TREATMENT OF SUB-CLINICAL MASTITIS IN LACTATING COWS EVALUATION OF A NEW PROTOCOL CALLED "SIMULTANEOUS TREATMENT"

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SUMMARY

The efficacy of a cephalexin-based intramammary preparation was evaluated for treating sub-clinical mastitis (SCM) during lactation. Simultaneous treatment (ST) consists of treating simultaneously the clinical mastitis (CM) and quarter(s) affected with SCM.

Using a cow-level economic model, SCM treatment alone proved to be unprofitable whatever the stage of lactation. Conversely, with the same model, the ST protocol proved to be profitable during the first 6 months of lactation when the expected cure rate was 50% higher than the spontaneous cure rate. Its value was more limited with a lower cure rate. The efficacy of ST was investigated during two field trials in France. Cows with CM and SCM (detected by CMT) were included, then randomly assigned to two groups. In the control group (C), the treatment with 200 mg of cephalexin for 4 consecutive milkings was restricted to quarters with CM. In the ST group, the same treatment was applied to SCM and CM quarters.

In the first trial, the individual somatic cell count was significantly reduced in the ST group 2 months after treatment. In the second trial, the bacteriological cure rate for CM did not differ between C (63%) and ST (62%) groups whereas a statistically significant difference (p = 0.02) was observed between C (27%) and ST (63%) groups regarding the SCM bacteriological cure rate. The ST protocol should be considered as a tool for SCM treatment in lactating cows and a valuable procedure in mastitis control.

INTRODUCTION

Mastitis is a very costly disease of dairy herds (1, 11, 18). Over the last few decades, efforts have been directed towards improving treatment efficacy, owing to the high frequency of clinical mastitis (CM) and the demand for high quality milk. The management of sub-clinical mastitis (SCM) is driven by regulatory (only milk with less than 400,000 cells/ml can be delivered in
the EU) and economic constraints (milk sale price related to cell count and impaired milk production) (10). In addition, the mastitis treatment improves animal welfare (16).

Traditionally, the treatment of mastitis during lactation has been limited to its clinical form whereas the economic value of lactation therapy of SCM is generally considered to be limited because of low cure rates and the cost of milk discard during the treatment and withdrawal period (5, 6, 7, 36, 37). Except in certain instances e.g. herd blitz therapy for Streptococcus agalactiae infections (5, 19), SCM is usually treated at drying-off (22).

However, in cows exhibiting CM, some practitioners recommend identifying SCM in other quarters and treating simultaneously every infected quarter (10). Such a procedure, also called simultaneous treatment (ST), does not result in increased milk discards in comparison to the treatment of clinical mastitis alone as the withdrawal period for intramammary products is the same whatever the number of quarters treated. Consequently, the direct cost incurred is moderate, consisting of the expenditure on intramammary products. The ST protocol seems to be profitable on the premise that despite being low, the treatment cost will be outweighed by an increased chance of cure, and thus compensatory gains in milk production.

The aim of this communication is to present an evaluation of the potential of ST, shown in three studies:

- an economic study, based on a specific model;
- a first field trial to assess the efficacy of ST on the recuperation of somatic cell counts (SCC);
- a second field trial to assess the efficacy of ST in achieving bacteriological cure of SCM.

**MATERIALS AND METHODS**

**Economic study**

The simulation was designed to evaluate the economic impact of SCM and to describe the economic value of the ST protocol. Factors taken into account:

- potential milk production, estimated at 8000 kg per lactation;
- individual loss of production due to SCM estimated at 5% when somatic cell count (SCC) was 400,000 cells/ml, (17) and proportional to the amount of milk likely to be produced (26);
cost of milk discard due to SCM treatment during lactation estimated at 5-days milk production (2-days treatment + 3-days withdrawal time) * milk price (0.3 euro/litre); however, for SCM treatment using the ST protocol, no increased milk discard is implied, therefore cost is nil;

- treatment cost (ST protocol) estimated at 10 euros, including the cost for California Mastitis Test (CMT) and the cost of intramammary treatment in the SCM-quarter(s);

- additional cure rate (25 to 50%), defined as the difference between the bacteriological cure rate in SCM-quarters treated by the ST protocol and the spontaneous cure rate (24, 25, 35);

- margin or average profit per litre of extra milk produced in case of cure estimated at 0.2 euros, i.e. milk sale price (0.3 euro/litre) minus feed cost (0.1 euro/litre) for a dairy farm having not exceeded the milk quota;

- expected profit estimated by [additional cure rate * production loss * margin] – [cost of milk discard + cost of treatment]

**First field trial**

**Animal selection**

The first trial was conducted in 9 veterinary practices (North-West of France) in 1998.

Lactating cows in the first half of lactation, with CM present in one quarter and showing no systemic signs were selected and were tested for SCM on the other quarters using CMT. The animals were included provided they had at least one quarter with positive CMT (+ to ++++) (Table 1) in addition to CM.

**Table 1 California Mastitis Test scoring (27)**

<table>
<thead>
<tr>
<th>Score</th>
<th>Reaction</th>
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<tbody>
<tr>
<td>-</td>
<td>No precipitate</td>
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<tr>
<td>Traces</td>
<td>Slight precipitate</td>
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<tr>
<td>+</td>
<td>Distinct precipitate</td>
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<tr>
<td>++</td>
<td>Gel formation</td>
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<tr>
<td>+++</td>
<td>Thick gel</td>
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</table>
Treatment group and administration

Cows were randomly assigned to ST and C groups in each herd. Cows of both groups were treated by intramammary infusion of 200 mg of cephalaxin (Rilexine 200LC, Virbac) for 4 consecutive milkings in quarters with clinical mastitis, according to label recommendations. The same treatment regimen was given to the ST group for the treatment of the quarter(s) with SCM. The withdrawal period was 6 milkings from the last treatment. All cases that received any other antimicrobial treatment during the study period were excluded.

Milk sampling and examinations

Milk samples were taken on the day of inclusion (D0) from the 4 quarters of each cow included in the study. Samples were sent to the “Laboratoire interprofessionnel URIANE” (02260 La Capelle, France) for determination of quarter somatic cells counts (QSCC) by the fluoro-opto-electronic method.

Individual cow SCC were recorded for each cow by the Milk Recording Service on months M0 (occurrence of CM) and on the 2 following months (M1 and M2).

Interpretation of results and statistical analysis

The accuracy of CMT for the detection of sub clinical quarters was assessed comparing positive CMT and QSCC greater than 150,000 cells/ml. The cut-off point of 150,000 cells/ml lies in the recommended range of correlation of CMT with QSCC (3). The specificity of the CMT was defined as the proportion of CMT-positive quarters with a QSCC above 150,000 cells/ml. The positive predictive value of the CMT was defined as the proportion of quarters with a QSCC above 150,000 cells/ml in quarters CMT positive. SCC were compared between C and ST groups on monthly measurements (M0, M1 and M2) using log transformed data using a two-tailed t-test. For each cow, the milk production loss was also calculated from individual SCC on M0, M1 and M2 using a correspondence between SCC and milk loss (Table 2), allowing to estimate a mean milk loss per group for M0, M1 and M2.

Table 2  Estimation of the individual milk production loss according to the individual milk SCC (17)

<table>
<thead>
<tr>
<th>SCC (x1000 cells/ml)</th>
<th>0 to 75</th>
<th>75 to 150</th>
<th>150 to 300</th>
<th>300 to 600</th>
<th>600 to 1200</th>
<th>1200 to 2400</th>
<th>&gt;2400</th>
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<tbody>
<tr>
<td>Milk loss (%)</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
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</table>
Second field trial

The second trial was performed in the main French dairy farming areas in 6 veterinary practices (Aquitaine, Auvergne, Brittany and Champagne-Ardenne) from July 1999 to December 2000.

Animal selection

The criteria were identical to those defined in the first trial.

Treatment group and administration

The design was identical to that of the first trial.

Milk sampling and examinations

Single milk samples were taken from quarters with CM and SCM on the day of inclusion (D0) and 2 weeks later (D14) (FDA-Center of Veterinary Medicine - Guideline N°49, 1996). Samples were immediately frozen at -20°C and submitted to the Laboratoire de “Développement et d'Analyses des Côtes d'Armor” (LDA 22, Ploufragan, France) for bacteriology according to NMC recommendations. Organisms were identified using standard laboratory techniques and API system (BioMérieux SA, France).

Interpretation of results and statistical analysis

Contaminated samples i.e. isolation of 3 or more pathogens, were excluded from analysis. Culture-negative samples on D0 and pathogens with a missing culture result on D0 or D14 were excluded as well. When 2 organisms were isolated from the same milk sample on D0, each organism was assessed separately for bacteriological cure or treatment failure on D14. Bacteriological cure rate was defined as the isolation of the pathogen on D0 and negative culture on D14.

Failure was defined as the isolation of the same pathogen on D0 and D14. Bacteriological cure rates were calculated separately for CM and SCM and compared between control and ST groups using the chi-square test.

In both studies, two-tailed statistical tests were applied and p<0.05 was considered as significant.
RESULTS

Economic model

The results of the simulation are presented in Table 3 and Figure 1. In the absence of CM treatment, the treatment of SCM implied higher costs than foreseeable profits. Conversely, the model showed that the ST protocol generated profits up to 30 euros per treated cow when implemented during the first 3 and 6 months of lactation with additional cure rates (difference between bacteriological cure rate in SCM-quarters treated by ST protocol and spontaneous cure rate) of 25% and 50% respectively.

Figure 1  Comparison of expected profits or losses due to subclinical mastitis treatment (SMC) in case of SMC alone or in case of Simultaneous Treatment (with two levels of expected cure rate: 25% and 50%)
Table 3  Estimates of the economic costs and expected gains due to subclinical mastitis (SCM) and its treatment during lactation. Treatment of SCM is considered alone and as part of simultaneous treatment for bacteriological cure rate of 25 or 50 % higher than self-cure. Financial calculations are made at different lactation stages.

<table>
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<tr>
<th>Days in milk</th>
<th>Theoretical milk production(a)</th>
<th>Production loss(b)</th>
<th>Theoretical daily production</th>
<th>Treatment cost(c)</th>
<th>Treatment of one SCM-quarter alone</th>
<th>Treatment of one SCM-quarter by ST</th>
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<tbody>
<tr>
<td></td>
<td>Cost of milk discard(d)</td>
<td>Expected gain(e)</td>
<td>Cost of milk discard(d)</td>
<td>Expected gain(e)</td>
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</table>

(a) Theoretical milk production (litre): remaining to be produced at the time of SCM identification and treatment

(b) Production loss (litre) = 5% * Theoretical milk production

(c) Cost of treatment (Euro) = cost of California Mastitis Test + cost of intramammary treatment

(d) Cost of milk discard (Euro) = 5-day milk production * milk sale price (0.3 Euro/litre)

(e) Expected gain = (Additional cure rate * Production loss * margin[0.2€]) – cost (milk discard + treatment)
First field trial

In total, 42 cows with CM were included, 20 and 22 cows respectively in the C group and the ST group. CMT was positive in 57 quarters (Table 4). The sensitivity and specificity of CMT were respectively 0.73 (45/62) and 0.74 (34/46). The positive and negative predictive values of CMT were respectively equal to 0.79 (45/57) and 0.67 (34/51).

Table 4 Distribution of 108 udder quarters without CM according to CMT reading and QSCC level

<table>
<thead>
<tr>
<th></th>
<th>QSCC &gt;150,000 cells/ml</th>
<th>QSCC &lt;150,000 cells/ml</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive CMT</td>
<td>45</td>
<td>12</td>
<td>57</td>
</tr>
<tr>
<td>Negative CMT</td>
<td>17</td>
<td>34</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>46</td>
<td>108</td>
</tr>
</tbody>
</table>

The geometric mean SCC was high in both groups on M0 then decreased from M0 to M2. The geometric mean SCC on M2 was significantly lower in ST group than in C group (Figure 2).

Figure 2 Evolution in the control and the ST groups of the geometric mean SCC (x 1000 cell/ml) from the month of the clinical mastitis (M0) and during the following months (M1 & M2)

Using the model presented in Table 2 and the SCC results, the estimated average milk loss decreased from 6.6% on M0 to 2.9% on M2 in ST group, corresponding to an estimated milk gain of 3.7% between M0 and M2. In C group the estimated average milk loss decreased from 6.9% on M0 to 5.7% on M2, corresponding to an estimated milk gain of 1.2% between M0 and M2. Thus, the estimated difference of milk gain between ST and C groups
was 3.7% - 1.2% = 2.5% on the 2-month period following treatment (Table 5, Figure 3).

**Figure 3   Evolution of the estimated milk loss in both groups**

![Graph showing milk loss estimation in Control group and ST group](image)

**Second field trial**

Eighty-five cows examined for CM were included, providing 88 quarters with CM and 113 quarters with SCM. Eighteen cows were subsequently excluded due to failure to comply with the treatment protocol of the clinical mastitis (animals receiving any other treatment). Many quarters were excluded from the analysis of cure rates (32 and 52 quarters with CM and SCM respectively) because of negative culture on D0 or sample contamination on D0 or D14. Finally, the bacteriological cure rate was calculated for 42 and 45 pathogens isolated from CM and SCM-quarters.

The pathogen distribution on D0 is presented in Table 6 and Figure 4. Negative culture rates for SCM and CM were similar (32 and 28% respectively). The relative importance of *Staphylococcus aureus*, coagulase-negative Staphylococci (CNS) and *Streptococci* (*Streptococcus uberis* + *Streptococcus dysgalactiae* + others) can be observed in SCM quarters. In CM quarters, the main pathogens isolated are *S. aureus*, *Str. uberis*, *Str. dysgalactiae*, *Escherichia coli* and CNS.
Table 5  Distribution of SCC and evaluation of economic loss

<table>
<thead>
<tr>
<th>Month</th>
<th>SCC</th>
<th>Number of cows for each class level of SCC</th>
<th>Mean loss per cow (*)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>0 to 75</td>
<td>75 to 150</td>
</tr>
<tr>
<td>Control</td>
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<tr>
<td>M0</td>
<td>604</td>
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<td>3</td>
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<tr>
<td>M1</td>
<td>631</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>M2</td>
<td>361</td>
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<td>Simultaneous Treatment</td>
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<tr>
<td>M0</td>
<td>535</td>
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<tr>
<td>M1</td>
<td>338</td>
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<tr>
<td>M2</td>
<td>118</td>
<td>6</td>
<td>3</td>
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</table>

SCC: geometric mean (x1000 cells/ml)

(*) Loss calculated using the formula presented in Table 2
Bacteriological cure rates for CM did not differ significantly between groups C (63%) and ST (62%) (Table 7). For SCM, a statistically significant difference was found between groups C (27%) and ST (63%) (P=0.02).

