – High

Quiet handling affects cow behaviour and production. On-farm experience shows that heifer familiarity with the farm dairy is of benefit.

Research priority – Low

Methods of achieving changes in cow handling by stock people and milking staff may be important.

Technote 6.1 gives more details about interpreting cow behaviour.

- When handling cows, people should use positive behaviours. Negative behaviours should be discouraged. If cow flow is an issue a review of the facilities and milker routines should be undertaken to identify problems.
- If a cow is behaving as required, and if there is an opportunity, positive reinforcement should be used.
- It is important to recognise that the repeated use of even moderate slaps and hits will result in cows becoming fearful.

Technote 2.2 describes training heifers in the milking area.

See the DairyNZ MilkSmart programme for useful tips on managing cow flow at www.milksmart.co.nz.

5.2

Foremilk strip cows to detect abnormal milk.

Foremilk stripping is used to detect clots, wateriness or discolouration in the first few streams of milk. Changes that persist for more than three squirts suggest that a cow has mastitis. Quarters with a few flecks only in the first three squirts may be left untreated and checked again next milking.

Foremilk stripping involves the careful removal of 2-4 squirts of milk from each quarter before milking. An effective method, illustrated in SmartSAMM Healthy Udder is to roll the thumb down whilst holding the top of the teat closed. Foremilk should be stripped onto a black surface e.g. dark paddle, piece of black plastic, or a strip cup to aid detection of discoloured milk.

Milk with abnormal changes will usually indicate clinical mastitis, but foremilk stripping will also indicate blood in milk or milk not suitable to go into the vat.

Confidence – High

Adopting management practices to detect cases of mastitis soon after calving has been a successful control strategy in herds with *Strep. uberis* problems.

Research priority – High

Research is being conducted to evaluate in-line conductivity and other automated means to improve their detection rate and thereby reduce the labour required to detect clinical mastitis cases and/or cows with high SCC. See Advisor Note on 'Detection of mastitis' for more information.

Role of foremilk stripping in detecting clinical mastitis

Early detection of clinical mastitis is one of the main potential benefits of foremilk stripping. When practised at the beginning of lactation, it helps detect clinical cases earlier at a time when the clinical infection rate is highest, as well as accustoming cows to having their teats touched and providing an effective signal for milk ejection. Prompt treatment of new intramammary infections resulted in quicker, and more effective, bacterial cure rates (Milner *et al* 1997).

SmartSAMM strongly recommends foremilk stripping of all quarters of all cows in the colostrum mob at least once a day.

Routine foremilk stripping of freshly calved cows is not widely practiced in NZ. Only 22% of 40 herds surveyed stripped every cow at every milking in the colostrum mob, although a higher proportion stripped cows once per day (Compton & McDougall, 2008, unpublished data).

Technote 4.2 defines the signs that a cow has clinical mastitis and should be treated.

The benefits of checking all quarters during the colostrum phase increases as the occurrence of clinical cases during the calving period (especially *Strep. uberis*) increases in importance. Field experiences in herds with outbreaks of *Strep. uberis* mastitis indicate that cases detected early are more likely to respond to treatment.

Whether people choose to continue foremilk stripping after the colostrum phase will depend on the risk levels in the herd. There are good reasons for routine foremilk stripping during periods of high risk, such as when:

- The clinical new infection rate is high.
- Bulk milk SCC (BMSCC) is approaching a penalty threshold.
- Clots are found on the milk filter.

Farmers should consider systems to allow continuation of regular foremilk stripping all season.

When clots are found on the filter, and the cause is not established, every quarter of every cow should be checked for abnormal milk by foremilk stripping before applying the machine at the next milking. In large herds, spreading the job over two or more milkings is a practical approach to achieving a thorough inspection.

Routines for implementing foremilk stripping of the whole herd.

System	Description	Comment
Strip all 4 quarters prior to every milking.	All four quarters are 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 next 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.
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

Use of 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 in combination with foremilk stripping, to identify cows that require treatment for clinical mastitis.

Current knowledge does not support the general treatment of subclinical mastitis i.e. those with no visual signs, with lactating cow therapy. These tests were designed to detect subclinical mastitis and not all test-positive cows need to be managed as clinical cases.

