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EVALUATION OF BOVINE TEAT CONDITION IN COMMERCIAL DAIRY HERDS: 1. NON-INFECTIOUS FACTORS

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ABSTRACT

Classification of bovine teat condition can be used to assess the effects of milking management, milking equipment or environment on teat tissue and the risk of new intramammary infections. Veterinarians and others require a simple and reliable method for evaluating teat health in dairy herds. A protocol for systematic evaluation of teat condition in commercial herds is proposed. Guidelines for interpretation of observations are given. The relative influence of non-infectious factors affecting short-, medium- or longer-term changes in teat condition are reviewed briefly and discussed. The main short-term (single milking) effects include changes in color, swelling and firmness of the teat-end and barrel, and the degree of openness of the external teat orifice. The main medium-term effects (requiring a few days or weeks) include changes in teat skin condition and incidence of petechial haemorrhages. Changes in teat-end hyperkeratosis appear to be longer-term effects (typically 2-8 weeks) in the absence of unusually harsh weather conditions. Very long-term effects (typically occurring over a few or many months) such as changes in size, tissue fibrosis and thickness of teats, are not discussed in this paper.

INTRODUCTION

Maintenance of healthy teat skin and teat-ends is a key part of any effective mastitis program. Changes to teat tissue, particularly the skin of the barrel, teat-end, and teat canal, alter the risk of new mastitis infections (7,11,26), sub-clinical mastitis inferred from CMT scores (19) or clinical mastitis (30). Instruments and measurement techniques used to assess the condition of teat tissue include changes in teat thickness with a modified cutimeter, ultrasonography, sub-cutaneous oxygen tension (8,11,12), and pulse oximetry (21). These techniques vary in practicality in the field, the expertise and cost required to use them, and in their demonstrated repeatability and precision. Simpler methods for quantifying the short- or medium-term effects of milking on teats were proposed by Hillerton et al. (14,15) who noted that many effects of machine milking are easily recognisable immediately after cluster removal.

Numerous classification systems for teat-ends and skin condition have been published (for example: 2, 25, 27, 38, 41, 43, 44). Visual assessment of teats, comparison with photographs, and scoring schemes in nominal categories are the most common methods. In addition, many veterinarians and advisers have devised their own unique classification systems. Simpler methods that reduce time and effort for the evaluator, and also minimize interference with milking routines, would increase their utility for assessing teats in commercial dairy herds.

The purposes of this paper, by an informal discussion group of researchers and udder health advisers self-styled as the “Teat Club International”, are:

1) to review non-infectious factors affecting short- or medium-term changes in teats;
2) to propose a simple protocol for systematic evaluation of teats in commercial dairies;
3) to propose guidelines for interpretation of these observations.

The full version of this paper with many references, example pictures and sample recording charts is posted on the UW-Madison Milk Quality website (http://www.uwex.edu/milkquality/). Other companion papers in the "Teat Club" series in this AABP/NMC Conference Proceedings discuss infectious factors (13), data collection and analysis (39), and the relationship between teat-end hyperkeratosis and mastitis (31).

Short-Term Changes In Teat Condition (Responses To A Single Milking)

Faults in milking machines or milking management are the primary cause of short-term changes in color, firmness, thickness or swelling of teats, or degree of "openness" of the teat orifice.

Color changes

Some teats are noticeably red, either at the teat-end or over the entire teat, when the cluster is removed. Others may become reddened within 30-60 s of cluster removal. In extreme cases, teats become blue or already appear blue when the cluster is removed, indicating cyanosis (14, 15). See examples 1-3 in the attached Powerpoint "Teat Slides" file (from 15).

Poor teat color after milking may be worse for short or slender teats (37). Color changes are exacerbated by overmilking (14), especially with wide-bore liners (16) or tapered liners with wide upper barrels, unusually heavy cluster weight (15), high milking vacuum (36), faulty pulsation (17, 22, 40), or mismatch between type of liner used and mean teat size within a herd.