Table 7  Bacteriological cure rates in clinical (CM) and sub-clinical mastitis (SCM) 2 weeks after treatment with an intramammary preparation containing cephalaxin

<table>
<thead>
<tr>
<th>Infection type</th>
<th>Group</th>
<th>Cure number</th>
<th>Failure number</th>
<th>Cure rate</th>
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<td>C</td>
<td>11</td>
<td>7</td>
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<td>ST</td>
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</tbody>
</table>

SCM-quarters received the same treatment as CM-quarters in simultaneous treatment (ST) group but were untreated in the Control (C) group. Failure means isolation of the same pathogen on D0 and D14. Cure means isolation of the pathogen on D0 and sterile culture on D14.
<table>
<thead>
<tr>
<th>Group</th>
<th>Number of quarters</th>
<th>Negative culture</th>
<th>1 pathogen</th>
<th>2 pathogens</th>
<th>Cont(*)</th>
<th>S. aureus</th>
<th>Strep</th>
<th>E. coli or enterobact.</th>
<th>CNS</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical mastitis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>36</td>
<td>11</td>
<td>20</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>11</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ST</td>
<td>52</td>
<td>14</td>
<td>27</td>
<td>2</td>
<td>9</td>
<td>7</td>
<td>14</td>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sub-clinical mastitis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>47</td>
<td>17</td>
<td>23</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>ST</td>
<td>66</td>
<td>20</td>
<td>33</td>
<td>4</td>
<td>9</td>
<td>10</td>
<td>14</td>
<td>0</td>
<td>15</td>
<td>2</td>
</tr>
</tbody>
</table>

(*) Contaminated samples: 3 or more pathogens

*Strep*: Streptococci  
*Enterobact*: Enterobacteriaceae  
*CNS*: coagulase negative Staphylococci
DISCUSSION

Economic model

The simulation showed the lack of economic value in treating SCM alone mainly because of the cost of non-marketable milk. In contrast, the potential profitability of the ST protocol was marked for the first 3 months of lactation for lower cure rates (25%) and during the first two thirds of lactation for higher cure rates (50% above spontaneous cure rate). Nevertheless, the limits of the simulation must be taken into account when assessing these results. The benefits expected from a mastitis control programme reportedly vary from 1 to 10 depending on the model used (28).

Underestimation of the benefit of the ST (and also of the treatment of one SCM quarter alone) may have been made. In our model, the value of ST protocol is assessed using hypotheses defined at the cow level, i.e. bacteriological cure and stage of lactation at the time of treatment for a given level of production, without consideration for herd effects. In particular, no allowance is made for the beneficial impact of decreasing the reservoir of infection and the lower risk of spread of infection. At a herd level, elimination of sub-clinical infections may also result in a decrease of bulk milk tank somatic cells count (BMSCC) and improvement of milk value through premium milk quality, which is not investigated in the present simulation. In addition, the financial loss due to the loss of milk is estimated in our model at only 0.2 euros/litre, on the presumption that lower producing animals will eat less (the loss is the difference between the milk price, 0.3 euro/l and the estimated price of feed, 0.1 euro/l). This hypothesis is rarely taken into account in other studies.

Overestimation of the benefit of the ST may have come from the possible re-infection of cured quarters, the lower milk price in dairy farms exceeding their quota and the unnecessary treatment of uninfected but CMT-positive quarters.

A more efficient model would need more available information concerning elements such as the effects of ST on the dynamics of infection, new infections rates and variable expected cure rate according to the lactation stage.

Use of the CMT for ST implementation

The four quarters of a cow can be considered as independent with regard to leucocytosis (31, 32), although this independence has been questioned (12, 15, 30). Moreover, the CMT is a valuable tool for a semi-quantitative evaluation of milk cell concentration and a good indicator of inflammation (2, 3, 13, 14); its use in the detection of sub-clinical infections is thus justified.
In study 1, accuracy of the CMT in field conditions to detect SCM (using a QSCC cut-off point of 150,000 cells/ml to discriminate uninfected and infected quarters) was confirmed by satisfactory positive and negative predictive values.

**Individual somatic cells counts and estimation of production losses (study 1)**

The efficacy of simultaneous treatment in study 1 was assessed from significant decrease of SCC in ST group during the 2-months period following the treatment. An estimation of milk production gain between ST and C groups on this period was 2.5%, thus consistent with the economic model. An individual loss of 5% and additional cure rate of 50% lead to an estimated mean gain of 2.5% following ST.

**Bacteriological culture results (study 2)**

In our study, 30% of culture results were negative. This result is comparable to those reported from studies conducted in similar conditions (8, 9), although it is higher than that reported by others (11 to 13% depending on the stage of lactation) where only quarters with CMT score higher than + had been sampled (2). However, this rate is lower than the one reported by Sol et al. (more than 60%) who analyzed frozen milk samples with SCC higher than 400,000 cells/ml (34).

Moreover, various studies have shown that handling frozen milk decreased the frequency of isolation of Enterobacteriacea and Arcanobacterium pyogenes. But, other studies have noted the increase for coagulase negative Staphylococci and S. aureus (34) or the lack of effect on the frequency of isolation of Streptococci and S. aureus (29). In our study, all samples were frozen, allowing the comparison of bacteriology results between the control and the ST groups. A comparison of our results with those of previous studies must take into account the variations in the study design, in particular the absence of freezing.

For CM, the frequency of isolated pathogens on D0 was similar in the two groups and the bacteriological cure rates were not significantly different. This was to be expected, as the treatments were identical.

Conversely, the ST approach to SCM resulted in a 63% bacteriological cure, significantly higher than spontaneous clinical cure in the control group (27%). This difference of 36% between the spontaneous cure rate and the ST groups lies between the two reference values (25% and 50%) used in the economic model. This result validates the selected parameters and the conclusions subsequently drawn. To have more information to validate the economic model it should be interesting, in a further study, to perform bacteriological analysis at the end of lactation in order to evaluate the new infection rate in both groups (C and ST).
In our study, the spontaneous cure rate (27%) is consistent with those reported by others, ranging from 15 to nearly 25% if all pathogens are taken into account (24, 25, 35). Values are lower (15 to 18%) for infections due to *S. aureus* than for infections due to coagulase negative Staphylococci (34%) (24).

Bacteriological cure rates of treatment of SCM during lactation vary according to a number of factors including causative pathogen, duration of infection, number and location of the infected quarters, parity and lactation stage (4, 6, 7, 10, 20, 23, 33). High bacteriological cure rates (>75%) are obtained for *Streptococcus agalactiae* infections after intramammary treatment in lactation, whereas spontaneous cure is unusual (about 25%) (6, 7, 36). In contrast, cattle with SCM caused by *S. aureus* have cure rates ranging from 3% to 25 - 35%, the higher cure rate being observed for recent infections (70%, < 2 weeks) compared to longer standing infections (35%, > 4 weeks) (20). The lactation stage is an important parameter, especially for *S. aureus* infections. Sol et al. (33) reported lower cure rates in cows treated in early or mid-lactation than in late lactation.

In our study, the benefit of ST approach was evaluated in lactating cows during the first 5 months of lactation regardless of the type of pathogen involved. These remarks underline the fact that the ST approach cannot be regarded as a universal measure but as an additional tool for farmers to control sub-clinical infections whose implementation must be adapted by the practitioner to the specific situation of each herd (level of production, causative pathogen, fulfillment of quotas, etc.).

**CONCLUSION**

Under given conditions, the ST protocol has proven to be profitable and efficient in the reduction of SCC, in the bacteriological cure of SCM and can be a valuable tool as part of a mastitis control program.

The ST is a tool that each veterinarian may use when farmers call him. It also can be achieved by the farmers, provided they are trained to recognize CMT and use intramammary preparations prescribed by the veterinarian for the herd and which effectiveness has been proven in such conditions. Further work is needed to assess the efficacy of the ST protocol in reducing the incidence of new intramammary infections and its impact on the BMSCC level.
REFERENCES


PRACTICAL USE OF ORBESSEAL®

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Institute for Animal Health, Compton, Newbury, Berks RG20 7NN

SUMMARY

Recent studies on dry cow treatment (DCT) showed that comparable benefits to those achieved in the original development trials are still likely in preventing new intramammary infection (IMI) in the dry period. The inert teat seal, OrbeSeal, gave comparable results to DCT in cows uninfected at dry off. Combination of DCT and OrbeSeal resulted in further significant reduction in the rate of new IMI, in three studies reported from three continents. The effectiveness of OrbeSeal appeared to continue for an undetermined time when the dry period was extended. Selection of the dry period treatment strategy to be used for any one cow requires knowledge of its infection status at dry off. This and the cost of the treatments will affect the cost-benefit of any programme.

INTRODUCTION

The Five-point Mastitis Control plan, that bastion of good practice that has served the dairy industry so well for more than 30 years, encourages the use of dry cow treatment (DCT) on all cows that will remain in the herd after the next calving (6). A variety of antimicrobial preparations is available offering broad spectrum effect and, for some, longevity for most of the target 56-day dry period. The established effectiveness from a series of trials over many years is to reduce the rate of new intramammary infections (IMI) by two-thirds and to eliminate more than 60% of existing infections (8). The major objection to DCT comes from protests about use of prophylactic antibiotic in uninfected animals in the food chain. Until accurate prediction of susceptibility to infection is available then this supposed overuse cannot be overcome without significantly compromising the welfare of dry cows.

Alternative strategies may be used other than blanket-use of DCT. However, selective use of DCT should be at the cow level and not the quarter level (5). Other antibiotic treatment, parenteral or immediately pre-partum, requires either greater loads of antibiotic or significant additional cost in determining the status of animals for selective treatment.

A traditional approach to protecting dry cows from summer mastitis was to use an external teat barrier. Stockholm tar and colloidon films work only partly in this way and can only be of temporary benefit. Other external seals may reduce new dry period infections, but require frequent replacement (14).
For years the use of the inert internal seal created by intramammary bismuth subnitrate was ignored in the UK, but reformulation has provided a suitable protection against new infection (12). This product appears to satisfy those objecting to prophylactic antibiotic use and so meets many of the needs of the organic dairy sector. However, farmer use of products is usually not restricted to following simple instructions and a report on various ways in which the user could apply OrbeSeal appears warranted.

**OrbeSeal and prevention of new dry period infection**

The efficacy of DCT determined recently (2) remains comparable with the original experimental data from Smith *et al.* (13), see Table 1. Field trials in various countries produced a range of efficacy levels encompassing these results (8).

Trial data (Tables 1 and 2) have shown that OrbeSeal is comparable with leading dry cow antibiotics in the prevention of new IMI in the dry period. In a simply preventive role the advantages over no dry cow antibiotic are clear.

**Table 1** Percentage of quarters with a new IMI in the dry period as determined at calving. Different symbols within a row indicate a statistically significant difference.

<table>
<thead>
<tr>
<th>Study</th>
<th>Dry period prophylaxis</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>DCT</td>
<td>OrbeSeal</td>
<td>DCT + OrbeSeal</td>
</tr>
<tr>
<td>Berry &amp; Hillerton (2002a)</td>
<td>13.4†</td>
<td>4.5*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Smith <em>et al.</em> (1967)</td>
<td>9.5†</td>
<td>3.3*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Huxley <em>et al.</em> (2002)</td>
<td>-</td>
<td>15.4†</td>
<td>11.1*</td>
<td>-</td>
</tr>
<tr>
<td>Berry &amp; Hillerton (2002b)</td>
<td>11.6†</td>
<td>-</td>
<td>3.4*</td>
<td>-</td>
</tr>
<tr>
<td>Woolford <em>et al.</em> (1998)</td>
<td>13.1†</td>
<td>2.3*</td>
<td>2.4*</td>
<td>1.6*</td>
</tr>
<tr>
<td>Gooden <em>et al.</em> (2003)</td>
<td>-</td>
<td>21.1†</td>
<td>-</td>
<td>17.5*</td>
</tr>
</tbody>
</table>

Different levels of new IMI between trials reflect different methods of estimating infection. Smith *et al.* (13), Woolford *et al.* (15) and Berry and Hillerton (2, 3) all used the IDF method and so their data are comparable.
Table 2  Percentage of quarters with clinical mastitis in early lactation. Different symbols within a row indicates a statistically significant difference.

<table>
<thead>
<tr>
<th>Study</th>
<th>Dry period prophylaxis</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>DCT</td>
<td>OrbeSeal</td>
<td>OrbeSeal + DCT</td>
</tr>
<tr>
<td>Berry &amp; Hillerton (2002a)</td>
<td>6.7†</td>
<td>2.7*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Huxley et al (2002)</td>
<td>-</td>
<td>3.6*</td>
<td>3.2*</td>
<td>-</td>
</tr>
<tr>
<td>Berry &amp; Hillerton (2002b)</td>
<td>6.6†</td>
<td>-</td>
<td>1.9*</td>
<td>-</td>
</tr>
<tr>
<td>Woolford et al (1998)</td>
<td>4.2†</td>
<td>1.9*</td>
<td>1.2*</td>
<td>2.2†</td>
</tr>
<tr>
<td>Gooden et al (2003)</td>
<td>-</td>
<td>8.0†</td>
<td>-</td>
<td>5.9*</td>
</tr>
</tbody>
</table>

Comparable benefits of limiting new IMI in the dry period from use of DCT or OrbeSeal extend to preventing clinical mastitis in early lactation, shown in all studies (Table 2) although the length of the lactating period studied varied from 60 to 100 DIM.

DCT and OrbeSeal are comparable in price such that cost-benefit analysis shows either is financially beneficial in control of new IMI in the uninfected cow (4). The only economically viable option for an infected cow is DCT, whatever the cause of the infection. A practical drying-off strategy requires knowledge of the infection status of the udder.

**Combined use of OrbeSeal and DCT**

*New Zealand study and US studies*

The original New Zealand study (15) found that all dry cow treatment methods, OrbeSeal alone, DCT alone or a combination of the two, in a within-udder trial, were substantially better than no treatment, but could not distinguish any significant difference between them in prevention of new IMI (Table 1). Benefits occurred in limiting early lactation, clinical mastitis too, but results were equivocal between treatments (Table 2).

In the US, Godden *et al.* (7) compared the rate of new dry period infection in a within-udder study where all teats received Orbenin DC and two quarters per udder were additionally infused with OrbeSeal. The OrbeSeal was the same preparation as marketed in the UK whilst the DCT contains only 500
mg cloxacillin (benzathine salt), the product having only a 28 days with-hold period. The results suggest that fewer new dry period infections occurred in quarters receiving the combination treatment (Tables 1 and 2). The protection extended to clinical mastitis for the first 60 days post-calving.

The US data show relatively high infection rates [21% for DCT] compared with previous studies on (Table 1). They did not use the International Dairy Federation method of estimating infection (11) and the dry period was 28 to 100 days, mostly in excess of the protective period for the DCT.

**UK study**

Field information suggests that the combined use of DCT and OrbeSeal is not uncommon in the UK. Preliminary data follow from an in-house study of the relative effects of treating uninfected cows in the herd at the Institute for Animal Health over 15 months.

Uninfected cows were used, identified by two samples, 7 days prior to dry off and at dry off. Cows were allocated at random to be infused in all 4 quarters with Cepravin DC alone or Cepravin DC and then OrbeSeal using a proper aseptic technique. The rate of new infection was determined from quarter milk samples taken at the first milking after calving and again within 7 days of calving. A confirmatory sample was taken within 7 days if results were inconsistent. Bacteriology was according to the International Dairy Federation method (10).

<table>
<thead>
<tr>
<th>No. quarters at calving</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DCT</td>
</tr>
<tr>
<td>Uninfected</td>
<td>351</td>
</tr>
<tr>
<td>Infected (%), diff p=0.001</td>
<td>22 (6.3)</td>
</tr>
<tr>
<td>Total</td>
<td>373</td>
</tr>
</tbody>
</table>

The combined treatment significantly reduced the rate of new infection identified at calving compared to use of DCT alone (Table 3). As the first sample was taken at the first milking, then the probability of a true dry period infection is more certain than when samples are taken sometime in the first 3 days post-calving as in the US study and others.