These tests can be used to identify suspicious quarters that require closer visual examination for mastitic changes in the udder or in the milk. In some specific situations, such as resolving a milk quality grading situation, they may be used to determine which cows to exclude from the factory supply.

Hand-held conductivity meters may help to identify cows with glands suspected to have mastitis, by identifying ions present in milk. Because these meters do not detect somatic cells in milk, they are of less value when resolving a milk quality grading situation or screening cows for high SCC, prior to adding their milk to the vat.

The 'Detection of mastitis' Advisor Note describes the Rapid Mastitis Test and hand-held conductivity meters that can be used for cow-side detection of subclinical mastitis.

In-line filter systems for detecting mastitis

In-line filters designed to detect mastitis in individual cows can be fitted to the long milk tube, between the clawpiece and the main milkline, in a position where they can be easily read. Milk flows through a wire mesh designed to trap large particulate matter, such as milk clots. This material is viewed through a transparent window in the filter. In-line filters can give users a false sense of security (Blowey and Edmondson 1995) as they only detect mastitis when:

- The filters are checked after each cow is milked.

- Infected cows are passing milk clots rather than watery milk.

They need to be cleaned whenever clots have been seen.

In-line detection systems for mastitis

New automatic sensing systems for monitoring mastitis in individual cows are being developed. The performance of such sensing systems is improved markedly when they are linked with reliable cow ID, data storage and processing (Mein, 2010).

The 'Detection of mastitis' Advisor Note describes in-line electronic diagnostic methods that can be used to detect cows that are suspected to have clinical or sub-clinical mastitis.

A reliable automatic monitoring system should be capable of facilitating at least three main tasks for effective mastitis management:

- Prompt detection of clinical cows, or simplifying the search for clinical cows if clots are found on the milk filter sock, especially during the high risk period of early lactation.
- Providing regular, reliable lists of the 'millionaire' cows (those with ICSCC greater than 1 million cells/mL) to simplify management of BMSCC, especially during the last three months of lactation.
- In the last month of lactation, providing a reliable list of cows with subclinical mastitis to simplify the selection of cows for antibiotic therapy at drying off.

None of the commercially available monitoring systems can achieve 100% accuracy in carrying out these three tasks. The best that can be achieved, at present, is to simplify these tasks by reducing the size of the pool of suspect cows (Mein, 2010). All of these tasks need to be achieved, whilst minimising false identification of cows.

5.3

Put cups on clean, dry teats – wash and dry dirty teats.

Mastitis risk is a 'numbers game'. The new infection risk is reduced by keeping bacterial numbers low on or near the cows' teat ends. A simple method developed and validated by Dr. Pamela Ruegg (Schreiner and Ruegg 2003) for scoring udder hygiene has proved an invaluable tool to monitor the effect of the cow environment on udder cleanliness. Udder hygiene scores have been shown to be correlated with BMSCC and mastitis infection rates on farms in the USA.

Confidence – Moderate

Extensive data, mainly from the United States, show benefits in milk quality when environmental contamination is reduced.

Research priority – High

It would be worthwhile to evaluate the effect of teat preparation on environmental streptococcal infections in NZ conditions. Similarly, a comparison of flamed udders, 'one-step preps' and techniques currently used in the industry could be assessed in a pre-milking hygiene trial.

Although environmental conditions are quite different in NZ compared with Wisconsin, the tool is likely to have value in any climate. It allows for a quick and easy assessment (usually no more than 20 minutes), and more importantly, provides a quantitative measure of performance that can be used to test the efficacy of different animal management strategies. Indeed, a strong link was found between cleanliness of cows and incidence of mastitis due to environmental pathogens such *E. coli* and *Strep. uberis* across four British herds (Ward *et al* 2002).

Overseas research has shown significant advantages through reducing water usage and milking dry teats (Galton *et al* 1986, McKinnon *et al* 1983). Udder surfaces should be dry (even if dirty) and teats should be clean and dry before milking.

Milking wet teats is unacceptable for both mastitis and milk quality issues. The incidence of intramammary infection is highly correlated with the number of mastitis pathogens on the teat end at milking (Galton *et al* 1988). Research at Cornell University (Galton 1995), in Australia (Hubble and Mein 1986) and elsewhere suggests 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 practice reduces milk quality (mainly by increasing bacterial counts) and increases the risk of mastitis (mainly from environmental pathogens such as coliforms and *Strep. uberis*) (Smith and Hogan 1997).