Black teats must be excluded from any color-based evaluation. Changes can be classified according to the proportion of light-colored teats that, when examined within 1 min of cluster removal, are:

- Normal (pink)
- Reddened (part of or all the teat-end or barrel may be discolored)
- Blue-colored (part of or all the teat surface appears to be tinged with blue or purple).

Because the causes of reddened or bluish teats may differ, red and blue classes should be recorded separately. However, a further simplification is to combine the red and blue categories into a single category for analysis of Normal (pink) versus Discolored (red or blue-colored).

Swelling at or near the teat base

When examined after milking, the upper part of the teat may have a visible line or mark caused by contact with the liner mouthpiece lip. Alternatively or in addition, there may be visible swelling (with a palpable, thickened ring) in the unsupported area that was inside the liner mouthpiece chamber near the end of milking (14). See examples 4 and 5 in the attached Powerpoint "Teat Slides" file. To avoid confusion with physiological swelling of teats and

udders, cows with obvious signs of udder edema, or cows that calved within 1 week of teat evaluation, should be excluded.

Factors commonly responsible for swelling around the top of the teat as a direct result of milking include: high mouthpiece vacuum associated with wide-bore liners (32); overmilking, especially with wide-bore liners or tapered liners with wide upper barrels (16); teatcup crawling; or liner mouthpiece lips that are unusually stiff or narrow in relation to teat size.

These effects can be evaluated according to the proportion of teats that, when examined within 1 min of cluster removal, are:

- Normal (no ring, little or no swelling)
- Visible mouthpiece lip mark or "garter mark"
- Marked swelling or palpable thickened ring.

To simplify data analysis, the "Normal" and "Visible lip mark" classes were combined into a single category by Hillerton et al. (15) even though they were recorded separately. Pooling data into two categories, Normal (no or mild swelling or lip marks) or Swollen (marked swelling or thickening) is recommended to simplify the evaluation and statistical analysis.

Hardness at or near the teat-end

Many teats feel soft and compliant after milking and they contract when touched. However, some teats feel swollen or firm or, in extreme cases, hard and unresponsive to touch (15). Teats often look flat or "wedge-shaped" after milking. "Wedging" describes the (typically slight) flattened shape of the teat-end due to the compressive load applied by the opposing walls of a collapsed liner. Severe wedging which induces a reduction in teat end volume may result from hard liners, liners mounted under high tension, a prolonged D-phase or failure of the liners to open fully (Hillerton, Ohnstad, personal communications).

Factors commonly responsible for swelling near the teat-end include overmilking (8), use of wide-bore liners (14) or liners with high mouthpiece chamber (36), high vacuum (4,10), pulsation failure (24), insufficient rest phase of pulsation (9) or short A- and C-phases of pulsation (29).

Teat-ends can be classified by simple visual examination supported by manual palpation, as:

- Normal (soft and supple)
- Firm, swollen or hard, or severely wedged.

Openness of the teat orifice

When examined immediately after milking, the external teat orifice may appear to be closed, slightly open or, in extreme cases, with a funnel-shaped opening about the size of a match-head. See example slide 6 in the attached Powerpoint "Teat Slides" file (from 15). According to independent unpublished observations by three co-authors, both the new infection rate and the proportion of teats with open teat orifices were reduced in several mastitis problem herds in Australia, UK and USA following changes to milking equipment or procedures. In most of these anecdotal reports, a change in liner type was thought to be the single largest contributory factor in solving the mastitis problem (unpublished field data: Mein, Morgan, Ohnstad).

Factors linked with short-term, post-milking openness of the teat orifice include high milking vacuum (4), overmilking, design of liner mouthpiece, unusually heavy cluster weight (15), or high liner mounting tension (3).

Teat orifices can be classified, by qualitative assessment within 1 min of cluster removal, as:

- Closed
- Open (more than 2mm wide or deep).

A clean paper towel can be used to remove milk residue from the teat end. When estimating the degree of openness, it is helpful to compare the width or depth of an open orifice with a common object such as a match-head (about 3mm in diameter) or the shaft of the match (about 2mm).

