

## DETECTING MASTITIS COW-SIDE

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The most important practical concern on mastitis is to prevent it happening. Assuming that there has been a failure to prevent invasion of the mammary gland by bacteria and an infection has occurred then it is prudent to know of this. What needs to be known, and when, becomes a matter of relative urgency, investment and purpose.

The milker and manager will want to know about udder health if it affects milk quality, especially when it affects bulk tank value, when it affects the performance of the cow, the parlor and the herd. They also need to know if there is a good chance that a response can restore the status quo. Usually there is only extreme urgency to know about grossly abnormal milk – the clinical case of mastitis. It may be useful to know of pre clinical conditions if bulk tank quality is affected and early detection can be profitable. There is usually little need to know immediately of low grade new infections. That information can be gathered in due course.

Clinical mastitis has become a relatively rare event. The incidence in developed dairy industries is probably 20-40 cases/ 100 cows/year depending on season and location. When milking cows twice daily for 305 days each lactation, that means a case every 6000-12000 quarter milkings or in a family herd of 65 cows one or two cases a month. There may be many more infections, measurements by bacteriology and cell count suggest at least twice as many infections occur as clinical mastitis cases result. Detection of the abnormal is then a matter of concentration on the job, methods, perhaps luck and certainly technique. It must also be influenced by the degree of change in the milk, the severity of the clinical signs, and so is also influenced by interpretation. The threshold has traditionally been when milk becomes significantly abnormal. It is becoming clear from field studies that identification of this varies greatly, especially with the incentive and commitment of the milker to take action. When herd emphasis, purchaser demand and legislative requirements are for quality, low bacterial content and few leukocytes, then mastitis has to be recognised speedily, action e.g. treatment, must be taken quickly, and the fact recorded. At the opposite extreme is the type of herd where, for the less severe mastitis cases, the usual response is not to intervene, Then concentration on detection is less and recording of mastitis less frequent. More mastitis occurs on farms where staff are interested in milk quality and are prepared to treat disease.

### Traditional Detection Methods

The time served methods rely on the quality of the milker and animal husbandry. These involve use of eyes, hands, ears, taste, smell and memory.

Memory	- knowing the cow's behavior and attitude in the milking parlor
Smell	- occasionally used to detect purulent odors
Taste	- many older milkers still taste milk, if suspicious, to determine if it is 'salty'

Ears	- used to assist when the cow is in discomfort or pain
Hands	- frequently used to assess pain, swelling and local temperature
Eyes	- first information about the cow, the udder and the normality of the milk, its color and integrity

The sensitivity of these methods varies with the skill of the milker and the severity of the case but have been reported in field studies to average as high as 80% at a single milking (Dodd *et al.*, 1969). Therefore, all cases should be detected if signs persist for 3 milkings. Increasingly the growth of herd size and the pressure for increased, and cost effective, performance has reduced the time that a milker spends with each cow. In many cases time is saved from less pre-milking attention, little udder preparation and no fore milking. Observation is often not easy in some parlor conformations, especially in parallel parlors or swing-over types, and when there is a high cow/milker ratio, a high milk production rate, often in rotary parlors.

### Simple Detection Aids

The first method available when milkers stopped milking into a bucket was provision of the strip cup to examine fore milk. This is probably the gold standard method as milk from each quarter of each cow can be examined. It takes effort and time. The need to save time led to introduction of in-line filters. These are useful if the milker bothers to look at them but are a hindsight source of information in direct-to-line milking parlors. The least immediate detection aids are the milk sock and the bulk tank analysis.

### Indirect Detection Aids

There are a variety of these aids. They vary in their sensitivity and specificity but often more importantly in the immediacy with which information is provided. Most are useful in supplying supportive data but are not suitable at the current stage of development of sensors for wholesale screening.

*Milk cell count* provides one of the most useful indicators of inflammation but measuring is a laboratory procedure at present. The less sensitive *California Mastitis Test* is a work horse cow-side method but not a primary test and it is time intensive for any form of routine use. *NAGase* (N-acetyl glucosaminidase) activity is related to inflammation and may be discriminatory between 'major' and 'minor' pathogens but it is not applicable at cow-side at present and basic determinatory parameters are lacking. Milk composition, especially *lactose* content is indicative of disturbed secretion but is not measurable cow-side at present. Various whey fraction proteins, especially acute phase proteins, change during the pathogenesis of mastitis and appear a sensitive indicator but they are not easily measurable cow-side (at present). The truly confirmatory test would be to detect *bacteria* or their products in milk cow-side. In principal this should be possible e.g. by use of detection antibodies but practice has made this difficult so far because of limits to sensitivity and time to complete the test. One test for Gram negative bacteria used to a limited extent has a predictive value of 70% (Waage *et al.*, 1994). At best it appears a secondary or confirmatory assay.

The most successful methods have been physical changes in milk measured by simple sensors. It is easy to measure *temperature*, *selected ions* or milk electrical *conductivity*. Tests to do this have been a regular feature of the mastitis literature for 60 years. Availability of practical systems has been more limited and is more recent. Devices are now available that give data in real time but they often give too much data and sensible information is difficult to discern.

### Cow-Side Testing in Real-Time

Early tests at cow-side in the 1940s were still indirect and used a rapid analysis of milk. The most useful was measurement of chloride ions until it was shown that directly measuring the electrical conductivity of milk was as accurate and as well correlated with milk cell count as concentration of any ion (Malcolm *et al.*, 1942).