The risk of infection from environmental pathogens appears to increase with increasing level of milk production per cow, and with increasing concentration of cows in large herds.

Research in NZ (Lacy-Hulbert *et al* 2002) observed very high levels of clinical and subclinical mastitis, caused by coliform bacteria, when cows were maintained on a total mixed ration in zero-grazing environments. The combination of a high starch content in the diet coupled with high faecal contamination in the environment, led to large numbers of bacteria residing on the teats. All teats had to be washed and dried before every milking, especially during wet weather, to reduce the risk of new infections.

Pre-milking teat preparation

In NZ, the risk management programmes operated by most dairy processors require milk to be harvested in accordance with a Code of Practice, currently NZCP1 (NZFSA, 2009).

Confidence – High

When environmental circumstances results in teats becoming wet, dirty and soiled, washing and drying of teats before milking is highly beneficial for reducing the risk of mastitis.

Extract from NZ Code of Practice 1 regarding teat preparation

> **7.11 Teat Preparation**
>
> Animals' teats must be clean and should be dry before applying the cluster. Teat washing facilities must be available for this purpose and must be adequately maintained.
>
> Volume washing is not recommended and can cause milk contamination problems through overwetting.

Technote 26 describes how to fix areas that make udders muddy.

A "rule of thumb" to comply with this Code is:

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

Dry/Dusty teats

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

Wet/Dirty teats

A low pressure water supply, combined with manual cleaning and drying by the operator, is the preferred method for washing teats. It will result 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 and should only be used for washing away manure from the dairy floor and railings. Teats should be dried after washing, with one towel used per cow to prevent spread of contagious bacteria from cow to cow.

Dirty teats should be washed with clean, low-pressure water, and dried.

Some examples of cloths or towels that can be used to wipe dusty teats, or dry teats after washing, include:

- disposable paper towels,
- old newspaper torn into squares,
- cloth towels, such as Chux-type cloths or face flannels.

Cloths need to be laundered between milkings. i.e. washed, rinsed in 200 ppt per million chlorine and spun dry in a washing machine. Damp Chux-type cloths can be used to wipe dry/dusty teats, whereas dried cloths will be more efficient at drying wet teats.

Strategic washing

In situations of high environmental challenge e.g. housed systems, gross contamination with dirt, or faeces, it is recommended that all (contaminated) teats are washed and dried prior to cup attachment. This preparation should continue until the source of the teat contamination has reduced or been eliminated.

Wearing gloves will greatly improve milker comfort when washing and drying teats. Gloved hands are also much easier to keep clean and free from bacterial contamination, compared to ungloved hands (Olde Riekerink *et al* 2008). Gloved hands should be kept free of gross dirt and should be rinsed under running water after every few cows.

Technote 8.2 describes the importance of hygiene at milking time and the benefits of wearing gloves.

Pre milking teat disinfection

In NZ, pre-milking teat disinfection is not currently recommended, but in other countries where mastitis caused by environmental bacteria is more common, pre-milking teat disinfection using registered pre-dips is a widely recommended practice.

It typically involves:

1. Pre-clean teats as necessary.
2. **Strip –** Foremilk strip to check for clinical signs (may be done before or after applying teat dip).
3. **Dip –** Apply teat dip and allow for manufacturers' contact time.
4. **Dry –** Wipe off teat dip with single use paper towels.
5. **Apply –** Attach teat cups.

Pre-milking teat disinfection has three recognized effects:

1. Milk quality

Studies on the effects of pre-milking udder preparation methods (Galton *et al* 1984, 1986) have demonstrated that pre-milking udder preparation can reduce bacterial counts and sediment in milk if performed properly. However, if the wiping stage is performed poorly or skipped, iodine-based disinfectants can result in significant iodine residues in milk. Effectiveness of pre-milking disinfection is also reduced if cows' teats are wet and dirty. Wet and dirty teats should be washed and wiped before the pre-milking disinfectant is applied.