The dry cow product alone controlled new IMI to a level highly comparable with earlier experiences (Table 1; 8). Adding OrbeSeal enhanced that protection.
This was a trial under commercial circumstances that used all eligible cows in the herd over more than one year. The length of the dry period should be approximately 8 weeks, but a number of cows had an extended dry period. The efficacy of the DCT varied with the length of dry period (Table 4). The results confirmed that the DCT, which has a withhold period of 54 days, performed entirely to specification. A much higher rate of new IMI was found in quarters receiving DCT alone when the dry period exceeded 10 weeks. However, the prevention of infection when OrbeSeal was used in combination with DCT continued virtually unchanged (Table 4). It appears that the efficacy of the teat seal is durable.

Table 4  Percentage of quarters with a new infection at calving, with respect to length of dry period

<table>
<thead>
<tr>
<th>Length of dry period</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DCT</td>
</tr>
<tr>
<td>Less than 10 weeks</td>
<td>4.9</td>
</tr>
<tr>
<td>10 weeks or more</td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>DCT + OrbeSeal</td>
</tr>
<tr>
<td>Less than 10 weeks</td>
<td>1.4</td>
</tr>
<tr>
<td>10 weeks or more</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Practical use of OrbeSeal

The benefits of any dry period protection against new intramammary infections are a combination of the level of prevention of infection and the cost or effort in achieving infection control.

It is essential to know the infection status of the udder at drying off. Individual cow cell counts are a guide, but may not be sufficiently accurate (1). Quarter information from CMT, cell count or some other diagnostic, including access to udder health records, is essential if no DCT or OrbeSeal alone is to be used. OrbeSeal alone in the uninfected udder gives overwhelming benefits, in disease control and economic justification, over no treatment. It is comparable with use of DCT and should be recommended where use of DCT is not desired.

The effects and benefits of OrbeSeal continue as the dry period extends, but must have a finite limit. If no accurate calving prediction is available then the best protection comes from a combined use of DCT and OrbeSeal. No economic advantage in combination use is likely under normal circumstances unless the value of the cow is high, the animal will suffer a high level of exposure to new infection e.g. on straw beds in winter, or previous experience shows that dry cow management is poor and a high rate of infection and clinical mastitis is likely post-partum.

Selection between DCT alone, OrbeSeal alone or a combination of DCT and OrbeSeal to protect dry cows requires sufficient knowledge of udder health at dry off, mastitis risk, dry period management capability and the predicted
calving date. All risks and management needs can be covered by one of these strategies to protect the dry cow effectively and viably. Omitting dry cow protection is not an option in managing milk quality and protecting animal welfare.

REFERENCES


THE CONTROL OF MASTITIS ON ORGANIC UNITS

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\textsuperscript{2} School of Clinical Veterinary Science, University of Bristol, Langford House, Langford, Bristol, BS40 5DT

SUMMARY

While organic herds demonstrate some differences in mastitis epidemiology to that generally seen on conventional units, once the reasons for these differences are understood, then usually the same control principles are applicable whatever the system of management - relying on sound management and husbandry techniques. In the author’s experience very good results are achievable in the control of both clinical and sub-clinical mastitis if such techniques are employed.

INTRODUCTION

The epidemiology of mastitis on organic units is recognised to differ from conventional units. For this reason it is important to take account of the peculiarities of mastitis aetiology on organic units in order to develop suitable and effective control measures, thus minimising both welfare and production costs. As always these measures need to focus on the two precepts of disease control, namely reducing the level of challenge by potential pathogens and enhancing the host’s immunity.

EPIDEMIOLOGY OF MASTITIS ON ORGANIC UNITS

UK data describing the aetiology of mastitis on organic units are lacking. Comparison between organic and conventional farms using data from a Danish organic survey (26) suggested a possible increase in the prevalence of contagious pathogens and a reduction in the level of environmental organisms particularly \textit{Escherichia coli}. This observation of higher levels of contagious mastitis on organic units was further supported on analysis of levels of sub-clinical mastitis. Hovi and Roderick (14) found that overall bulk milk and mean individual somatic cell counts were significantly higher on organic farms compared to conventional herds. This finding was also reported by Weller and Cooper (28), who found an increase in mean BMSCC on farms that were in the process of, or had recently converted to, organic production.
Pathogen prevalence and aetiology

We investigated the prevalence of mastitis-causing bacterial pathogens during the dry period by assessing the bacteriological status of quarters at drying off, 2 weeks pre-calving and at calving. All clinical mastitis cases in the subsequent first 100 days of calving were sampled.

The data on the prevalence of pathogens at drying off needs to be interpreted with care, as for some cows this was the end of their first lactation under organic regulations. Intuitively, it would seem likely that a more accurate representation of pathogen prevalence on organic units would require the cows to be managed to the standards for a longer period of time. Despite this a relatively high rate of infection by coagulase positive Staphylococci (9.3% of quarters infected) and low rates by Streptococcus uberis (0.5%) and Enterobacteriaceae (0.2%) indicate a predominance of contagious over environmental pathogens. This supports the work by Vaarst (26), suggesting that this is a pattern seen on organic units.

The prevalence of the Enterobacteriaceae significantly increased prior to the onset of colostrogenesis, and the relatively high contribution of these infections (42%) to new intramammary infection (IMI) at calving is interesting as it supports the work of Bradley and Green (6) on Enterobacterial infection during the dry period. A significant rise of S. uberis during the dry period from 0.5% of quarters infected at drying off to 6.4% at calving was also demonstrated. This is in marked contrast to the work of Bradley (5) on conventional farms using blanket antibiotic dry cow therapy, where a rise of only 0.35% in the number of quarters infected with S. uberis during the dry period was found. This supports the work of Berry (2) that found that DCT significantly decreased the rate of new IMI by S. uberis.

Analysis of the relative contribution of early and late dry period infection to new IMI at calving, suggested that the late dry period was the critical point for the acquisition of infection with 75% of infections identified at calving occurring within the last 2 weeks of the dry period.

Clinical Mastitis

Our preliminary results identified a marked difference in the pathogens isolated from the clinical cases between the dry and lactating period. S. uberis was isolated from 42.8% of dry period cases but from only 20.7% of cases occurring in lactation, whereas Enterobacterial organisms were isolated from only 4.8% of dry period cases, but 20.7% of cases in lactation. There was little difference between the incidence of coagulase positive Staphyloccocal spp. during the dry period (4.8%) and lactation (6.1%).

The relatively low level of dry period clinical mastitis caused by the Enterobacteriaceae, 5% of dry period cases despite Enterobacteriaceae causing 23% of all new major pathogen IMI at calving, would continue to
support the accepted theory (23) that the dry gland is relatively resistant to Enterobacterial proliferation.

Hovi and Roderick (13) also compared the temporal distribution of clinical mastitis between organic and conventional herds. They found that mastitis was significantly more common amongst organic cows during the first week of lactation and during the dry period. These findings are supported by our work investigating mastitis aetiology on organic units. As clinical mastitis during lactation was only determined for the first 100 days, it is impossible to compare the relative incidence of dry period to total amount of clinical mastitis in the lactation. However, 34% of cases occurred during the dry period as compared to 66% in the first 100 days of lactation - this level of clinical mastitis within the dry period is higher than would be expected on conventional units, where an average incidence of between 3.6-4.2% of cases has been reported (11). This result supports the conclusions of previous authors (3, 23) that new IMI rate and clinical mastitis rate are dramatically increased in the absence of antibiotic DCT.

The distribution of mastitis cases in the first 100 days is similar to that reported by Hovi and Roderick (14). Some 63.0% of all mastitis cases occurring in the first 100 days of lactation occurring within the first 10 days of lactation. The authors also investigated the relationship between new dry period IMI identified at calving, and clinical mastitis occurring within the first 100 days of lactation. Approximately 60% of coagulase positive Staphylococcal and Coliform infections and 75% of S. uberis infections occurring in the first 100 days of lactation appeared to be derived from a dry period infection. It should be noted that, as no specific DNA typing was performed, these figures could be distorted by cure and subsequent re-infection, however the very tight clustering of cases immediately after calving would tend to mitigate against this.

These findings support the work performed into the significance of new Enterobacterial and Gram-positive IMI during the dry period, in relation to clinical mastitis during lactation by both US (21, 22, 25) and UK researchers (6).

Conclusions

The primary conclusions that can be drawn from the above epidemiological investigations are firstly, that control of infection within the dry period, and in particular during the period of colostrogenesis, is absolutely critical to the overall control of mastitis in the herd; and secondly, infection caused by contagious pathogens is far more common on organic units. Given that the principle difference between the management of organic and conventional cows in relation to mastitis control is the general prohibition of prophylactic antibiotic DCT on organic units, these results are perhaps not surprising.
The principles that govern the control of both dry period infection and contagious mastitis are equally applicable in the most part to both conventional and organic units and have been reviewed in many previous publications. Consequently there is little value in discussing such areas within the context of this paper. The remainder of this discussion, therefore, covers preliminary data from new research and development, or management tools that the authors feel are particularly relevant in the organic context.

**Factors affecting the acquisition of new intramammary infections during the dry period**

**Teat Sealants**

The efficacy of Orbeseal® in preventing new IMI during the dry period has been well established both in New Zealand (29) and in the UK (4, 15) with results indicating significantly better control when compared to no therapy, and equivalent to or significantly better control when compared to antibiotic DCT. The product has now been commercially available in the UK for approximately two years and provides an invaluable tool to the organic producer in combating dry period infections and consequently both clinical and sub-clinical mastitis.

The use of internal teat sealants does carry the risk of iatrogenic introduction of infection through unhygienic insertion of the sealant. A less invasive, and therefore theoretically safer, method of protection is the use of external teat sealants.

A new formulation, DryFlex® (DeLaval) was released onto the UK market in 1998. It is recommended as an adjunct to DCT, with application to occur at drying off and ten days prior to the predicted calving date. However, preliminary data from our recent studies have demonstrated that, where this product is used to maintain a permanent seal for a period of greater than 8 days prior to calving, a significant reduction in new intramammary infections (of 85%) is obtained in the absence of antibiotic dry cow therapy. In the light of these findings this product may hold promise as an aid in reducing dry period infections on organic units.

**Management strategies**

A preliminary analysis of a variety of management factors to assess whether they significantly affected the chance of developing a new IMI at calving with

- All major pathogens
- Enterobacteriaceae
- *S. uberis* and
- Coagulase positive Staphylococci
has been performed. Various factors were significant on univariate analysis.

**Cow factors**

Increases in 305-day milk yield, lactation number, yield at drying off and an episode(s) of clinical mastitis in the previous lactation were positively associated with an increase in new IMI to one or more of the classes of major pathogen described above.

A positive correlation between lactation number and dry period IMI has been reported by a number of researchers including Todhunter *et al.* (24), Sargeant *et al.* (18) and Dingwell (9). Similarly, Hovi and Roderick (14) found that an increase in parity was significantly correlated with an increase in dry period clinical infection on organic farms in the UK. Thus, the age structure of the herd should be considered when investigating or developing mastitis control strategies.

The mechanism by which yield at the point of drying off affects the rate of new IMI has been suggested to be an increase in intramammary pressure, and hence an increased likelihood of leakage of milk, which has been shown to increase the chance of developing clinical mastitis (20). The increased volume of milk in the gland is thought to lower the concentration of the protective factors found in milk (17). It is perhaps therefore not surprising to find that an increase in milk yield at drying off is positively associated with an increase in new IMI to coagulase positive Staphylococci and *S. uberis*, agreeing with US studies (9, 10). Consequently, mechanisms to reduce yield prior to drying off should be considered, though this should be through reduction in nutrition and not through once daily milking. The lowest level of infection seen during the trial, was when yields were at 5-10 litres at drying-off. Interestingly, lower yields (<5 litres) were associated with a predisposition to infection.

The increased susceptibility of cows infected in the preceding lactation, to new IMI at the subsequent calving, was identified by Browning *et al.* (8). It is supported by the finding of our studies in which cows that had a history of clinical mastitis in the previous lactation were more susceptible to developing a major pathogen IMI during the dry period. However, in this trial, is it possible that these cases were not new IMI but persistently infected animals where sampling failed to detect infection at drying off. This illustrates the importance of ensuring good recording systems are in place to allow infections to be tracked throughout the dry period and into the subsequent lactation (see later).

**Environmental factors**

Housing of cows was positively associated with an increase in new IMI to all major pathogens, *S. uberis* and coagulase positive Staphylococci. The housing of cows on sand yards as compared to straw yards was associated with a decrease in new IMI to *S. uberis*. 
Housing has been previously identified as a risk factor for clinical mastitis and is thought to be related to an increase in exposure to environmental pathogens (1, 19). Similarly the significant decrease in new IMI to \textit{S. uberis} is likely to be a result of the ability of straw to harbour high levels of \textit{S. uberis} (7) versus the bacteriologically inert nature of sand (12).

**CONTROL OF CONTAGIOUS MASTITIS**

As many of the control strategies for the prevention of contagious mastitis are similar for conventional farms and well understood, e.g. the importance of a hygienic milking routine, we will only discuss areas critical and commonly wrong on organic farms.

**Importance of good records**

The tracking of infection by maintenance of good herd recording systems is always a vital component of mastitis management and never more so than when managing contagious mastitis. The recording of all treatment is a prerequisite of organic regulations. However, the way this information is recorded and the use to which these records are then put varies enormously between units.

Analysis of clinical and sub-clinical (cell count) records will allow the following factors to be assessed:-

- The incidence of clinical and prevalence of sub-clinical mastitis during lactation and the dry period.
- The effectiveness of any treatment regimes employed, alternative or conventional.
- The effectiveness of any management control strategies.

These will facilitate the implementation of appropriate decisions about the management of individual cows and the unit as a whole.

The performance and analysis of individual cell count recording on organic units is therefore a vital tool in the management of mastitis within organic units.

**Biosecurity**

The potential impact on welfare and production that can occur on an organic unit as result of introduction of a new pathogen in bought-in cows is enormous. This may not just be the result of the transmission of a new species e.g. the introduction of \textit{Staphylococcus agalactiae} onto the unit, but possibly also through the introduction of a more pathogenic strain than already present on the unit.
Ideally organic herds should be closed units. However, where economic or production circumstances dictate that replacement stock has to be purchased, then a biosecurity policy should be adopted to reduce the potential risk of introduction of new mastitis pathogens (as well as other potential non-mastitis related pathogens). One obvious policy may be to only purchase maiden heifers, though this does not eliminate the risk, as even heifers may already harbour sub-clinical infections.

If purchase of lactating cattle is unavoidable then analysis of the clinical and sub-clinical mastitis history of the vendors herd and the individual cows to be purchased is essential. This should be coupled with strict segregation (especially during the milking process) and screening of cows for high cell count quarters (e.g. using the Californian Mastitis Test) and subsequent bacteriological assessment to minimise the risk of inadvertent introduction and subsequent spread of mastitis pathogens.

**Treatment of mastitis**

The appropriate treatment of mastitis to ensure both full clinical and bacteriological cure and, therefore, minimising the potential for further spread or recurrence of that infection, is a vital component of mastitis management.