The major problems with these systems were the speed of use, the number of samples that could be handled, and what to do with the absolute measurements obtained. The whole process was useful only as a scientific tool until the first forms of automation and electronics became available. Single numbers then became available for single milk samples. Converting these data into information has required many more developments. The principal advances have followed automatic collection of data and use of algorithms to produce information. The main problems have been in calculating useful data from continuous measuring and separating real events from the natural variance in the data. The effectiveness of any system is in the sensitivity and specificity with which the data describe an event.

In reality, there is little to choose in sensitivity between the traditional and the best automated systems for detecting clinical mastitis (Table 1). The specificity of detection varies with the definition of the event. This should be relatively easy for clinical mastitis. Visual inspection allows a specificity of 100%, there are clots or there are no clots. Yet the sensitivity is only 80% because errors in sampling and operation come into play. Other detection systems have to match these levels in performance. Practically they have to achieve these levels cost-effectively. The balance is in the comparison between staff effort for inspection of foremilk versus the cost of the system replacing that time.

### Current Automated Systems

Most sophisticated parlors installed in the last 5 years have electronic data collection and management systems. Very useful data can be obtained and it has been shown how valuable these systems may be in monitoring herd and management performance (Stewart *et al.*, 1999). All of the systems use milk electrical conductivity for various purposes. It is a tested method for yield and flow determination but has been less well accepted as an indicator of milk quality. Part of the problem is in the additional use of the primary signal. The main problems have been in the use of relative measurements and making convincing information of clear purpose available to the user. Some studies have been reported to start to remedy this problem (Milner *et al.*, 1997; Hillerton & Semmens, 1999).

Automated systems collect nearly continuous electrical conductivity data but unfortunately in parlor systems measurements are usually of whole udder milk thus the sensitivity of any happening

at the individual quarter is immediately reduced. Data are further reduced in accuracy by selection of one or a few values based on averages or peaks of signal often over a whole milking. The value obtained is then compared with historical data but usually over 10 previous milkings or days. This lead to a further loss of sensitivity from ignoring diurnal events. The historical time scale may rarely reflect the pathogenesis of infection.

Most systems also use other data. Milk temperature is frequently included and a rise greater than 0.5°C occurs in some 50% of cases of clinical mastitis. Yield is often used but a sufficient drop in whole udder yield may not be easily discernible against the background variance. Information is provided from use of algorithms comparing the data obtained with historical and possible herd averages. There are simple flaws in these systems, some inherent to parlor milking, and others from a lack of attention to physiology. Diurnal effects are usually ignored even though yield is very much affected by milking interval, and this may also occur even with 12-hour intervals. No account is taken of the pathogenesis of infection. The timing of events is important in the averaging period, too long a time reduces the sensitivity. Thresholds for changes have to be higher to cope, thus increasing the likelihood of false negative results. The main disadvantage is from measuring pooled milk.

Table 1 Comparison of performance between manual and automated cow-side tests.

	<u>% sensitivity</u>	<u>% specificity</u>	<u>Speed</u>	<u>Effort</u>
<u>Manual</u>				
Milk/cows inspection	80	100	immediate	30s/cow
CMT	80	?	immediate	30s/cow
NAGase	60	?	laboratory	minutes - hours
Conductivity hand held	- 70-100	95	immediate	30s/cow
Bacteriology-culture	70-80	~100	>18h	significant
Bacteriology Limulus	- 63	97	cow-side	?
Temperature milk	- 50	70	immediate	0
Yield - manual	20-40	low	immediate	0

*(continued)*

	<u>% sensitivity</u>	<u>% specificity</u>	<u>Speed</u>	<u>Effort</u>
<u>Automatic</u>				
Conductivity	70-80		immediate	0
Temperature	50	70	immediate	0
milk				
Yield	20-40	low	immediate	0
EC+temp+yield	85-90	95	immediate	0

There are at least two practical systems available using quarter milk electrical conductivity data and applying a better algorithm to the data could give useful information. A minimum of 80% predictivity for clinical mastitis has been achieved experimentally using an algorithm combining temperature and time of day production directly with a running average conductivity for the target quarter and a relative conductivity between quarters. Including animal activity also allows these algorithms to be applied to predict estrus and lameness. The important difference here is not in detecting clinical mastitis when disease is apparent but in identifying a pre clinical quarter.

### Automated Milking Systems

The most immediate need for application of mastitis detection and prediction systems, giving reliable information in real-time, is in the fully automated milking systems (robotic milking). These have no direct human supervision yet there is a statutory requirement to detect cows with clinical mastitis and to reject all abnormal milk. At present the attitude of regulatory bodies, and some milk buyers, is that systems should be absolute and detect abnormal milk with 100% sensitivity and 100% specificity. This is unrealistic given that the gold standard of human observation using fore milking only detects 80% of cases. The data available suggest that the better automated systems, using quarter sampling of milk electrical conductivity, milk temperature and production with the best algorithms, achieve at least the same accuracy that a human milker can manage. There is still scope for improvement and the most useful may be in prediction of clinical mastitis for which these systems already show benefit, and coupling of other cow-side tests to allow diagnosis of the infection.

### References

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