2. Udder health

Overseas research has shown some success with pre-milking teat disinfection for reducing the risk of mastitis, mainly due to environmental pathogens (Pankey *et al* 1987; Galton *et al* 1988). In contrast Hillerton *et al* 1993, in a paired herd study involving 18 herds in England, found no reduction in new intramammary infection for cows that were pre-dipped.

The effectiveness in NZ is unproven. A study of pre-milking teat disinfection, in addition to post-milking teat spraying, found no additional benefit for control of early lactation infections due to *Strep. uberis* (Williamson & Lacy-Hulbert, unpublished results). Only teat sprays that have been approved for use for pre and post milking disinfection can be used in NZ. The manufacturer's instructions should be followed fully, to reduce the risk of milk contamination.

3. Milk let-down

The benefit of udder preparation on the milk let-down response in cows is not well understood by NZ dairy farmers. Research to date has found only minimal benefits of foremilk stripping prior to applying the cups in terms of shortening milking duration (Edwards *et al* 2012).

Section 5.4 discusses timing of the attachment of teat cups.

Dairy water quality

Good quality water must be used in dairies, for preparation of cows, making up teat disinfectants, general hygiene and cleaning of equipment and the plant. In NZ, farm dairies are required to meet the Farm Dairy Water Quality requirements stated in DPC2: Animal Products (Dairy) Approved Criteria for Farm Dairies (NZFSA, 2008). This standard states that water may come into contact with raw milk intended for manufacture of dairy products, during milking or as a result of cleaning the milking plant, so long as it meets the following criteria:

Technote 7.3 discusses water quality for teat disinfectant solutions.

- *E. coli* – absent in 100ml; and either
- turbity – maximum 5 NTU (Nephelometric Turbidity Unit); or
- clarity – correlated to the listed reference method for turbidity.

Water used in the farm dairy may be obtained from a number of sources (rain, river or creek, bore or underground spring and dam or irrigation channel). As the water passes through the atmosphere, over the surface of land and through the soil it may change in quality in many ways. It collects physical impurities (sediment, turbidity, organic matter), mineral impurities (hardness, alkalinity, iron) and biological impurities (algae and micro-organisms).

Impurities can cause problems with the performance of chemicals used in dairy hygiene and mastitis control. Many quality problems can be avoided or minimised by prudent sourcing and correct storage of the water, or by treatment. Under standard NZ conditions, treated water on tap is not always available or feasible on a regular basis. Nevertheless, water treatment is an important issue as the industry strives for high quality milk.

Suitable treatment can be achieved by the use of commercial equipment (automatic) or by farmer-built treatment systems (less expensive batch treatment but can be semi-automated). Details of quality problems commonly experienced in dairy farm water supplies and suggestions for their treatment are given in Hubble (1981a, 1981b, 1989a, 1989b, 1990) and Flowerday (1998).

In situations where water is suspected to be contaminated with bacteria, it can be treated with chlorine to a level of 0.5 parts per million free residual chlorine (as measured by a swimming pool test kit). The water must be free of suspended clay and organic material prior to treatment.

Udder flaming

A major source of bacteria and organic matter that enters the bulk milk is from the teat and udder. Hair is a good base for organic matter to collect and accumulate. A hairless udder 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 or flaming once or twice per year. Flaming is much quicker and more efficient. Udder flaming is a procedure using a soft, warm orange flame from a propane torch to de-hair the lower parts of an udder.

Udder flaming is not painful. Cows tolerate the process very well, and it is significantly quicker, less stressful and more thorough than clipping. Flaming is best performed on a still, dry day in a farm dairy that has adequate ventilation, using an orange flame. Scrunched up newspaper, or a long wax taper can also be used to create an orange flame.

To flame a whole herd, one extra person in the pit is required – adding about 15 minutes per 100 cows to the milking time. Flaming should occur before milking and before wetting. The task can also be conducted in the dry period. All cows should be flamed as soon as they enter the milking herd. Typically, the process needs to be repeated every 6 months. The rate of regrowth depends on cow hairiness and climate.

Udder flaming is performed as follows:

- Adjust a torch flame so that it is 150 mm high and throws a yellow flame.
- Slowly pass the flame about 150-200 mm below the udder ensuring that the hair is singed to the skin but not set alight.
- Blow flames out and brush ash away with a gloved hand or a soft car brush.
- Make sure the floor of the udder, especially around the teats and around the back of the udder, is flamed and brushed.
- Remove ash before attaching clusters at milking so that it does not end up in the milk.