Organic regulations state that alternative remedies should be used in preference to chemically synthesised allopathic veterinary medicinal preparations, provided that they are effective and safe for the condition to be treated. In practice, the certification body, leaves the choice of treatment to the discretion of the farmer and advising veterinary surgeon and will only intervene where records indicate that there appears to be an excessive number of mastitis cases or treatments used on the unit.

A wide range of alternative treatments to antibiosis have been suggested for the treatment of mastitis including homoeopathy, frequent stripping by machine or calves, topical treatments such as udder mint or cold hosing of the udder. Unfortunately, there are also a variety of unlicensed, and consequently illegal, intramammary preparations containing products such as aloe vera and tea tree oil, which are all too commonly adopted.

A full discourse on the relative merits and ethics of alternative treatments, and in particular the use of homoeopathy are out with this paper, though it is of concern to the authors that the most widely used alternative remedy, homoeopathy, lacks proven efficacy. To date clinical trials of investigating the use of homoeopathy in mastitis control have generally suffered from poor study design and have not produced any clear indication that homoeopathy is efficacious.

A recent study by Mueller (16) investigated the treatment of clinical mastitis with homoeopathy in a positive-controlled, blind, randomised clinical study involving 80 cases in 67 cows, affected with mainly environmental
pathogens. The results showed no significant difference in clinical cure at the 14th milking, 47.4% (homeopathic group) vs. 67.6% (antibiotic control group), but bacteriological cure was significantly lower (50% vs. 75%, p<0.03) for the homeopathic group. While this represents only one study the message should be that any treatment regime should be closely monitored to ensure that it is demonstrating suitable efficacy. This is because poor efficacy will not only result in potential welfare issues, but may also lead to substantial production losses, as treatment costs form only a small fraction of the overall cost of mastitis. Loss of yield constitutes a far more significant cost; the impact of reduced yield on profitability will be extremely high where treatment strategies are failing, not withstanding the further costs of higher recurrence rates, higher bulk somatic cell counts and the potential spread of infection between cows.

Finally it is important to note that one of the most useful tools in the management of chronic infection is antibiotic dry cow therapy. This remains permissible on organic farms, provided that it is being used for treatment and not prophylaxis and that programmes to reduce its use in the long term are seen to be in place.

REFERENCES


DESIGNING MILKING UNITS FOR OPTIMUM PERFORMANCE USING MILK FLOW SIMULATION AND FINITE ELEMENT ANALYSIS

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SUMMARY

Historically many liners and milking units were developed empirically although some were evaluated scientifically using animal trials while others were field evaluated. A finite element model was developed to study the response of a liner to changes in composition, geometry, tension and differential pressure. In addition the vacuum at the teat end and in the pulsation chamber significantly influences liner movement. This information aids the process of new liner design and evaluation. This paper highlights the importance of measuring vacuum when the liner is open and closed and shows that liners must be evaluated in a specified milking unit configuration so allowing the design to optimise the forces on the teat end while milking cows quickly and completely.

INTRODUCTION

The differential pressure across the liner is the difference between the pulsation chamber vacuum level and the teat end vacuum level. It is this pressure difference that influences liner movement for specific liner geometry and material characteristics.

When teat end vacuum level is altered this changes the liner response because the differential pressure between the teat end and pulsation chamber is altered. Design changes in the milking unit have a significant effect on teat end vacuum level. Pulsation vacuum levels are very well defined and easily measured.

It is possible, using milk flow simulation data, to predict the influence of various dimensions of components on the teat end vacuum and liner differential pressure. However, if a new liner is being developed it is not possible to predict the deformation or liner wall movement in response to a given differential pressure. It was proposed to develop a model based on finite element analysis (FEA), which could model accurately the liner wall movement profile at a number of discrete points on the surface of the liner.

The importance of liner wall movement has been shown previously (9, 11). It has been shown that poor liner wall movement, as a consequence of

A finite element model was developed to model the response of a liner to changes in liner material, geometry, tension and differential pressure. In addition the vacuum at the teat end and in the pulsation chamber significantly influences liner movement are also taken into account.

It is well known that high levels of liner slip contribute significantly to the rate of new infection of mastitis (1, 11). The latter publication also notes that vacuum fluctuations per se do not increase the rate of new infection, unless this fluctuation is accompanied by liner slip. Large fluctuations at the teat end tend to reduce the differential pressure between the teat end and pulsation chamber. This results in a lower compressive load on the teat end when the liner is closed. It has been shown that this reduction in vacuum level and its subsequent positive effects on teat physiology more than offset the reduction in compressive load on the teat (4). It has also been suggested that excessive overpressure may affect hyperkeratosis (8).

While vacuum measurements in themselves quantify the physical conditions that exist at a particular cow’s teat, milk flow from individual cow’s teats vary. In order to achieve a significant degree of experimental repeatability when evaluating clusters it is necessary to control the milk flow rate through the cluster. This can be best achieved by simulated milking tests using artificial teats. Flow simulation has been used in field testing in the United States (13). Physical measurements on a flow simulator can be used to explain some of the variation in milking-time tests.

It is important to take consideration of these vacuums and pressure differences when designing a liner.

Finite element analysis is a computerised numerical analysis technique which can be used for solving differential equations relating to structural mechanics.

Mathematically, the structure to be analysed is sub-divided into a mesh of finite sized elements of simple shape. Within each element, the variation of displacement is assumed to be determined by simple polynomial shape functions and nodal displacements. Equations for the strains and stresses are developed in terms of the unknown nodal displacements. From this, the equations of equilibrium are assembled in a matrix form, which can be programmed and solved on a computer. After applying the appropriate
boundary conditions, the nodal displacements are found by solving the matrix stiffness equation. Once the nodal displacements are known, element stresses and strains can be calculated. This technique allows liner wall movement to be predicted accurately for a given set of conditions.

MATERIALS AND METHODS

Flow simulation experiments

A flow simulator of four artificial teats, each separately connected to four water reservoirs, was used to measure effects on liner differential pressure. The level in each of the reservoirs was maintained constant to provide a uniform head pressure to the artificial teat at all times and aid obtaining a constant flow rate through the teat. Flow was measured by in-line flow meters and by monitoring the rate of weight change in the reservoirs. A standard teat for simulated testing is described in ISO 6690:1996 (7), however there are limitations with this teat in terms of its ability to close off properly when the liner is collapsed. This was an unintentional design feature of the ISO artificial teat and as a result a new artificial teat was developed (10). Vacuum levels in the pulsation chamber, teat end, claw and system vacuum level were measured for over 2000 milking unit configurations using the flow simulator. Data are presented for simultaneous and alternate pulsation with claw volumes of 150 ml and 323 ml on a mid-level milking plant with 1.4 m milk lift and a 16 mm diameter long milk tube.

Figure 1  Location of sensors on cluster
Geometry and material characteristics

Liner material properties were measured for four liners by carrying out tensile tests on the materials in accordance with BS903:A2 (3). Two of the liners were used during the milk flow simulation experiments and two were experimental liners with different material characteristics. The liner geometry was obtained from both part drawings and internal mould impressions. Three were wide bore tapered liners and one was a narrow bore liner. The dimensions and elastic moduli are shown below.

Table 1  Liner dimensions and elastic moduli

<table>
<thead>
<tr>
<th>Liner</th>
<th>Type</th>
<th>Upper barrel bore (mm)</th>
<th>Lower barrel bore (mm)</th>
<th>Axial stretch (mm)</th>
<th>Modulus (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wide bore tapered – soft</td>
<td>32</td>
<td>22</td>
<td>20</td>
<td>0.83</td>
</tr>
<tr>
<td>2</td>
<td>Wide bore tapered – medium</td>
<td>32</td>
<td>22</td>
<td>20</td>
<td>2.4</td>
</tr>
<tr>
<td>3</td>
<td>Wide bore tapered – hard</td>
<td>32</td>
<td>22</td>
<td>20</td>
<td>4.8</td>
</tr>
<tr>
<td>4</td>
<td>Narrow bore</td>
<td>22</td>
<td>19.5</td>
<td>27</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Finite element analysis

A non linear finite-element model was developed with 8-noded solid elements using Ansys 5.6 (Ansys Inc., Southpointe, 275 Technology Drive, Canonsburg, PA 15317, U.S.A) to model the collapse of the liner. The model geometry was defined parametrically in terms of upper barrel bore, lower barrel bore, barrel length, wall thickness, axial stretch and radial stretch.
The elastic modulus for the material was also entered as a parameter. The Poisson ratio was fixed at 0.49. A two dimensional section of half the liner was constructed by defining various keypoints and areas, as shown in Figure 2.

These areas were meshed with a special element, which is intended for multi-step meshing operations, such as extrusion, that require a lower dimensionality mesh to be used for the creation of a higher dimensionality mesh, i.e. sweeping a 2-D mesh into a 3-D mesh. Model meshing was additionally parameterised; the parameters for meshing included the number of elements through the wall thickness, the element size and the number of elements in a 180° rotation.

This mesh was rotated about 180° and the mesh elements were converted to solid 8 noded elements used for 3-D models with materials that obey linear material constitutive laws. The element is defined by eight nodes (one at each corner) having three degrees of freedom at each node, i.e. translations in the nodal x, y, and z directions. This selection of element type is based on the fact that all materials were linear and isotropic in behaviour in the strain area of interest.

![Figure 2](image2.png) Finite element two dimensional section for the construction of areas

![Figure 3](image3.png) Liner model mesh showing elements and plane of symmetry
Even though the geometry of the liner was axisymmetric it was necessary to model half the geometry as the deformed model would only have one plane of symmetry. The model mesh is shown in Figure 3.

Specific groups of nodes were defined as components C1 to C5 within the geometry, the purpose of which was to simplify the application of loads and boundary constraints.

Since the geometry was perfectly symmetrical and the loading pattern was uniform about the axis of symmetry the finite element model had no material ‘imperfections’ and it would not deform correctly if loaded. This is due to the fact that the liner barrel would contract in the radial and circumferential directions and the material would go into compression. It was necessary to introduce an imperfection in the model so that buckling would occur. An eigenvalue buckling analysis was completed to determine the initial buckling mode shapes. An imperfection was introduced by applying miniature nodal offsets based upon the first buckling mode shape. The nodal offset was computed as 10% of the normalised buckling mode shape, which equated to a maximum offset of 0.1 mm. The first four buckling mode shapes are shown in Figure 4. It can be seen that the first buckling mode is the only mode which occurs in practice, so this is the reason for selecting this buckling mode to introduce an imperfection.

**Figure 4   Liner buckling modes from eigenvalue analysis**

<table>
<thead>
<tr>
<th>First eigenvalue buckling mode.</th>
<th>Second eigenvalue buckling mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third eigenvalue buckling mode.</td>
<td>Fourth eigenvalue buckling mode.</td>
</tr>
</tbody>
</table>
In order to avoid the virtual liner collapsing through the plane of symmetry, which is physically impossible in reality, a solid plane was constructed at the line of symmetry and contact between this plane was modelled so that deflections would not penetrate this area. A contact element was used to model contact and sliding between 3-D "target" surfaces (elements on the symmetry plane) and a deformable surface (i.e. liner internal barrel). The contact elements themselves overlay the solid elements describing the boundary of a deformable body and are potentially in contact with the target surface. This target surface is defined by a set of target segment elements and is paired with its associated contact surface via a shared real constant set.

The model was constrained by preventing movement on certain nodes. Nodes on the inner surface of the liner hood were grouped to form component C1. Nodes in component C1 were restrained in the radial direction to model the liner stretching over the shell. Nodes on upper surface of liner hood were grouped to form component C2. The nodes from liner to shell restraining ring where the lower end of the liner is mounted in the shell were grouped to form component C3. Nodes in components C2 and C3 were restrained in the Z direction, restraining C2 were used to hold the model static and placing an offset on components C3 were used to control liner stretch. Nodes on inner surface of liner barrel were grouped to form component C4, this facilitated application of loads. Finally nodes on the plane of symmetry were grouped to form component C5 and were restrained in the Y direction.

Initial loading consisted of the radial and axial stretch to which a liner is subjected when placed in the shell. These loads were applied to C1 in the radial direction and C3 in the Z (axial) direction. Non-linear geometry options were enabled due to the large deflections expected. Ansys solution control options were also enabled. The model was then solved at the initial time step because loading may be path dependent and the principle of superposition would not apply.

The data presented show liner response when the differential pressure was varied linearly across the liner.

A differential pressure (−25 kPa to 45 kPa) was placed across the liner barrel and the solution was obtained for various individual pressures both on the collapse and opening cycles. Further details of the model and factors affecting the pressures around the liner have been described (4).
RESULTS AND DISCUSSION

Milk flow simulation, teat end vacuum and liner differential pressure

Mean teat end vacuum levels during the B phase (TVMeanB) and D phase (TVMeanD) of the pulsation chamber waveform are shown below.

Reducing the vacuum level at the teat end just prior to liner collapse will reduce the milk flow velocity from the teat and will reduce shear stresses on the teat end as the liner collapses.

Table 2  Average teat end vacuum and liner differential pressure during the B-phase and D-phase of the pulsation chamber waveform

<table>
<thead>
<tr>
<th>Treat</th>
<th>Pulsation</th>
<th>Claw volume (ml)</th>
<th>Liner</th>
<th>TV MeanB (kPa)</th>
<th>TVMeanD (kPa)</th>
<th>DPD (kPa)</th>
<th>DPB (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 x 0</td>
<td>150</td>
<td>2</td>
<td>43.0</td>
<td>14.1</td>
<td>13.6</td>
<td>-11.9</td>
</tr>
<tr>
<td>2</td>
<td>2 x 2</td>
<td>150</td>
<td>2</td>
<td>35.3</td>
<td>28.6</td>
<td>28.1</td>
<td>-13.2</td>
</tr>
<tr>
<td>3</td>
<td>4 x 0</td>
<td>323</td>
<td>4</td>
<td>35.7</td>
<td>30.7</td>
<td>30.3</td>
<td>-13.1</td>
</tr>
<tr>
<td>4</td>
<td>2 x 2</td>
<td>323</td>
<td>4</td>
<td>36.0</td>
<td>33.3</td>
<td>32.7</td>
<td>-12.2</td>
</tr>
</tbody>
</table>

The mean liner differential pressure during the B phase (DPB) is of little importance in this test, however it is important that this value is always negative otherwise partial liner collapse during the B phase may result. The mean liner differential pressure during the D phase (DPD) indicates the average pressure closing the liner, however it is also interesting to look at the maximum and minimum values of DPD which can be seen in Figures 5 to Figure 8. With treatment 1 there is the highest TVMeanB which will result in quicker milking when compared to all other treatments. It has the lowest TVMeanD and DPD. This can offer advantages from a milking viewpoint provided the liner design is correct.