Medium-Term Changes In Teat Condition (Responses Visible Within A Few Days Or Weeks)

Machine-induced changes in the incidence of petechial haemorrhages or larger haemorrhaging may occur immediately or may take several days before becoming evident. Changes in teat skin condition associated with harsh weather or chemical irritation may take a few days or weeks.

Teat skin condition

Healthy teat skin is coated with a protective mantel of fatty acids that are derived from the dermal layer and which retard the growth of bacterial pathogens (5). When exposed to cold, wet and windy conditions, the skin of machine-milked teats often becomes scaly, irritated or chapped (broken skin) and the protective surface coating may be removed, thereby allowing colonization of pathogens such as *Staphylococcus aureus* (5, 33). Cold, wet or muddy conditions induce hardening or thickening of teat skin. Mud, as it dries, draws moisture from the skin with a consequent loss of elasticity of the teat skin. Machine milking exacerbates problems of chapping or cracking. Chemical irritation associated with disinfectant type or concentration, or inappropriate type or concentration of emollients, may exacerbate the effects of harsh weather conditions and promote teat chapping. Skin conditioners or emollients either reduce evaporation from the skin or act as humectants to maintain or improve the teat skin condition (38). The dryness of black teats tends to be over-estimated by observation alone. Evaluation is improved by lightly rubbing the teat skin with a finger. In the absence of cracks and sores, differences in skin condition classed as smooth or rough do not seem to influence new mastitis infection rates (38). Consequently, we propose the following simple classification system:

- Normal (smooth sheen, soft, healthy skin)
- Dry (scaly, flaky or rough skin but with no cracking).
- Open lesions (allow space for specific description, eg., chapped, cracked, blackspot).

Vascular damage

The proportion of teats with petechial haemorrhages, or more extensive haemorrhaging, is one indication of the extent of any vascular damage. Vascular damage usually reflects some type of pulsation failure (22, 24), often associated with high vacuum and/or prolonged over-milking. Incidence is lower in herds milked with narrow-bore liners, at low vacuum, and/or with automatic detachers. See example slide 7 in the attached Powerpoint "Teat Slides" file.

Longer-Term Changes In Teat-End Condition

The degree of teat-end hyperkeratosis (roughness, cornification or callosity) is a dynamic condition. Status of teat-ends for an individual cow or herd can change within days, especially in regions subject to harsh weather conditions or sudden weather changes (44). Seasonal conditions may affect dryness and hardness of keratin (2, 44). In the absence of unusually harsh weather conditions, however, changes in teat-end status occur over a period of 2-8 weeks.

Apart from seasonal weather conditions, major factors affecting teat-end hyperkeratosis include teat-end shape, production level and stage of lactation, and interactions between milking management and machine factors (especially slow milking and over-milking). According to some experienced observers, the genetic predisposition of individual cows appears to influence the degree of hyperkeratosis. This genetic influence is in addition to the more obvious effects of teat size and shape (Hillerton, Timms, personal communications). In general, teat-end scores are poorer for long pointed teats (1, 27), slow milking cows or higher-producing cows (23, 27,42). Teat scores change with stage of lactation and parity. Teat-end hyperkeratosis may be exacerbated by disinfectants that cause chemical irritation to teat skin or may be improved by the use of a disinfectant with a high concentration of an effective emollient.

Of the milking management or machine factors, the total time per day when milk flow rate is less than about 1 kg/min appears to have a major effect on teat-end condition. Teat-end roughness is influenced by pre-milking udder preparation, timing of cups-on and by threshold settings for automatic cluster removal (35). These effects are exacerbated by high vacuum (16, 18), over-milking (34), use of liners with stiff mouthpieces or liners that are mounted at high tension (3).

The association between teat-end hyperkeratosis and mastitis is discussed in a companion paper (31). Those results provide the framework for our proposed international system for classifying teat-ends as follows.

1. For research studies, use the scoring method developed by Neijenhuis et al. (28).
2. For routine field evaluation, use the following simplified system.