5.4

Attach cups using a calm and consistent routine.

Picking the best time to attach teat cups has the benefits of: cleaner, quicker milking out; improved teat condition and, in some situations, higher milk yield per cow (Hamann and Dodd 1992, Reneau *et al* 1994).

Reneau *et al* (1994) concluded that the optimum 'window of time' to apply teat cups was 60-90 seconds after the cow's teats and udder were first touched by the milker. This window allowed time for milk ejection to occur in most cows while making optimum use of the milk ejection hormone, oxytocin (Gorewit 1983).

Putting cups on too soon can result in teat cups crawling during the first minute of milking. Teat cups crawl higher up the teats when milk flow slows or stops, as the cisternal milk is removed, and before the main milk fraction is ejected from the alveoli into the milk ducts and cisterns. When teat cups crawl early in milking, milk harvesting is less complete and less efficient near the end of milking, because the milk pathway between the gland cistern and teat sinus becomes restricted more quickly once peak milk flow has finished. However, the prevalence of teat cup crawl, and hence the benefits of reducing it have yet to be proven under NZ conditions.

Recent NZ research on pre-milking preparation has found that delaying cup attachment by up to 45 seconds from the normal timing did not affect milking time or milk yield. Foremilk stripping prior to cup attachment led to a reduction in milking time, but by only 18 seconds (Edwards *et al* 2012).

Although firm but gentle touching or rubbing of teats is an effective stimulus for milk ejection, it is not the sole stimulus. Cows are creatures of habit. The sights and sounds of milking and the predictability of a calm, consistent

Confidence – Moderate

Research and field experience have shown the benefits of correct timing of teat cup application are quicker milking out and improved teat condition.

Research priority – High

Higher yields resulting from correct timing of teat cup application have not been demonstrated under NZ conditions of minimal pre-milking udder preparation.

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.

milking routine can elicit a good milk ejection in most cows, especially in the first six months of lactation.

Whatever routine is adopted in any given herd, the golden rule is to choose a set of procedures that requires each milker to be absolutely consistent at every milking, and to utilise cupping techniques that maximise comfort and minimise risk of injury to both cow and milker.

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

Air admission during cup attachment should be minimised in order to maintain the effective carrying capacity of the milkline. Sudden in-rushes of air during cup attachment can lead to 'slugs' of milk forming in the milkline, which reduces the carrying capacity of the milkline. This may lead to irregular fluctuations in the milking vacuum that are severe enough to cause other clusters to slip or fall off. Cluster slip may result in the formation of 'impacts' (see section 5.6 below).

DairyNZ Milksmart describes different cupping techniques and procedures, at: www.milksmart.co.nz.

The sizing of milklines has changed over the years to improve the effective carrying capacity of the milkline, thereby improve stability of the milking vacuum during cup attachment. This relationship between air admission and the carrying capacity of milklines is acknowledged in international guideline tables for sizing milklines, where a distinction is made between 'careful' and 'typical' operators (ISO 5707:2007). For simplicity, NZ Milking and Pumping Trade Association performance standards and guidelines are based on 'typical' operators only.

Looped milklines can have a higher number of milking units per milkline slope compared with a dead-ended line because the flow-rate of transient air admission per slope is halved (that is, any air admitted can flow to the receiver via two pathways rather than one). For example, current standards suggest a 60 mm looped line at 1.5% slope can have 12 units per slope (24 units on the loop) compared with 9 units for a dead-ended line at the same slope.

Technote 25.2 shows nominal pipeline diameters and slopes for dead-end and looped milk lines.

5.5

Eliminate machine stripping from your milking routine.

Machine stripping refers to the practice of putting weight on a cluster at the end of milking. This re-opens the connection between the udder cistern and the teat sinus and may result in the removal of a small amount of milk left in the udder cistern.

Published evidence on the relationship between completeness of milking and new mastitis infection rates is conflicting. Most of the older publications reviewed by O'Shea (1987) show that mastitis increased when machine stripping was omitted. In contrast, at least nine studies indicated that small quantities of milk left in the udder did *not* increase the new infection rate or clinical mastitis, and at least three studies found higher levels of infection associated with machine stripping.