Finite element analysis

Finite element analysis allows results to be obtained at any node in the model but it would be unpractical to try to attempt to present data for all nodes so it was evident that only some data can be presented. One node approximately midway down the liner barrel was selected and results are presented for displacements at this point as shown in Figure 9.
Figure 5 Vacuum traces over a single pulsation cycle with 4x0 pulsation, 150 ml claw and wide bore tapered liner (2), flowrate 8 kg/min

Figure 6 Vacuum traces over a single pulsation cycle with 2x2 pulsation, 150 ml claw and wide bore tapered liner (2), flowrate 8 kg/min

Figure 7 Vacuum traces over a single pulsation cycle with 4x0 pulsation, 323 ml claw and narrow bore liner (4), flowrate 8 kg/min

Figure 8 Vacuum traces over a single pulsation cycle with 2x2 pulsation, 323 ml claw and narrow bore liner (4), flowrate 8 kg/min
Figure 9  Node numbering for upper liner section

Figure 10  Contour plot of liner movement in the Y direction

Figure 10 shows that displacements can be shown visually across the liner surfaces.

Displacements and rate of displacement with respect to pressure change are shown for liners 1-4 in Figure 11.

Based on FEA the liner collapse pressure of liner no. 1 is 1.6 kPa. Liner no. 2 is geometrically identical to the first except that the material is harder. The collapse pressure is 7.07 kPa. Liner no. 3 is harder than the previous two and the collapse pressure was found to be 11.73 kPa. Liner no. 3 is an
experimental liner designed only for testing finite element modelling. The purpose of modelling liner no. 4 was to compare differences between narrow bore and wide bore tapered liners and to verify the model operated for narrow bore liners. The collapse pressure (10.49 kPa) of the narrow bore liner was higher than typical wide bore tapered liners. It can also be seen that based on FEA the liner must reach 14.5 kPa at this point for the walls to be fully closed (9.9 kPa for Liner 2). Knowing this information is important because it should be noted that the D phase teat end vacuum cannot be lowered for the liner to have adequate pressure to close properly and this must be taken into account when designing the milking unit.

**Figure 11  Liner wall movement and rate of liner wall movement in the Y direction**

**CONCLUSIONS**

- Simulated milking with a correct design of artificial teat and measuring parameters relative to the pulsation chamber waveform allows milking unit evaluation with an excellent degree of experimental repeatability under defined flow conditions thereby supplying very useful design information for the development of milking equipment.
- Teat end vacuum had a causal effect on the magnitude of liner differential pressure and hence the liner wall movement.
- The collapse pressure for a narrow-bore liner was higher than that for a wide-bore tapered liner and hence the former needs a higher teat end vacuum in the D phase to collapse.
The extent to which the teat end vacuum of a cluster varies with milk flow determines milking characteristics, liner differential pressure and hence liner movement.

The vacuum at the teat end was higher when the liner was open with simultaneous pulsation than with alternate pulsation.

Teat end vacuum was significantly lower during the liner-closed phase with simultaneous pulsation than with alternate pulsation.

Reducing the D phase vacuum will reduce over-pressure on the teat.

Reducing the vacuum level at the teat end just prior to liner collapse will reduce the milk flow velocity from the teat and will reduce shear stresses on the teat end as the liner collapses.

Finite element analysis allowed the liner response to be determined based on knowledge of the liner geometry and material characteristics.

REFERENCES


MILKING FREQUENTLY

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INTRODUCTION

Although the potential benefits of milking frequently in terms of increased milk yield have been recognized for many years, for the majority of dairy farmers the additional labour costs outweighed the extra revenue. The introduction of automatic milking systems has the potential to change this largely economic argument. Apart from the initial capital investment, the additional cost of milking three or four times daily will be small when it does not involve labour. Furthermore, it is apparent from our recent research that frequent milking not only increases daily milk yield, but also improves lactation persistency and prevents the decline in milk protein quality typically associated with late lactation. The first is easy to achieve and easy to recognize, but for the latter two things to happen requires positive management to ensure that cows continue to be milked frequently and fed appropriately over long periods of time. This is where the information from milking becomes important. In this paper I shall consider how information can be used to maximize the economic efficiency of the entire lactation cycle whilst ensuring good welfare for the cow and good milk quality for the farmer and the processor.

MILKING FREQUENTLY INCREASES MILK YIELD

Moving from twice-daily to three-times daily milking increases milk yield typically by around 10% in a controlled situation, although under commercial conditions the amount will be dependent on the quality of management. Three-times daily milking does not necessarily maximize the response; in one study milking six-times daily increased yield by 20% over and above three-times daily (1). The example shown in Figure 1 is from a half-udder study in heifers in which four-times daily milking was performed in one udder half (only) for 6 weeks (4). The increased yield of the frequently milked half is very obvious. This illustrates an important aspect of the response, namely, that the effect is a localized one happening within the udder. Extensive research has been done to identify the biological mechanism, and although the details do not need to be understood it is relevant to know that the effect is not endocrine and not related to pressure within the udder. Instead, it is now known that milk contains a secretion-inhibiting chemical, in other words there is a self-regulating mechanism which matches the amount of milk produced to the demand (usually of the baby or calf but in this case, the milking machine). Supply and demand theory was not invented by business!
Figure 1  Half-udder milk yield of heifers milked twice-daily (●) or four-times daily (○) where indicated

MILKING FREQUENTLY INCREASES LACTATION PERSISTENCY

Recently we have extended the half-udder frequent milking approach to look at effects of milking frequency on lactation persistency. Starting at peak lactation, half of the udder was milked three-times daily for the remainder of the lactation, whilst the other half continued to be milked twice-daily (6). Our objective was to extend the lactation beyond its normal ten months duration, so the cows were not rebred until nine-months post-calving to achieve an eighteen-month calving interval. The effects of thrice-daily milking on lactation persistency are shown in Figure 2. For the period between weeks 9 and 64 of lactation, persistency was improved by almost 20%. By comparing cows fed conventionally with others allowed 3 kg/d additional concentrate as well as cows calving in autumn or spring we were able to show that lactation persistency was also improved by additional concentrate feeding and by calving in the autumn. The potential combined effect of these three management routines is shown schematically in Figure 3. For the period up to week 32 the fitted slopes are based on actual data, but beyond week 32 they are extrapolated. Had the predicted yields been achieved, the most persistent group of cows would have been yielding only 2.5 kg/d less at the end of the lactation (week 65) than at peak lactation. In fact this was not achieved, for two reasons. Firstly our nutritional management was not up to the challenge of the late-summer decline in grass quality (although in a subsequent lactation we overcame that problem). Secondly, having rebred the cows it was very evident that persistency was negatively affected during the last third of the pregnancy (Figure 4).
Figure 2  Lactation persistency for udder-halves of cows milked twice-daily (○) or thrice-daily (●)

Figure 3  Actual and extrapolated lactation persistencies for cows on different treatments. Extrapolation begins at vertical dotted line
CONSEQUENCES FOR LACTATION-CYCLE MANAGEMENT

Milk yield increases rapidly after calving to a peak value and declines gradually thereafter. This apparently inevitable decline has dictated dairy cow management for many decades; the sooner the cow is got back in calf, the fewer days she will be dry and the quicker she will return to peak output. Hence lactation management has revolved not around milk yield, but around reproduction. This has its drawbacks. Parturition is the greatest biological challenge faced by the dairy cow, closely followed by the metabolic demands of the early lactation period (3) and the biggest risk factor is failure to re-conceive, which accounts for more than a third of all culls. Both problems could be lessened by extending the lactation cycle. Changing from twelve to eighteen month lactations would reduce exposure to risk by one-third in a three year period, for instance. So, the economic argument apparently favours short lactations whereas the health and welfare argument favours long lactations. How can the two be reconciled? By delaying rebreeding and at the same time managing for improved persistency, one could theoretically retain the welfare benefits of extended lactation and at the same time achieve a good economic return. Since the number of dry periods will reduce in the same way as exposure to risk does, above a certain degree of persistency the extended lactation cycle will actually be the most economic strategy, as we have previously demonstrated in modelling studies (5). I have just shown that persistency can be improved by milking more frequently and by feeding extra concentrate. To assess the effects on annualised output we maintained the cows on two consecutive eighteen-month extended lactations. This not only provided a more rigorous analysis, but also specifically removed the compounding influence of calving season. On average the extended-lactation cows produced 8,300 kg/year, which is modest by modern standards but should be seen in the light of our
herd average over the same period of 5,800 kg/year for cows managed conventionally. This represents a 43% improvement in annual yield, considerably more than the 10% or so we would have expected from changing to thrice-daily milking.

DATA MANAGEMENT CONSIDERATIONS

Our observation of increased persistency as a result of increased milking frequency is new. In Israel, Moshave (family farms) almost invariably milk twice-daily, whilst most Kibbutz milk three-times. Analysis of the national milk records database confirms that the yields of Kibbutz farms are higher, but there is no detectable difference in lactation persistency between the two. All the cows were, presumably, being managed for traditional twelve month lactations. I suggest, therefore, that it is the combination of frequent milking, appropriate nutrition and delayed rebreeding that creates the more persistent extended lactation. This inevitably introduces an element of risk. With conventional rebreeding management, provided the cow gets back in calf, the farmer need not worry too much about persistency as yield will be restored after the next calving, whereas if rebreeding has been delayed, milk output has to be maintained. But is it not time that more effort was given to doing exactly that? It is my experience of talking to dairy farmers (including those using AMS) that they pay little account to stage of lactation, or to changes in milk yield happening over weeks or months. The modern computer-based milking system is perfectly capable of gathering and storing information on milk yield at each milking, collating it into a daily yield, collating that into a weekly yield and presenting this as a graphed output of how the lactation is progressing for each cow in the herd. At this point I should confess to being a biologist rather than an engineer or computer buff, but the step from that point to producing predictive ‘early-warning’ computer software that automatically identifies individual cows that are deviating from the desired lactation curve should not be impossible, in my view. If one is managing for persistency, the question that then arises is why is that cow not doing as well as she should? At that point one would go through an iterative process something like this:

- Is this a sudden drop in yield? If yes, the cow may be ill and should be examined by herdsman and, possibly, vet. If no (i.e. yield is falling gradually) one goes to next question.
- Is nutrition adequate and is it being consumed? If no, one increases feed or again examines the cow for digestive disturbance of some sort. If yes, one goes to next two questions.
- Is the cow in the latter third of pregnancy? If yes, accept decline in yield. If no, one goes to next question.
- Is the cow putting on excessive weight?
➢ Is the cow attending for milking often enough? These questions are asked in tandem because they are interrelated. The cow that is not being milked very often and is putting on weight is well known to farmers as one that ‘puts it on her back’. The solution is to enforce more frequent milking so as to restore the milk output stimulus. The cow that is not attending often and is not putting on weight needs to be treated the same, but in addition her nutrition needs to be re-examined.

➢ Is there no obvious reason why the cow is not performing? At this point the system would examine historical records for the cow in question and her ancestors. Previous management interventions that have or have not been successful could be identified, but the end conclusion could be that this cow has genetically-entrained poor persistency and should not be used for breeding.

This may or may not be an exhaustive description of what can be done, but the point is that these are all simple management issues that are capable of being addressed using existing technologies. Some of these technologies go hand in hand. Automated weighing, for instance, is reliable if done frequently in a relatively standardised way (e.g. at milking, before feeding) whereas once-weekly weighing is fraught with inaccuracies due to rumen-fill. Other technologies may be added; the milk yield:body weight:nutrition interrelationships might be improved by pedometer-based activity monitoring, for instance. The challenge is to use the available information in a way that has a definable objective, and in the scenario that I have described this means managing the cow to achieve greater persistency. I have glibly suggested that the solution to some identified problems would be to enforce more frequent milking. I recognize that in AMS as currently practiced this is not always possible, so farmers who make the decision to manage their cows for persistency must be aware of this need from the outset.

MILK QUALITY AND UDDEr HEALTH

The gross composition of milk changes quite markedly with stage of lactation (7). Milk protein content is shown in Figure 5 for the extended lactation cows, and the gradual increase from around 3% at peak lactation to around 4% in week 60 is very evident. The effects of the different treatments were small by comparison, although there was a significant increase in those cows on additional concentrate. This increase in protein is good news for the farmer but, paradoxically, not such good news (or even rather bad news) for the processor. Illustrated in Figure 6 is casein number, which effectively relates the amount of casein to the amount of total protein and is a good index of processing quality. This time there is a marked treatment effect, in that the cows which had the poorest persistency (those milked twice-daily and fed conventionally) showed a distinct fall in casein number as lactation advanced. This fall was not evident in the frequently-milked, supplemented cows. The first take-home message is that milking
frequently and feeding well improves milk quality in late lactation. The second is that straightforward analysis of gross protein content gives only a partial indication of milk quality, and as on-line technologies are developed for milk compositional analysis this point should be borne in mind.

**Figure 5**  Milk protein content of cows during 60 weeks of extended lactation

![Graph showing milk protein content](image)

**Figure 6**  Milk processing quality (casein number) for extended lactation cows treated as shown. 2X and 3X is twice- and thrice-daily milking. LO and HI are conventional and supplemented feeding

![Graph showing milk processing quality](image)
The reason for these changes in protein content and quality are complex, and not directly related to protein synthesis in the milk secreting cells. Early in the lactation these cells are tightly joined together forming an impermeable barrier between blood and milk, but in late lactation they become ‘leaky’. As a result, proteolytic enzymes leak into the milk, where they degrade the milk casein, resulting in a reduction in casein number. This same change happens, acutely, during mastitis and is a pivotal factor in the somatic cell response. One would predict, therefore, that SCC would increase during late lactation and that this increase would be reduced or prevented by frequent milking. Figure 7 shows that this prediction is accurate. Used as a measure of acute mastitis sudden changes in SCC are extremely useful (see the sharp rise around week 38 in Figure 7). Used as a management tool for identifying chronic sub-clinical mastitis for the purpose of culling SCC is also potentially very useful, but it is apparent that stage of lactation and milking frequency should be taken into account. To properly consider milking frequency in relation to mastitis would be a full review in itself and I am not best qualified to do that. Suffice to say that a number of technologies are available for detecting mastitis either already on-line or potentially on-line. Conductivity has been around for several decades and is, in my view, reliable provided the analysis is done on a quarter basis, looking for changes in one (diseased) quarter relative to other (healthy) quarters. At the other chronological extreme, analysis of acute phase proteins in milk is a very recent development which has potential to diagnose mastitis sooner than conventional methodologies (2). One thing is certain regarding the using of information from milking. An increasing amount will be available, so the secret of success will be to first identify what one wishes to achieve from the information and then to identify which type of information used in which way will deliver that objective.

**Figure 7**  Somatic cell count of milk from cows milked twice-daily (o) or thrice-daily (●)
REFERENCES


ON-LINE SENSORS FOR EARLIER, MORE RELIABLE MASTITIS DETECTION

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SUMMARY

The cause-effect spectrum allows a more complete understanding of the progression of bacterial infection in the mammary gland. By strategically identifying components in the spectrum that are of diagnostic benefit, on-line sensors will enable farmers to automatically detect the onset and progression of mastitis. In the future, these technologies will allow earlier, more reliable detection of sub-clinical and clinical infections.

INTRODUCTION

Most farmers, consultants, veterinarians and milk processing companies around the world have listed “mastitis detection” as the primary need for development of on-line sensing technology. However, when these groups of people were asked what exactly they wanted to detect and what they thought “mastitis” referred to, it became obvious that there exists a large amount of confusion regarding mastitis and mastitis detection.

This is because the true definition of mastitis is quite specific, while the term is often used to refer to a broad and complex sequence of events. “Mastitis” is defined by Webster and the International Dairy Federation as an “inflammation of the…udder.” If this is “true mastitis,” two interesting questions become obvious.

