Updated guidelines for the recording, evaluation, and genetic improvement of udder health in dairy cattle

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Abstract

Dairy cattle require healthy, functional udders to produce high-quality food for human consumption. Consumers also expect their food to be produced in a manner that safeguards animal health and welfare. Clinical and subclinical mastitis are the most frequent and costly diseases associated with dairy production, implying that effective mastitis control and improvement programs are very important. A successful recording scheme for udder health includes the collection of information on animals, such as veterinary diagnoses and other observations about udder health, as well as udder conformation, milking speed, and culling data. Additional data are generated through milk analysis, including findings from bacteriological examination of milk samples, udder health indicators like somatic cell count (SCC), electric conductivity, and milk mid-infrared spectral data. Farm-level data include bulk tank SCC and information about the environment in which the cow is housed and milked. The current Guidelines for Recording, Evaluation, and Genetic Improvement of Udder Health (Section 7.3 in the June 2016 edition of the ICAR Guidelines) include recommendations for collection and use of some, but not all, of this information. This report describes current best practices with regard to udder health that should be applied to dairy cattle populations for the improvement of health, welfare, and profitability, and will continue to evolve as the technology available for monitoring cow performance changes and more precise phenotypes become available for lower costs. The goal of providing dairy farmers with useful tools for making management and breeding decisions remains unchanged.

Keywords: clinical mastitis, recording guidelines, somatic cell count, udder health.

Introduction

A healthy udder is free from mastitis, an inflammatory response typically caused by microorganisms. Mastitis is the most costly disease of dairy cattle because of its high incidence and physiological effects on, e.g., milk production (Halasa *et al.*, 2007). Genetic selection for highly productive dairy cows has been very successful; however, udder health has declined in many breeds because of its unfavorable correlations with production (Ødegård *et al.*, 2003). Decreased udder health increases veterinary and health care costs, results in higher rates of involuntary culling, decreases revenue, and harms animal welfare. Accordingly, genetic selection for improved udder health is an important part of dairy cattle breeding programs (Schutz, 1994; Heringstad *et al.*, 2003).

Udder health phenotypes

Improvement schemes for udder health require recording of direct and/or indirect indicators of mastitis (ICAR, 2014). Subclinical mastitis is typically derived from individual somatic cell counts (SCC). Other indirect traits for recording mastitis include milkability (milking speed), electrical conductivity, and udder conformation traits (e.g., udder depth, fore udder attachment, teat length). The revised guidelines include recommendations for direct measurements of clinical mastitis, as well as several indirect indicators of clinical and subclinical mastitis (Table 1).

Clinical and subclinical mastitis

Mastitis is an inflammation of the mammary gland, typically caused by infectious microorganisms. Clinical mastitis results in altered milk composition, and often is accompanied by a painful, red, swollen udder (e.g., Bramley *et al.*, 1996). In subclinical infections there is no change in the appearance of the milk or udder but milk composition is altered. Subclinical mastitis is most commonly detected based on elevated SCC, but electrical conductivity of the milk, N-acetyl-ß-D-glucosaminidase (NAG-ase) enzyme levels, and cytokine levels are sometimes used, as well.

Table 1. Direct and indirect measures of udder health included in the revised guidelines.

Type	Measure[1]	Reference	Type	Measure	Reference
Direct	Clinical mastitis	Bramley *et al.* (1996)	Indirect	Changes in SCC patterns	De Haas *et al.* (2008)
	Subclinical mastitis	Bramley *et al.* (1996)		Differential SCC	Schwarz *et al.* (2011)
Indirect	SCC	Schukken *et al.* (2003)		Electrical conductivity	Norberg *et al.* (2004)
	Milkability	Sewalem *et al.* (2011)		Lactoferrin content	Soyeurt *et al.* (2012)
	Udder conformation	Nash *et al.*, (2002)		Pathogen-specific mastitis	Haugaard *et al.* (2012)

[1] The indirect measures listed in italics were added to the revised guidelines.

Bacteriological milk sample results

The use of pathogen specific mastitis information for genetic evaluation was analysed by Haugaard *et al.* (2012). Their study shows that mastitis caused by different pathogens can be considered as partly different traits. The availability for breeding purposes is a challenge as the findings are not always comparable across laboratories. The knowledge of pathogen specific mastitis is a valuable information especially for herd management and treatment.

Somatic cell count and related traits

Somatic cell count is an appropriate indicator of udder health for use in genetic improvement programs because:

1. SCC is routinely collected in most milk recording systems, providing accurate, complete, and standardized observations;
2. SCC shows genetic variation and has a moderate to high genetic correlation with clinical mastitis;
3. It reflects the incidence of subclinical intramammary infections. Somatic cells are present in milk in response to tissue damage and/or clinical and subclinical inflammations.