The latter findings are not surprising. It is likely that the new mastitis infection rate will be increased by vigorous machine stripping which causes sudden air admission into one or more teat cups just before the teat cups are removed. Extra weights placed on claws affect the balance of a cluster and

Confidence – High

Because machine stripping is a major interruption to the milking routine for little or no benefit, those few cows that require routine machine stripping in any herd should be culled.

Research priority – Low

Machine stripping is not important, especially if pre-milking udder preparation is effective and consistent. Research on maximum milk out time (MaxT) shows no benefit of allowing slow milkers to complete their milking.

increase cup slippage which, in turn, increases the risk of mastitis.

Recent studies on truncating the milking time of the slowest milking cows in the herd show no adverse effects, in terms of increased mastitis incidence or reduced milk yields (see section 5.8 below).

5.6

Take teat cups off by cutting the vacuum and allowing them to slip free of the teats.

Irregular fluctuations in the vacuum of the milking machine (such as a sudden entry of air as clusters are attached, detached or when liners slip) may propel milk droplets towards the teat end with sufficient velocity to partially or totally penetrate the teat duct (Bramley 1992). These 'impacts' may carry bacteria from the surface of the teat into the teat canal beyond the reach of teat disinfectant.

The effect of sudden air admission into the cluster appears to be more critical near the end of milking than at the time of cluster attachment. In experimental studies in the United Kingdom, cows exposed to unstable vacuum conditions around the end of milking had higher new infection rates (Bramley 1992). Rough cup removal increased the new infection rate 3-4 times (National Institute for Research in Dairying, unpublished results, 1972). These results imply that bacteria thrown against a weakly-closed teat canal, around the time that the cups are removed, have little or no chance of being flushed from the teat orifice or teat canal by milk flowing from the teat.

The recommended method for removing teat cups is the use of automatic cup removers (ACR). In the absence of this, the recommended method for manual removal of the teat cups, as described in SmartSAMM Healthy Udder, is as follows:

1. **Break** the vacuum, by closing the clamp or kinking the long milk tube, close to the cluster.
2. **Wait** a couple of seconds for the vacuum to break and the cluster to fall away from the cow. **A slight twist** of the cluster can help the vacuum to dissipate and cause all 4 teat cups to come away from the teats simultaneously.

Confidence – High

Attaching clusters: New international and national standards for milklines are based on the principles of fluid dynamics, laboratory research and field experience, and have greatly reduced the risk of cup slip during cup attachment.

Detaching clusters: The way in which teat cups are removed is often more important for mastitis than the timing of removal.

Research priority – Low

There is little or no effect of irregular vacuum fluctuations on mastitis unless overload of milklines increases the frequency of liner slips or teat cup falls.

5.7

Select the end-of-milking point that is appropriate for the herd.

Selecting the most appropriate time to remove teat cups has been widely debated over the years. At the heart of the issue is finding a balance between removing milk from the majority of glands in a time-efficient manner, at the same time as minimising the risk of mastitis, or losses in milk production, caused potentially by leaving too much milk behind.

Avoid (excessive) over milking

Over milking defines the period when teat cups remain attached to teats after the milk flow rate from an individual cow has fallen below an arbitrary

Research priority – Moderate

Definitive data is required to describe the circumstances when incomplete milking, or prolonged over milking, have a detrimental effect on the risk of new infections.

‘end-point of milking’. A flow rate of 200 mL/minute is a commonly accepted end-point for herds in NZ.

Some over milking is inevitable because individual quarters milk out at different times. Both field experience and research studies indicate that the effects of a moderate amount of over milking (say 1 or 2 minutes) are relatively minor so long as the milking system is functioning correctly.

However, over milking for 5 minutes per cow induced marked changes in the firmness of teats after milking (Hillerton *et al* 2002) and led to an increase in the new infection rate of mastitis in herds when applied in conjunction with pulsation failure (Mein *et al* 1986).

Technote 9.1 describes the changes to teats associated with over milking.