- How can you build a sensor that detects “inflammation?”
- Is “true mastitis” really what everyone wants to detect?

Each person has formulated their own definition of what they really want to detect when they use the phrase, “detecting mastitis.” Some define “detecting mastitis” as when a test of bacterial pathogens is positive, others when somatic cell count (SCC) reaches a particular level, others when clinical signs such as clotting of milk or swelling of the udder occur. An overall picture of mastitis can be described in a cause-effect spectrum (Figure 1).
We are working on a range of sensors covering the cause-effect spectrum. The rationale underpinning the cause - effect spectrum is that the further away from the cause (bacterial infection) then the more likely a physiological effect is caused by something other than the infection. The following mastitis detection systems are being investigated:

- Lactate. Because bacteria produce lactate as they grow and multiply in the udder, lactate is one of the earliest direct indicators of bacterial infection.
- MAA. The cow’s immune system’s initial response to an infection is the so-called Acute Phase Response. Acute phase proteins, such as Milk Amyloid A (MAA) are produced by the cow’s udder.
- SCC. Somatic cell count is very important for herd management for many farmers. We have a direct on-line SCC sensor.
- Conductivity. Conductivity is further along the cause-effect spectrum. It is a direct effect of tissue damage, but many other things apart from bacterial infection also affect conductivity. Nevertheless, it can be used to detect mastitis if all four quarters are measured throughout milking, and these data are compared with that cow’s previous quarter conductivity data.

**Lactate**

The lactic acid (lactate) level in milk has been shown to be a good indicator of clinical and sub-clinical mastitis in dairy cows (2). During an infection the milk oxygen level decreases, leading to an anaerobic environment and the subsequent production of lactate. The on-line measurement of lactate thus provides useful information for herd management as an early indicator of an infection.

Sensortec has installed a commercially available L-lactate measuring device in an automated milking parlour for on-line analysis. One quarter was monitored during each milking of every cow over the period of one month. The data were matched to herd management software providing information on volume, conductivity, visual infections and treatments.
It was found that cows with high SCC and known infections had continually elevated levels of L-lactate. Lactate levels often varied widely between milkings indicating changes in infection status or severity. Figure 2 shows some typical lactate curves for one infected cow and three uninfected cows.

**Figure 2**  A cow that had an infection which has self-cured after an 18-day period

![Graph showing lactate levels](image)

**MAA**

Acute phase proteins (APP) are produced by all mammals to varying degrees in an acute phase response (APR) to an episode of infection, trauma or disease. Production is induced by cytokines, as part of triggering the body’s defense and repair mechanisms. APP used in monitoring animal health are Haptoglobin (Hp), Serum Amyloid A (SAA) and C-Reactive Protein (CRP), as they show the most pronounced and rapid rise in the majority of species.

Recently, amounts of SAA have been discovered in the milk of infected cows. It is thought that this is an isoform of the APP, SAA, namely MAA, and is synthesised in the udder (3). MAA is an APP, which helps trigger the immune system to respond to an antigen or challenge to the udder. This early signal may be in response to a bacterial infection or also physical damage and other stress. The levels of MAA in milk increase before SCC levels rise and may be useful as an early warning of infection.
SCC

A common off-line test for SCC is the California Mastitis Test (CMT). The CMT was developed in 1957 by Schalm and Noorlander who modified the Whiteside test (4). The test involves the addition of an anionic surfactant to the milk. The reagent interacts with the DNA and proteins in somatic cells to form a gel. The viscosity of the gel is then measured and calibrated against the somatic cell concentration. Figure 3 shows the apparent viscosity of the gel over time (5).

Figure 3 Illustration of the time dependency of detergent-DNA gel formation and degradation, showing gradual formation of gel (rheopetic phase), maximum gel formation and the rheodestructive phase

We have undertaken extensive farmer consultations with groups in 7 countries and 11 markets, which illuminated the two likely major uses for an on-line SCC sensor. The first is early mastitis detection, when SCC begin to rise, which could prompt an immediate action to maintain optimal animal health. The other major use is bulk tank SCC management, where farmers can identify, remove or treat problem cows. Different markets were then interested in several measurement levels depending on the market’s testing thresholds for bulk tank SCC. From this, we determined a need for flexible band reporting, rather than strictly quantitative results.

The SCC thresholds for this trial were selected based on the market results. The system that best fits most markets is a five-band scale: <200; 200–500; 500–1500; 1500–5000; >5000 kcels/ml (kcels = 1000's cells). However, it is possible to fine-tune these thresholds to the requirements of each specific market.
Table 1 and Figure 4 show the data leading to the thresholds chosen and the sensor performance in each band. The SCC sensor prototype described here has a level of performance adequate for use as a mastitis control tool and for managing cell concentration in the bulk milk tank.

Table 1  Summary of SCC sensor prototype performance: time-to-drain thresholds, the total number of milk samples (n), and the number of correct (n_correct) and proportion of correct (p) measurements from the calibration and on-line testing.

<table>
<thead>
<tr>
<th>SCC band (kcells/ml)</th>
<th>Time-to-drain thresholds (s)</th>
<th>n (lab)</th>
<th>n_correct (p) (lab)</th>
<th>n (on-line)</th>
<th>n_correct (p) (on-line)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;200</td>
<td>&lt;1.1</td>
<td>38</td>
<td>36 (95%)</td>
<td>64</td>
<td>62 (97%)</td>
</tr>
<tr>
<td>200 – 500</td>
<td>1.1 – 1.7</td>
<td>39</td>
<td>33 (85%)</td>
<td>2</td>
<td>2 (100%)</td>
</tr>
<tr>
<td>500 – 1500</td>
<td>1.7 – 6.2</td>
<td>59</td>
<td>45 (76%)</td>
<td>2</td>
<td>1 (50%)</td>
</tr>
<tr>
<td>1500 – 5000</td>
<td>6.2 – 59</td>
<td>60</td>
<td>43 (72%)</td>
<td>0</td>
<td>0 N/A</td>
</tr>
<tr>
<td>&gt;5000</td>
<td>&gt;59¹</td>
<td>42</td>
<td>40 (95%)</td>
<td>1</td>
<td>1 (100%)</td>
</tr>
<tr>
<td>Overall</td>
<td>N/A</td>
<td>238</td>
<td>197 (83%)</td>
<td>69</td>
<td>66 (96%)</td>
</tr>
</tbody>
</table>

¹The sensor time-out was set at 60 seconds

Figure 4  Calibration curve for SCC sensor prototype (lab testing only), showing the location of SCC band boundaries.
Quarter Conductivity

Attempts to measure the electrical conductivity (EC) of milk as a means of detecting mastitis date back to the first half of the last century. Those early efforts (in common with several conductivity devices on the market today) failed, however, because of the normal biological variations in conductivity of milk that have nothing to do with mastitis. Historically, the value of EC as a mastitis detection tool has been disappointing, principally because the conductivity of milk is influenced by variations such as those listed below.

- From cow-to-cow within a herd, from herd-to-herd, from breed-to-breed
- Over the course of a lactation and in response to varying milking intervals
- Over the course of a milking in response to changing fat content of the milk
- In response to varying feed types and intake amounts
- In response to changes in milk temperature
- As a result of dirt, milk stone or milk fat build-up on the sensor electrodes

A quarter conductivity sensing system has been developed in an attempt to eliminate or control all the non-mastitic variables that can affect milk conductivity in order to focus solely on those factors that cause an increase in conductivity as a consequence of tissue damage within the cow’s udder.

Examples of recent results

1. The results of a recent study in New Zealand’s only automatic milking herd for the period August 1, 2002 to March 1, 2003 showed that:

   - All 8 quarters with clinical mastitis were correctly identified by quarter and date
   - 12 of the 13 quarters infected with a major mastitis pathogen were correctly identified by quarter and date
   - Only 7 of 26 quarters infected with minor pathogens appeared on the alarm list

If the presence of a major pathogen is defined as a "True positive", the Sensitivity was 92% (12 of 13 quarters) and Specificity was 95% (391 of 411 quarters).

This system is currently in use on robotic milking systems, where quarter milk is kept separate until it passes through the individual quarter conductivity sensors. It may be possible to apply this technology to conventional milking systems. We are currently working on methods of applying quarter separation to conventional claws.
REFERENCES


MASTITIS IN LARGE HERDS – A FARMER’S PERSPECTIVE

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BACKGROUND

I am presenting this paper in my role as company secretary, farm business consultant, wages clerk, bookkeeper and on occasion bottle washer on behalf of the managing family business partner, David Barnes and his right hand man, Martyn Braithwaite. They, like the speaker that filled this spot last year, have some self-confessed, personal shortcomings and the thought of standing up here is one of them! They, however, wish to see events such as this supported as mastitis is an issue close to all our hearts and pockets, but when it came to the public appearance I drew the short straw.

I became involved with this particular farm business in 1997 when the enterprises included a 300-hundred cow unit at Withgill and the neighbouring Bashall Town Farm, a 250-cow unit. Both units were profitable, achieving a credible technical performance and mastitis was not a major health issue. In common with many others, the business, at that time, was staring down the barrel of milk price cuts and in need of investment in milking parlours and buildings.

To cut a long story short the farming business evolved very quickly into a single-site dairy unit carrying just over 1,000 dairy cows. The unit has been operational since November 2000 and we are now approaching our 4th birthday having produced close on 35 million litres of milk in that time.

Typically, fertility is generally the biggest health concern and reason for cows leaving most dairy herds. I consistently see poor fertility as the reason for 35% of all culls, and mastitis and cell counts accounting for 15%. At Withgill these figures are reversed and that is not because the cull rate is particularly high, but because fertility is an area in which we feel we have some control and achieve some pretty good results.

Mastitis is our single biggest health issue and, as with other management problems, we have tried to concentrate on the most important areas first and the ones which will improve the bottom line quickest.

Mastitis accounts for 60% of our total vet bill and each “new” case costs on average £55 in veterinary drugs to treat. The vet bill per cow is nothing but average, but we felt that improvements could be made, especially coming from a background where a box of milk tubes would last all winter. We were experiencing 35 cases of clinical mastitis per hundred cows, around the national average.
The best way to describe our experience over the last three years is to discuss each issue separately.

- Parlour
- Milking Routines
- Dry Cows
- Cubicles
- Vet

PARLOUR

The cows are milked three times a day in a 48-point rotary parlour with a total milking time approaching 14 hours at peak production. It was installed on the back of what we saw on trips to New York State and California and how comfortable the cows and men seem to be operating it. We had initially planned on milking the cows with two men, one man if we needed to, but this quickly went out of the window. The first real issue that arose was the number of different people milking the cows. As cow numbers increased, we had to increase staff numbers quickly and, as many of you know, this is not easy. We went through a period of employing untrained staff to milk at least once a day, as we were still trying to complete the dairy unit. The use of ancillary staff to milk cows continues today, but at least one competent person is in the parlour at all times.

Physically detecting mastitis was also an issue with this system, so a routine had to be put in place to make sure this was achieved. To start with the milking staff were trained how to foremilk properly. A system of shedding-off infected cows was devised and a white board was put up in the parlour to let other staff members know the cow numbers and quarters affected. This has now been partly superseded by greater use of cell count information, the Californian Mastitis Test and greater use of the low milk recordings and conductivity devices built into the parlour management computer.

Problems then started with the parlour, caused mainly by a lack of experience and training. The parlour was initially operated incorrectly and despite asking for a clear service protocol to be devised it failed to materialize, leading to periodic mastitis flare-ups as the plant failed to milk cows correctly. If you had spent £250,000 on a combine harvester or similar piece of equipment, then you would expect some sort of training especially given the implications of what could go wrong, but that was not the case. We have a hate/hate relationship with the firm who installed the parlour so we do not mind saying that.

This was eventually rectified with the help of our local service engineer and the parlour manufacturer who helped provide a thorough daily, weekly and monthly routine. This could now be described as excessive with liners
changed every six weeks, for example, but the problems have largely stopped. A lot of the service work is carried out in-house.

The liners incidentally are now one-piece instead of two-piece liners, which has greatly reduced the number of twisted liners, which were proving difficult to detect. Monthly plant checks are made, as are half yearly dynamic tests. Take-off times have also been altered to suit our system and milk yields. We currently use 800 g per minute with a two-second delay.

**MILKING ROUTINES**

We have literally tried every system going, three men, two men, one man milking, paper wipes, wet wipes, pre-dips, foam dips, no dip, dipping units etc. etc. etc. and the biggest problem of all is getting staff to perform the tasks as you wish them to be done. Man management is always a difficult subject and a weakness of many. A good example is when we tried re-usable wipes. We would observe the staff wiping 10 cows with the same wipe and half the wipes would still be clean at the end of the milking? This is even more apparent with the members of staff who are a bit longer in the tooth and tend to milk when the sun goes down. Having just reminded them to use a clean towel for each cow you would not even get out of the parlour before they were back to what they were doing before. Old dogs, new tricks and all that!

Easy to solve you may think, but unless you stand over them for the whole milking, they will revert to what is easiest for them. Another strategy is required, or you milk the cows three-times-a-day yourself. The other danger is changing the routines too often, because like cows, milking staff are creatures of habit and it is not called a routine for no reason!

To assist with managing staff, regular meetings are now held to discuss issues and inform the staff of current milk hygiene and to praise or chastise when required. A staff bonus scheme was also devised based on milk hygiene and parlour cleanliness, but we quickly learnt that in terms of mastitis, what was being instigated outside of the parlour was as important and can have a greater effect than what happens inside. The scheme is still in place primarily because once such schemes are in place they are difficult to scrap and that is probably a lesson to us all.

Staff clothing is also important and they now all wear inspection gloves as gauntlets and good quality rubber gloves for their hands. The bonus money is used partly to keep staff clothing up-to-date and in good condition. Water buckets are also placed in the parlour to allow regular washing.

The milking position of the man putting units on was also seen as an issue on a rotary compared to a herringbone parlour as the cows obviously need time after being prepared to let their milk down. The danger is that cows are prepared and units attached to individual cows. It is our aim to milk cows
in groups of 6 or 8 to give time after teat preparation, typically 45 seconds, to encourage full let-down and achieve a thorough milking out.

Individual cow cell counting is undertaken every four weeks and the information is used to good effect. Some 70% of the cows have cell counts lower than 200,000 cells/ml and the herd average has rolled at 130-185,000 cells/ml for the last couple of years. Cows with cell counts above 1,000,000 cells/ml are separated into a high cell count group and milked last to avoid cross contamination. Cows that have had severe cases of clinical mastitis are also placed in this group and clearly marked using tapes.

Cow tails and udders are clipped on a regular basis to assist clean milking conditions. We have tried using lower grade and cheaper teat dips and sprays, but have always come back to the high emollient products and the good teat condition of the cows is often a comment made by visitors.

The parlour was initially equipped with a water-spraying device to keep the milking platform and units clean, but our experience is that it is a constant compromise between the platform and milking units being clean and dirty water droplets being splashed onto the cows’ udders. The compromise at present is to clear the platform of cows halfway through milking to clean it down and to keep the water usage to a minimum, whilst cows are being milked by spraying the deck only and not the units.

Another improvement in the routine has, of all things, been the foot bathing of cows as they walk into the collecting yard before milking begins. This is done in the walkways five times a week which has resulted in the cows not being as upset when being foot-bathed as it is now a daily event, but critically not having dirty footbath water splashed onto clean, newly milked, open teats.