- **No ring (N**) – a typical status for many teats soon after the start of lactation. This category includes teat-ends scored as HK0 in the UK or N in NL, and some teats scored as 1 in US.
- **Smooth or Slightly rough ring (S)** – a raised ring with no roughness or only mild roughness and no keratin fronds. This category includes teats classified as HK0 or 1 in UK, as 1A, 1B or 2A in NL, 1 in AU, and most teats scored as 2 in the US.
- **Rough (R)** – a raised roughened ring with isolated fronds of old keratin extending 1-3 mm from the orifice. This category indicates some breakdown in epithelial integrity. It includes teat-ends classed as HK2 or 3 in UK, 2B or 2C in NL, 2 in AU, or 3 in the US.
- **Very Rough (VR)** – a raised ring with rough fronds of old keratin extending >4 mm from the orifice. The rim of the ring is rough and cracked giving the teat-end a “flowered” appearance. This category includes teat-ends classified as HK4 or 5 in UK, 2D in NL, 3 in AU, or 4 in US.

The attached Powerpoint files show examples of teats in each of these categories, both as colored slides (slides 8 & 9, from ref. 28) and, for convenient use in the field, as B & W line drawings.

Examining Teats And Interpreting Results

- To simplify and streamline the procedure, teat condition should be evaluated immediately after the cluster is removed and before application of a teat disinfectant. However, if an observer wants or needs to assess skin changes in greater detail (see, for example, ref. 6), it will be necessary to evaluate teat skin condition just before milking.
- Exercise great care when approaching cows and handling teats – especially in herds where cows are not used to having their teats touched.
- Observe and record teats in a regular pattern.
- View the teats, initially, without handling.
- Dry the teat-end with a paper towel if milk residue or debris obscures the view of the orifice.
- View teats by gently grasping the teat above the teat-end. Observe the teat from side on and then from end on. Good lighting is essential. If lighting is poor, use a headlamp rather than a flashlight for hands-free evaluation. This is important for increased work safety.
- Score all teats of all cows in herds of up to 80 cows, or a random sample of at least 80 cows in herds with 80 - 400 cows, or at least 20% of cows in herds larger than 400 cows (see companion paper by Reinemann et al, 2001). To ensure confidence in the data, score a representative sample of cows from all feed groups and management groups.
- An automatic recording method, such as a dictaphone, enables a single observer to evaluate and record teats. If two people are present, one can observe teats while the other records data.

An example sheet for recording these data is appended.

How many cows?

Perhaps the most common weakness of teat evaluation procedures in commercial herds is that sample sizes are too small. Preliminary guidelines for the collection of statistically defensible data were published by LeMire et al. (20). One method for assessing and describing the teat condition status of a herd of cows is to measure the proportion of teats that have a particular condition classed as abnormal, eg., more than 20% of teats with rough teat-ends, or more than 20% of light-colored teats classed as reddened or blue-colored after milking. These and other statistical issues, such as the influence of herd size, are discussed in our companion paper (39).

Further investigations may be required if one or more of the following are observed:

Main short-term and medium-term effects (primarily associated with milking machine faults or poor milking management resulting in long periods of flow below 1 kg/min and/or overmilking)

- Color: more than 20% of cows with light-colored teats have one or more teats that are visibly reddened (congested) or tinged with blue (cyanotic).
- Swelling at or near the top of the teat: more than 20% of cows have one or more teats with marked swelling or palpable rings.
- Swelling and hardness at or near the teat-end: more than 20% of cows have one or more teats-ends classified as firm, hard or swollen, or severely wedged.
- Openness of teat orifice: more than 20% of cows have 1 or more teat orifices classed as open.
- Vascular damage: more than 10% of cows have petechiations on one or more light-coloured teats.

Main medium-term and longer-term effects (primarily associated with poor environment, management or chemical irritation, or cow factors such as teat shape, yield and genetics. These effects are exacerbated by machine milking, especially if poor milking management results in overmilking or prolonged milking at low milk flow rate. Faults in milking equipment are unlikely to be the primary causal factors if one or more of the short-term changes, as listed above, are not obvious)

- Teat skin condition: more than 5% of cows have open lesions (including chaps or cracks) on one or more teats.
- Teat-end hyperkeratosis: more than 20% of cows have one or more teats that are scored R or VR, or more than 10% that are scored VR.

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