Regular over milking almost always results in increased thickening of skin at the external teat orifice and increased teat congestion and oedema (Hamann 1987, Hamann *et al* 1994, Olney and Mitchell 1983). Danish research (Rasmussen 1993) indicated that automatic removal of clusters at a higher end-of-milking threshold (400 versus 200 mL per minute flow-rate) decreased milking time by 0.5 min per cow, improved teat condition and had no influence on milk yield. The incidence and prevalence of subclinical mastitis were not affected but, interestingly, significantly fewer cows in the early detachment group developed clinical mastitis.

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

Field research in the United States (based on the findings of Rasmussen in 1993) has shown that both teat condition and cow behaviour are greatly improved when the end-point flow-rate for cup removal using an ACR is set at 400 mL/minute or higher, especially in high-producing herds.

Studies in Australia and NZ have observed minimal effects of higher end-of-milking thresholds on milk production and mastitis. Clarke *et al* (2008) removed cups at a high threshold (800 mL/min versus 300 mL/min) and found a significant reduction in milking duration but little or no effect on milk production or mastitis, despite using cows with mild subclinical mastitis. Jago *et al* (2010a) found no difference in milk yield for end-of-milking thresholds of 0.4 compared to 0.2 kg/min during a whole lactation study, and suggested that no change in mastitis or SCC could be attributed to the end-of-milking setting.

Situations most at risk of causing excessive over milking are typically those that involve large numbers of bails per operator with no ACRs. In these situations, over milking can be solved through:

- Changing the milking routines – see **www.milksmart.co.nz** for tips on cupping procedures that reduce over milking
- Changing machine settings, including ACR settings – see an MPTA registered milking machine consultant for assistance in setting the most appropriate end point of milking for the herd.

Avoid (gross) under milking

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’. Milk left in the clusters of secretory cells (alveoli) is referred to as ‘residual milk’. ‘Residual milk’ cannot be removed by careful machine stripping or hand-stripping without an intramuscular injection of oxytocin. Typically, residual milk may be 1-3 kg or about 10-20% of total milk in the udder. Higher amounts can result from incomplete milk ejection associated with poor milking routines, frightened or nervous cows, cows with damaged and scarred teats, cows with sore teats or uncomfortable milking equipment.

Incomplete milk removal from normal, healthy teats usually occurs when:

- Teat cups are removed before the last of the available milk drains into the udder cisterns, or
- At least one of the four teats moves too deeply into its teat cup ('teat cup crawling'). Teat cup crawling is the more common cause of incomplete milking. When cup crawl occurs, the milk pathway between the udder cistern and teat sinus becomes blocked near the end of milking.

For practical purposes, completeness of milking of individual cows is estimated by one or more assessments of the 'strip' yield, through:

- Visual assessment of udder shape, and site and number of wrinkles.
- Measuring the volume of milk that can be hand-stripped from individual quarters after milking.
- Measuring the volume of milk that can be stripped out after re-attaching the milking machine.

Published evidence on the relationship between completeness of milking and new mastitis infection rates is conflicting (as described above). Experiments cited by Dodd and Griffin (1979) dating back to 1936 indicated that lactational yields were reduced by about 3% when 0.5 kg of milk was left in an udder after milking. As a guideline, Mein and Reid (1996) suggested that if milking clusters are correctly designed, well maintained, correctly applied and adjusted, then the mean strippings yield is typically less than 0.25 kg per cow. However, Clarke *et al* (2008) reported no detectable increase in cell count in infected or uninfected quarters when strip yields were increased from 300 mL to 530 mL per milking.

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 generally the preferred approach for identifying herds with problematic under milking.

Shorter Milking Times

New possibilities for milking herds more quickly with no apparent adverse effects have emerged from Rasmussen's research in conjunction with observations on setting a maximum time limit for milking slow cows (Clarke *et al* 2004, 2008; Jago *et al* 2010a, b).

The first results from Clarke *et al* (2004) showed that the use of timed maximum milking durations could save up to 35% of normal milking time of slow milking cows with no adverse effect on their daily milk yield (averaging up to 26 L/d), milk composition, teat condition or cow behaviour.

Subsequent studies (Clarke *et al* 2008) indicated that early termination of milking had no significant effects on the incidence of clinical mastitis, sub-clinical mastitis or average ICSCC in healthy quarters or in quarters sub-clinically infected with either *Staph. aureus* or *Strep. uberis*.