**DRY COWS**

We have always kept to the Five-Point-Plan with a certain degree of success and when moving to the new unit we continued to do what we had always done, “if it ain’t broke don’t fix it” as they say. The thing we quickly learnt was that our drying-off routine was not good enough. Typically you would find us scrabbling under cows in a handling race to dry them off in less than hygienic surroundings. Quickly this changed to drying the cows off on a set day, preparing them on the milking platform in “hospital” conditions, wearing gloves to “dry” cows, then moving them to the other farm a mile away from the milking machine on to straw and water for a couple of days with daily checks to make sure that all was OK.

This type of approach also extended to the calving yard where great care is taken to get the “fresh” cow out of the yard as soon as possible, typically within three hours after calving, and away from all the bacteria and back into cubicles.
CUBICLES

We are quite proud of the cubicle buildings as a lot of time was spent designing them. Cow comfort was our main concern during the unit design process and we believe we have created cow comfort on a par with the best. This is not the case from a mastitis point of view!

The passages are scraped three times a day whilst the cows are being milked, the beds are brushed off and good quality sawdust and lime is replaced. The beds are routinely sprayed with peracetic acid and hydrated lime is applied as required.

Even with this routine, the big problem with the beds, as always, was still hygiene as the cows spent a long time in them lying down, standing and goodness knows what else on them. This creates a problem as too often the beds are found to be too wet and too dirty. To try and resolve this we have moved the head rail slightly to change the lying position and are using increasing amounts of sawdust and lime to maintain the bed in a decent condition. Again we have to reach a compromise, this time between cow comfort and hygiene.

VET

We decided to really focus on mastitis as a major cost issue approximately 18 months ago enlisting the help of our vet Chris Myerscough. His involvement has been, and continues to be, very useful in applying a structured approach to dealing with the disease. We now meet quarterly to review the situation and prepare a plan of attack for the coming quarter. His approach has been simple in that he tells us we need to know what pathogens we are dealing with by regular sampling of clinical cases to treat them. We manage the environmental exposure by keeping everywhere clean and dry. Do this and you have got a good chance of reducing the burden on the cow.

We also enlisted the help of Ian Ohnstad who came to the farm to look at what we were doing (and not doing). The best advice he gave us was to study the information we had collected in greater detail and a more managed fashion. We now look at cases in terms of which building they come from, the stage of lactation and cell count and clinical history. This has enabled us to isolate the issues that are contributing to this most complex disease. For example, his advice encouraged us to study the repeat cases in greater detail which lead us to using a different antibiotic resulting in a 40% reduction in repeat cases in a very short space of time.
CONCLUSION

In terms of controlling mastitis we probably commit three cardinal sins, which make the job harder than it should be in that it is a large, flying herd producing 10,000 litres plus per cow.

We have learnt, and learnt quickly, that you do not get away with anything in this situation. Attention to detail as in most things is the key to success. Cutting corners quickly leads to problems. What we have done since day one is to add routines to do the job properly. The benefit of a large herd is that all the problems are magnified and force you to do something about them whether your performance is average or not!

When you have got a problem such as mastitis it is all too easy to throw money at it in terms of the latest product of this, that and the other. Our experience is that quite often it is the manner in which you are carrying out the most basic tasks which causes the biggest effect. Routines are important to the point that a blueprint is created and all staff members need to adhere to that plan. It is often a case of 20% of what you do affects 80% of the result!

Setting goals and targets and critically monitoring them is as important with mastitis as it is with your cashflow. By doing this you have half a chance of getting to where you want to be and our current goal is no more than 5 cases of mastitis per week, which sounds a lot but equates to 24 cases per hundred cows. This brings clear benefits in terms of the cost of replacements, vets bill, milk yield and general sanity for all staff members involved!
THE BASIS FOR A LARGE HERD

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SUMMARY

Economic analysis of data on dairy herd production indicates that the larger the herd the lower the costs per unit of production. However, the search for economies of scale can be inhibited by the social and the non-production values placed on the resources needed for that increased scale of production. There are personal and psychological factors that are required for efficient production. These include Managerial, Perception and Personal qualities.

THE CONTEXT

Milk is essentially a commodity. It consists of water with added fat and minerals. It is called milk when produced directly by mammals. A similar product is produced when minerals and fat are added to spring water. The objective of dairy farming is to produce the commodity “milk” as cost effectively as possible.

A recent DEFRA funded survey (1) suggests that costs of production per litre are related to herd size.

\[
\text{Total Cost in pence per litre} = 47.35 - 6.1695 \ln(x)
\]

Where \( x \) is herd size in number of cows

The analysis of the data from the same survey calculated that Net Margin per litre was;

\[
\text{Net Margin in pence per litre} = -30.53 + 6.4867 \ln(x)
\]

Where \( x \) is herd size in number of cows

Tables 1 and 2 present the same core data related to various herd sizes. Table 1 presents the Total Costs per litre and Table 2 the Net Margin (margin overall incurred actual and imputed costs) per litre.
Table 1  Total Costs (pence per litre) for different sizes of Lowland Dairy Herds(1)

<table>
<thead>
<tr>
<th>Herd size</th>
<th>10-40 cows</th>
<th>41-70 cows</th>
<th>71-100 cows</th>
<th>101-150 cows</th>
<th>&gt;150 cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28.88</td>
<td>20.32</td>
<td>17.97</td>
<td>17.58</td>
<td>16.68</td>
</tr>
</tbody>
</table>

Table 2  Net Margin (pence per litre) for different sizes of Lowland Dairy Herds(1)

<table>
<thead>
<tr>
<th>Herd size</th>
<th>10-40 cows</th>
<th>41-70 cows</th>
<th>71-100 cows</th>
<th>101-150 cows</th>
<th>&gt;150 cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-10.30</td>
<td>-1.94</td>
<td>-0.03</td>
<td>0.87</td>
<td>1.48</td>
</tr>
</tbody>
</table>

Herd size tends to refer to the number of animals “housed and managed” as one unit. In economic terms “operational numbers”, i.e. the number of cows for which one is buying resources, and managing and selling commodities, may be a more useful calculation. This takes into account multiple herds, or herds where there is sharing of resource purchase and commodity selling, even if the animals are not housed as one unit. The DEFRA study had no herds over 350 cows. In a recent study by University of Nottingham (unpublished) the data collected suggests that further economies are still occurring at even larger operational numbers, Table 3.

Table 3  Total costs (pence per litre) for larger operational Numbers. (University of Nottingham (unpublished))

<table>
<thead>
<tr>
<th>Herd size</th>
<th>300-350 cows</th>
<th>350-400 cows</th>
<th>&gt;400 cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15.56</td>
<td>15.23</td>
<td>14.97</td>
</tr>
</tbody>
</table>

In order to elicit an idea of the attitudes and behaviours of managers the results of a number of focus groups and interviews conducted by the author are used. These involved either employees or active managing family partners, who were responsible for a relatively large number of animals, i.e. over 250 cows. This research looked at the satisfactions and objectives for the number of cows being managed, the inhibitors to expansion and the qualities necessary to make it all work.

WHY I AM GLAD I AM THERE IN THE BIG LEAGUE

“I have stronger buying power - I can considerably reduce my feed costs by ordering and buying in quantity.”

“By using contractors with large tackle I can get my silage costs down.”

“My staff can milk quicker, we can afford the latest parlour and do the job better. We can afford to have the spare parts on hand so quickly can solve
problems or failure in equipment. It is worth the dealer coming out, so I get good service, and I pay my bills.”

“We can have some specialisms in my staff, one likes machines the other cows, and I like to ensure cow health is the priority.”

“I have spare capacity if things go wrong, if one of my robots mis-functions I can at least put cows through one of the others. If I had one unit only I’d be in the s....”

“I can afford to computerise my records, use the automatic check lists and alerts, but above all I have time just to look. This is a good way of checking changes in cell counts etc., interesting what you can pick up if you have time.”

“There is no doubt every successful sector has now sought efficiencies and specialisation; Morrison’s do not have tonnes of stock in store, it comes in JUST IN TIME, saving money and space. Boots the Chemists do not run lorries, that is contracted to a specialist company. How did Eddie Stobart succeed if delegation to a specialist is not a sensible answer?”

“Working with cows gets boring, I need a team that can have proper relief, time off to recharge.”

“Disease control is better, we are not so tired, we can talk through problems, devise solutions and learn from each other. It is a loss of independence and individuality but the tasks are easier. We have time to do the jobs properly, cleaning for example. We check on one another too, this ensures quality is good.”

“I have time to check on welfare, animal behaviour, observing and reflecting.”

“I can run in-house training, my staff have the renewed expertise.”

“I will get better deals; in the future in collection of milk turn round time will be quicker, and it’s worth coming to collect, not just some drop in the bottom of the tank on a £50,000 lorry.”

“Cutting corners is what I am good at, trouble is which corners can you cut without knackering your tyres? However, now getting great at it, look at my margins.”

“I am in a position to cull cows that underperform or are disease prone, without too much negative effect on margins, a useful management tool.”
WHY I CANNOT GET WHERE I WOULD LIKE TO BE i.e. EVEN LARGER NUMBERS OF COWS

“Who in their right mind, in the contorted economic environment of farming, would put money into cows, better to do barn conversions, get into property, send kids to Law School, Business School or to be a Physiotherapist. Better still buy shares in a bottled water company. At any rate that last block of land was bought at some high price by that solicitor from Sheffield. It’s next to his house. He keeps horses, well his wife and kids do.”

“I need one size for efficiency in cows/person hour, one size for optimum bulk tank capacity, one size for maximum benefits on buying feed, and that ONE size is different for each! Lowest Common Multiple of all my requirements is 450 cows..can I get there, can I heck... land is too dear.”

“I can manage more cows, not like expanding a factory, just cannot get the space, market distorted by these family farms who do not know their costs and do not take a sensible pay, means I cannot expand.”

“I know how to control costs, but scale inhibited by land ownership emotions distorting productive capacity.”

“Family labour that is not paid means they have some money in bank and this distorts value of quota, it’s too high.”

“Just too many producers, we have no power or influence. Few want to co-operate and they are willing and able to maintain independence even if losing the potential economic gains. CAP doesn’t really help us, the efficient and motivated.”

WHAT I AM

There is much literature on the sort of skills required (2, 3). This paper presents self-report descriptors from those working with large numbers of cows.

MY MANAGERIAL QUALITIES

“I am highly focused.”

“Good at communication.”

“I am totally decisive.”

“Paying full attention to detail, that’s me.”
“I have time to use my skills and focus on the crucial issues, I am not running around like a headless chicken, I am organised.”

“Communication with staff is what it is about, I can do that.”

“I like making decisions, I am good at that, I could succeed in any sector, not just cows. I just like cows. Too much emphasis is placed on the system, that is not important - what is important is the way I run it. A person who can sell cars can sell computers, the bloke who runs Trentbarton buses, the most successful bus company, could run a successful chain of shops.”

“Money is made by putting the customer first and paying attention to the small things, often not costing much. The customers are my cows the rewards from the detail.”

**MY PERCEPTUAL QUALITIES**

“I see things with complexity, the context and the detail.”

“I apply logical search mechanisms.”

“I am an observer and detective.”

“If I see a picture I see it as very complex, see all sorts of things. My failing predecessor saw it all too simple, black and white.”

“I search logically, step by step, too many just jump in and make changes. I follow a research type methodology testing one thing at a time, all too complex otherwise, do not remember what has changed.”

“Easy to get involved in the detail, need to see the full picture how the detail fits in, not just the windows but how the windows suit the house.”

“You need eyes everywhere, noticing very small changes, like a good detective, is what it is all about.”

**MY PERSONAL QUALITIES**

“I am self-confident and self-contained.”

“I accept the value of ritual.”

“I have belief in system.”

“I’m possessive and proud.”

“Positive, that’s me.”
“Rejecting of the vernacular knowledge is the way.”

“Risk taking gets you there.”

“Taking time off is the key.”

“Actually I enjoy a bit of the ritual, I do things because of it, even if not always sure why. I will soon challenge and work out why.”

“I totally believe in what I am doing, I will make the large herd work.”

“I am very possessive and proud.”

“You need both rain and sunshine to make a rainbow, you need to think the positive otherwise it gets you down. The best bird song is after the rain.”

“The old wives’ tales are the scourge of farming, some are ok, most are rubbish. The trouble is sorting them out.”

“I am a risk taker I take risks in life, no good just hiding.”

“I take time off, getting away is the best way of solving problems, never solved by looking or staring at it”.

“I am not bothered a toss by what people think of me, I know that I am a damn good manager.”

CONCLUSIONS

The managerial skills may be present but the economic opportunity to fully exploit these skills is inhibited by many other factors. For example, the value of land and buildings which have aesthetic, security and status values over and above their productive value. In addition the relative weakness of the many producers, being generally small, inefficient and independent means they are put successfully under pressure by the commodity buyers who are large, efficient and highly skilled and hence highly powerful.

REFERENCES

MILK QUALITY CONSULTING ON LARGE DAIRIES

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All dairies, large or small, would be happy if they could buy that certain piece of milking equipment, or teat dip, to resolve current and prevent future mastitis problems. In over 30 years of doing milk quality work, I am still waiting too.

As dairies get larger, the manager has to learn how to deal with hired labour, operate increasingly sophisticated equipment and stay profitable. World-wide research shows that dairies that produce quality milk have healthier herds and are the most profitable. The larger dairies cannot afford to ignore the importance of milk quality, or they risk operating a dairy that is not profitable.

Large dairies require a different approach to that of the small family-operated dairy. In many cases in large dairies, the people making the decisions are not the same people who are doing the work. The senior management or owners are easily excited about making the necessary changes to improve, but the expected results are often not realised because the message of requirements is not properly passed down to the people actually doing the task at hand.

One of the biggest challenges that I face as a consultant veterinarian is to first evaluate the dairy completely. This includes evaluating milking routine, examining the milking equipment at milking time, and assessing the interactions between the cow and her environment. I call this the “Mastitis Triangle”. I have found one of the single biggest reasons that milk quality programmes fail is because the consultant does not look at the whole picture. It does not make any sense to change milking routine if the cows have badly damaged udders, nor does it make any sense to add new milking equipment if the milking routine is bad, or the cows are kept in a dirty environment. The highest level of success comes when someone evaluates the whole picture and then puts together a well organised and prioritised plan for the dairy.

The milking routine is one place where change can be made with minimal investment yet yield some of the most valuable results. Having the proper milking routine can improve milk quality by lowering cell count and clinical mastitis, can speed up milking, and increase milk production. The key is to have a consistent milking routine that every person milking the cows can and will follow. Cows are creatures of habit and they respond best to consistency: they dislike constant change. I always recommend that the milking routine is printed out on a poster and mounted in the milking parlour so there is a constant reminder of what is normal. I think having the routine posted is good for the owners and managers as much as for the
milkers because they can quickly see if the normal routine is being followed. Once the milking routine has been evaluated and the changes are presented, the most important step is to assign someone to train the milkers how to do the new routine. The vast majority of my time is spent going to the large dairies on a quarterly basis to train people. Many people need constant fine tuning and the larger dairies tend to have employee turnover all the time.