These cell numbers increase in milk as the cow's immune system works to repair damaged tissues and combat mastitis-causing microorganisms. As the degree of damage or the severity of infection increases, so does the level of white blood cells. Industry standards for bulk tank SCC are <400,000 in the EU and <750,000 in the United States (Norman *et al.*, 2011). Herds that can maintain a herd SCC <100,000 commonly have very low infection rates.

Changes in the pattern of test-day SCC may provide information about infection status that is not captured by a single value. de Haas *et al.* (2008) showed that it is possible to distinguish between environmental and contagious mastitis based on patterns of SCC change from one test day to another. "Low-high-low" patterns were indicative of environmental mastitis, while "low-high-high" patterns were symptomatic of contagious mastitis. The inclusion of several SCC traits in a selection objective is more effective in reducing liability to both clinical and subclinical mastitis than use of only SCC.

While SCC quantifies the total amount of leukocytes and epithelial cells present in a milk sample, it does not distinguish between different cell types. However, animals with higher leukocyte levels are more like to have infections of the mammary gland than animals with high concentrations of epithelial cells (e.g., Schwarz *et al.*, 2011). Research shows that while SCC and flow cytometric measurement of polymorphonuclear cells had similar sensitivity for detection of subclinical mastitis, flow cytometry had much greater specificity.

Milking speed

The amount of time cows spend in the milking parlor is of increasing importance, particularly as automated (robotic) milking systems continue to grow in popularity. While it was difficult to collect large datasets on milking speed in the past, those data are now routinely collected by milking systems and stored in on-farm computer systems. While several countries currently run genetic evaluations for milking speed, there is opportunity for considerable growth in the number of bulls evaluated now that data are more plentiful.

Electrical conductivity

The electrical conductivity of milk is measured routinely by most modern milking systems, and cows with mastitis produce milk with increased concentrations of Na+ and Cl-, which result in increased milk conductivity (Norberg *et al.*, 2004). Conductivity measurements at each milking can be compared to with previous measurements to identify changes that are consistent with subclinical mastitis. Real-time measurements are valuable because they permit more precise identification of infected animals than monthly milk testing.

Milk components predictable using mid-infrared spectroscopy

The increasing availability of instruments in milk testing laboratories equipped with mid-infrared spectroscopy modules (MIR) makes it likely that lactoferrin content and other milk components can be used to construct more accurate predictors of mastitis status from individual milk samples. Lactoferrin is an iron-binding glycoprotein secreted by mammary epithelial cells and naturally present in milk which is involved in host defense mechanisms and the inflammatory process (Soyeurt *et al.*, 2012), and milk lactoferrin and somatic cell score (SCS) correctly distinguished between mastitis and non-mastitis samples 92% to 95% of the time when used together. A number of other milk components that are linked to subclinical mastitis also can be predicted using MIR, including urea, lactose, and citrate (Pyörälä (2003); Soyeurt *et al.*, 2009; Brandt *et al.* (2010); Grelet *et al.*, 2016).

Uses of udder health data

Herd management

Optimized herd management is important for financially successful farming. Data on udder health can be described on an individual animal as well as a cohort basis to identify individuals that are performing above or below expectations. Summaries of the udder health of different age-group cohorts in the herd permit benchmarking of one farm against its contemporaries. This is important when milk pricing schemes include differential payment based on milk quality because high-SCC milk is of lower quality than low-SCC milk.

Monitoring population health

National monitoring programs may be developed to meet the demands of authorities, consumers, and producers. The latter may particularly benefit from increased consumer confidence in safe and responsible food production. For farmers, optimized health management in their herds has become crucial for improving sustainability and overall profitability of dairy production. A routine assessment of udder health will ensure that a complete picture of the health of the herd is available for monitoring cow health. Good udder health is also important for the reduction of use of antimicrobials in dairy cattle.

Genetic evaluation

Udder health data is also needed for genetic evaluations, both within country and across countries. Breeding values for udder health traits of marketed bulls should be published routinely. Countries using total merit indices (TMI) should consider including an udder health sub-index in their TMI. The udder health index itself could include estimated breeding values for both direct and indirect predictors of udder health. A combination information maximizes the accuracy of selection for resistance to clinical and subclinical mastitis.

Conclusion

The udder health guidelines will continue to evolve as the technology available for monitoring cow performance changes and more precise phenotypes become available for lower costs, while the overall goal of providing dairy farmers with useful tools for making management and breeding decisions remains unchanged.

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