The major practical outcome of these studies has been a marked reduction in the time required to milk herds in which the Shorter Milking Time

Confidence – High

The conventional wisdom, that under milking reduces milk yield, increases the risk of mastitis and may elevate cell counts, is no longer supported. There is increasing research and field experience suggesting that earlier teat cup removal results in improved teat condition, shorter milking times and negligible effects on mastitis and milk production.

Research Priority - High

The herd circumstances and/or residual milk threshold at which incomplete milking affects the risk of mastitis are unknown.

See *"How completely should we aim to empty cows' udders at milking time?"* Mein *et al* 2010 in Key papers list for a full review.

Technote 6.1 gives guidelines for assessing completeness of milking of individual cows, including definitions of good, poor and uneven milk out.

Technote 13 and the SmartSAMM Mastitis Investigation Kit provide a systematic approach for identifying problems with milking.

The combination of a pre-set maximum milking time and an end-point determined by ACR threshold (whichever comes first) has great potential to shorten milking times per herd by reducing or eliminating the bottlenecks caused by slow-milking cows.

guidelines are implemented. 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 and, thereby, induce some under milking in these cows.

New studies in NZ (Burke and Jago, 2011; Jago *et al* 2010 a, b) have confirmed and extended the results of the Australian studies in two ways. Firstly, the time-saving strategy of truncating the milking of slow cows can be started before cows reach the peak of their lactation. Secondly, further time savings can be achieved when the Shorter Milking Times strategy is applied more aggressively. On average, 30% of cow-milkings were truncated in the NZ study compared with a less aggressive target of 20% in the studies by Clarke *et al* (2004, 2008), with no detrimental effects.

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 Australian or NZ herd in which cows are producing an average of 10 L at a single milking will be milked in 6.3 minutes. If MaxT was applied at the suggested target level of 80%, then the slowest 20% of cows in that herd would have their milkings truncated by removing clusters after 6.3 minutes. This leads to the following guidelines for setting MaxT, for herds at different production levels (see Table below).

For more information on applying and calculating MaxT for an individual herd, see www.milksmart.co.nz.

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
10 L/milking	6.3 minutes
12 L/milking	7.2 minutes
14 L/milking	8.0 minutes
16 L/milking	8.8 minutes
18 L/milking	9.5 minutes
20 L/milking	10.2 minutes

In practical terms, a fixed time removal of clusters can be difficult to implement (challenging for farmers to measure it, set it and apply it in the farm dairy). A simplified version of MaxT could be applied at the 10-15% level in herringbone dairies. In a 10 aside, for example, farmers do not need to wait around for the last cow; in a 20 aside, they do not need to wait for the last 2 or maybe 3 cows, etc. In rotaries, select a platform rotation time and apply a strict policy that 'no cow goes around twice unless there is a specific reason' (e.g. the cluster had been kicked off).

In summary, revised guidelines to avoid under and over milking and to shorten herd milking times are as follows:

- Check that the herd meets the criteria described in the Table below.
- Aim to milk **most** cows as completely as possible, within a reasonable time, at every milking. This assumes a maximum ACR threshold setting of 400 mL/ min for herds milked once or twice daily.
- Aim to milk **all** cows out as evenly as possible. Why? Because uneven milk-out contributes to uneven distribution of milk yield between quarters, leading to less uniform udder conformation which, in turn, reduces the ease and efficiency of machine milking.

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.

Circumstances under which shortening the maximum milk-out time (MaxT) could be considered[1]

Criteria	MaxT – Yes	MaxT – unwise
Bulk milk SCC (seasonal average)	< 200,000 cells/mL	≥ 200,000 cells/mL
Annual clinical case rate (n cases per 100 cows in milk)	< 15	≥ 15
Calving clinical case rate (n cases per 100 cows calved, in first 14 d after calving)	< 10	≥ 10
Monthly clinical case rate (n cases per 100 cows in milk)	< 1	≥ 1
Strip yield from random selection of cows	< 500 mL per cow	≥ 500 mL per cow
Machine test	Annual test shows no faults	Annual test shows some faults
Action	Consider applying MaxT.	Resolve underlying mastitis issues before applying MaxT.

[1] These guidelines are arbitrary and represent a conservative approach to MaxT. They may change as the consequence of applying MaxT under different field conditions becomes more certain.

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