I try to keep all milking routines simple. In the larger dairies, people work long hours and do get tired. I have found that having a simple two-step approach works best. All my milking routines, whatever herd size or parlour type, are designed around having the correct lag time. In the USA we define lag time as the time from stripping fore-milk from each teat to unit attachment. The old, industry gold standard was to have a lag time of 60 seconds. Our new data and experiences are showing this lag time may be too short. One of the leading causes of poor teat end health is over-milking the cow at the beginning of milking. If units are attached to empty teats, this is really over-milking. By having a longer lag time, there is time for oxytocin to do its magic and assure good milk let-down. The lag time we are looking for on dairies is 90 to 140 seconds. By doing this, the herds are milking faster, there are fewer unit reattachments and the teat ends are staying much healthier. Data from Germany has shown that the more times a day the cow is milked, the longer the lag time should be. Most of our larger dairies are milking 3 times a day with many now trying 4 to 6 times a day in recently calved animals.

The first step in the milking routine I implement is to strip 2-3 squirts of milk from each teat and then pre-dip the teat making sure at least 90% of the teat is covered. This method is repeated on 4 to 8 cows depending on the speed of the milkers. After the group of cows have been stripped and pre-dipped, the milker then goes back to the first cow of the group and wipes the teats dry and attaches the milking unit. This is repeated until all the cows in the group are milking. An important part of this step is drying the teats. It is critical if a dairy wants to produce quality milk to dry all four teats, then flip the towel over and wipe the teats and teat ends clean. One of the biggest failures on a dairy is getting the milking employees to properly clean the teat ends. The drying process provides physical stimulation to the teat and removes the most bacteria from the teat skin and teat end. In our large dairies, over 90% use a single, dry, cloth towel per cow.

As the units come off, the teats are dipped with an effective teat dip. The secret to teat dipping success is to make sure at least 90% of the teat is covered with dip. The milking machine is one of the best washing machines ever invented and bathes the teats during milking. The reason coverage is so important is to make sure the milk film on the teat after milking is replaced with a layer of disinfectant.

I work with dairies milking as few as 20 cows and other dairies milking more than 20,000 cows. All dairies, regardless of size, can achieve the best
quality milk and fastest milking by using a complete milking routine. The bottom line is simple, if you want to milk cows fast and produce quality milk, you will carry out a full routine. When a dairy farmer tells me they do not have time for a complete routine, I show them that they do not have time not to perform a full routine.

A tremendous tool to use to evaluate timing and let-down is the Lactocorder from Switzerland. This tool shows the let down curve and flow rate of cows. Often I let the results of the Lactocorder do the convincing that a change is needed. If cows are properly prepared, they should give at least 7 kg of milk in the first two minutes. My best dairy is averaging 8.6 kg in the first two minutes.

If cows are not reaching this level of milk in two minutes, there is a problem with the milking routine, timing, or milking equipment. On the dairies I work with, another key number is the peak milk flow. The goal I set is to have a peak flow of 4 kg per minute or higher. It is not uncommon to see high production groups average 5.25 kg per minute at peak flow. I like to have the dairies monitor the time in low flow so you can have some idea if cows are being over-milked or they are dribbling milk rather than having a good let-down. I like to see the time in the low flow period as less than 20 seconds. By having some numbers to monitor you can quickly determine if your herd is on target or has some work to do.

The milking equipment is the work horse of a dairy. The hardest concept for most dairy farmers to understand is the more hours a day the parlour operates, the faster it will pay for itself. On most of my large dairies there is never a problem with this concept. The bigger challenge is to figure out how to get all the cows milked within the 24 hours in the day. A major reason some of the new large dairies have failed in the US is because they spent too much capital for the number of cows they milk. The milking parlour is a major capital investment for any dairy and often it is bought with the dairy farmer in mind rather than the profitability of the dairy farm. More and more of the mid-sized dairies are realising the need to add cows so the parlour efficiency is maximised.

I design many dairy facilities world-wide. I design the free stall barn and parlours for maximum cow comfort and for the best cost. I want my dairies to succeed because they did it right, rather than fail because they built a monument to themselves. One of the most difficult jobs I have is to stop dairy farmers from spending needless money on unnecessary bells and whistles. Ceramic tiles and stainless steel generally do not make any difference to milk production and milk quality. The key is to develop a plan and spend all the money where it will yield the largest returns. On many dairies I design a basic system, but use a flexible design so that extras can be added as cash flow allows.

As dairies become larger they think they must have meters to measure milk production. If the reason you are putting in meters is to know how much
milk your cows gave, do not spend the money. Most people do not realise that the majority of the larger dairies in the US do not have meters and can manage their dairies very well. The reason you want meters is so you have information to monitor the performance of your employees and not the performance of the cows.

One of the important components of the larger milking systems is Automatic Cluster Removal (ACR) systems. The purpose of the ACR is to make sure the cows are milked consistently every milking regardless of who is doing the milking. Unfortunately, there is much more to the picture than just having an ACR system. Recent studies we have conducted have shown we can affect the efficiency of a dairy dramatically by properly adjusting the ACR. Our study herds can reduce the average machine-on time from 6.8 minutes to less than 4.0 minutes on cows averaging over 40 kg per day. Most ACR units are factory set to come off when flow rate drops below 200 grams. Most of our systems are now set to come off at 1 kg of milk flow.

Changes are made slowly over time and each change is carefully monitored. The goal is to have a residual milk yield of 250 to 450 ml when the machine comes off. I find on many dairies the residual milk levels are often under 100 ml. When cows are milked too dry, the teat end health is often affected and milk quality also suffers. Another adjustable item in ACR systems is delay time. Once the flow rate reaches the set point, there is a count down before the cluster finally comes off. It was common to see ACR systems come from the factory set at 15 to 30 seconds. Most of our systems are now set at 1 to 3 seconds. Again, these changes are made slowly and each change is carefully monitored.

The level of vacuum in the cluster at peak flow rate affects milking speed. I really do not care what system vacuum is used, as long as the cluster vacuum during peak milk flow ranges from 36 to 42 kPa. One of the biggest beliefs of the dairy industry is that high vacuum causes poor teat condition. Our data show that the worse teat ends are as likely to be caused by low vacuum as high vacuum. Relatively higher claw vacuums, with aggressive ACR settings, will shorten machine-on time, keep teat ends healthy and improve the overall efficiency of the dairy.

The last part of the equation for success is to make sure the cows are comfortable 24 hours per day. The cows must have access to feed and adequate water at all times. Many dairies fail to reach their production goals because of limited water intake. All my clients are required to have in-line water meters, so water intakes can be monitored daily in each group of cows. I know the nutritionists won’t like this, but no-one has any secrets for balancing a dairy ration. In fact, most nutritionists are basically using the same balancing programs. The reasons most dairies do not have the milk production they want, is because cows are not drinking enough water or they do not have comfortable housing and beds.
A cow has to be kept clean, dry and comfortable. If this can be done, milk production and milk quality will not be an issue. Many of my large dairies are now housing the cows in free stall barns. I have learned that the most important part to the design of a good free stall is to have the proper divider. In order to reduce the injury and cull rates in dairy cattle and keep cell count low, the cow must have the ability to lunge in three directions. She needs to be able to lunge forward without any restriction, as well as to either the right or left. New data shows that herds that have proper side lunge have the lowest cell count and lowest cull rates. The dairies that I design have a maximum distance from the cow's bed to the top of the lower side bar of 25 cm. If it is possible, I prefer 20-22 cm as the ideal height for the side bar.

At every milking the alleys need to have the manure removed, the stalls need to have wet spots removed and levelled, and all cross alleys must be cleaned. The less manure the cow has to splash on her legs, the less risk there will be of new environmental infections.

Every dairy farm, regardless of size, will benefit by producing quality milk. It is not unusual to have dairies shipping over 100,000 kg of milk to the factory each day to average fewer than 125,000 cells/ml. It is not the size that makes the difference; it is the attitude of the managers and staff.
A MICROBIOLOGICAL SURVEY OF COW TEATS

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SUMMARY

Thirty seven farms were visited during morning milking between June and October 2003. A variety of herd management and cleaning practices were recorded and teat end swab samples were analysed for total viable count (TVC), Listeriae, staphylococci, coliforms, streptococci, aerobic and anaerobic spores. The cleaning treatments reduced the microbial load on the teats by up to 93%; however further work is required to compare the efficacy of the methods.

INTRODUCTION

Teat hygiene is one of the factors influencing the microbiological quality of milk. In order to assess the effectiveness of teat cleaning methods, the current pre-milking cleaning regimes and herd management practices were established. This involved visits to 37 farms where practices were observed and the microbiological load of the teats was assessed before and after cleaning. Details of parlour and herd management, and pre- and post-milking teat treatments were recorded. Teat ends were sampled before and after pre-milking treatments and assessed for TVC, Listeriae, staphylococci, coliforms, streptococci, aerobic and anaerobic spores. The data were analysed to assess any relationship between cleaning treatments and effectiveness, and to form the basis of further controlled studies on the effectiveness of selected commonly used cleaning methods.

MATERIALS AND METHODS

A questionnaire was sent to 1000 farms and from those that responded, 37 farms were selected for inclusion in the microbiological survey. Parlours included the common herringbone, rotary, robotic and abreast types. Farms were visited during morning milking between June and October 2003. Details of pre- and post-milking teat treatments were recorded and teats were scored for health and hygiene. Teat ends (n=20) were swabbed before (rear L or R teat) and after (rear R or L teat) pre-milking cleaning treatments and the swabs immersed into 5 ml recovery medium for transportation in a cool box to the laboratory. Swabs were vortexed and spiral plated for TVC (Tryptone soya agar, 37°C 24 h), and spread plated for Listeriae (Listeria selective agar, 37°C 24 h), staphylococci (Baird Parker, 37°C 24 h), coliforms
Institute for Animal Health

(MacConkey agar 37°C 24 h), streptococci (Edwards agar 37°C 24 h), aerobic and anaerobic spores (TSA 30°C 2 days aerobic, or anaerobic).

RESULTS

Cleaning practice

Cows were only washed when very dirty by 47% of farms. The majority of farms used only water for washing (87.1%) with 9.6% using a disinfectant and 3.2% using a detergent. Fifty one percent of farms fore- milked all the cows. A variety of pre-milking dips and sprays were used (40.5% of farms). Medicated wipes were used by 18% of farms visited. Post-milking, 40% of farms used a spray and 43% used a dip.

Microbiological survey

The overall mean counts (for all farms) before treatment, after treatment and the difference (after-before) are presented. The mean log_{10} TVC before treatment was 4.762 (range 2.610 to 6.561) and after treatment was 4.595 (range 2.610 to 6.561). This population was mainly due to staphylococci and aerobic spores. There was no significant correlation between mean teat TVC and mean teat hygiene score, although the cow teats were generally visibly clean (overall mean teat hygiene score 1.4). Cleaning was found to reduce the TVC by up to 93% and cleaning effects were observed for all organism groups except Listeriae, which were present in very low numbers.

DISCUSSION

The survey was conducted during a relatively dry period that may have resulted in cows being generally visibly clean and explains the low levels of coliforms detected. As visible teat cleanliness did not relate to TVC, this would indicate that cow teats should be cleaned whether visibly dirty or not. The mean microbial load before cleaning was 4.762 and mainly comprised aerobic spores and staphylococci. Cleaning effectiveness was variable but reductions in TVC and staphylococci appeared to be associated with herds where disinfectants were used as a pre-milking treatment.

CONCLUSIONS

The microbial load on cow teats was variable and the results show that cleaning treatments can reduce this population. However, controlled studies are ongoing to assess the effectiveness of a variety of cleaning treatments.

ACKNOWLEDGEMENTS

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INVESTIGATION OF THE EFFECTIVENESS OF PRE-MILKING TEAT CLEANING REGIMES DURING A WINTER TRIAL

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SUMMARY

The effectiveness of four pre-milking teat cleaning regimes on teat hygiene were assessed. The regimes were: 1) dry wipe; 2) iodine dip; 3) hypochlorite with glycerine wash; 4) alcohol based medicated wipe. Effectiveness was assessed by the reduction in total viable count (TVC) of teat end swabs taken before and after cleaning. Ten cows per regime were assessed on four occasions on each of eight farms (four herringbone and four rotary) during a winter period (November–March, 2003/04). Of the regimes, the most effective at reducing TVC was the chlorinated wash and the least effective was the dry wipe for both herringbone and rotary parlours. The relative effectiveness of the dip and medicated wipe were dependent upon parlour type.

INTRODUCTION

Pre-milking teat cleaning is recognised as an important factor in maintaining milk hygiene and minimising the spread of mastitis. Previous work on non-controlled studies have assessed the microbial load on cow teats and indicated that cleaning reduces the microbial population to varying extents. The aim of this study was to assess the effectiveness of a range of commonly used cleaning regimes in controlled studies, in both herringbone and rotary parlours, during a winter season.

MATERIALS AND METHODS

Farms were visited for sampling during the morning milking between November 2003 and March 2004. Ten cows were selected per treatment per farm and the cleaning regimes applied by all farms were: 1) dry wipe; 2) iodine dip; 3) hypochlorite with glycerine wash; 4) alcohol based medicated wipe. All materials and chemicals were provided with detailed instructions for use. The left and right rear teat ends were alternately sampled by swabbing before and after the application of the cleaning regime. Following sampling the swabs were immersed in 5 ml of recovery medium then transported to the laboratory for analysis. Swabs were vigorously vortexed and plated onto tryptone soya agar (TSA) using a spiral plater and incubated for 24 h at 37°C. The time taken to perform each regime in both parlour...
types was measured on separate occasions, when microbiological sampling was not undertaken.

RESULTS

Before cleaning total swab $\log_{10}$ TVC ranged from 4.89-5.79 (average=5.33) across the parlour types and sampling visits. No statistic relationships ($p<0.05$) were evident in relation to swab count before cleaning, for cleaning regime or sampling visit throughout the trial period.

For each sampling visit and farm type, fewer bacteria were recovered after cleaning, irrespective of cleaning regime, the reduction ranging from $\log_{10} 0.12$-0.7 (average=0.50). For both parlour types, the most effective cleaning regime was the hypochlorite wash, which caused $\log_{10}$ reductions of 0.53 and 0.74 for herringbone and rotary parlours, respectively. These reductions were significantly different ($p<0.05$) from the least effective cleaning regime which was the dry wipe, with $\log_{10}$ reductions of 0.32 and 0.33, for herringbone and rotary parlours, respectively. Average $\log_{10}$ reductions for the dip were 0.51 and 0.43 for herringbone and rotary parlours respectively, and 0.46 and 0.68 for the medicated wipe regime for herringbone and rotary parlours respectively. The average $\log_{10}$ reductions for the dip and medicated wipe regimes were significantly ($p<0.05$) greater than for the dry wipe.

The relative time taken to perform each regime was: wash>medicated wipe>dip>dry wipe, for both parlour types, although in general, they were performed more efficiently in the herringbone parlours.

DISCUSSION

All cleaning regimes reduced the microbial load on teat surfaces and consequently reduced the contaminants available to pass into raw milk and potentially reduce the pathogens capable of causing mastitis.

The use of cleaning regimes containing a disinfectant solution were significantly better at reducing the microbial population of cows teats than a dry wipe. The extent to which this is a consequence of the presence of the disinfectant, or possibly the method of application is, however, unclear and the subject of further study.

The time taken to undertake a cleaning regime is an important factor when considering the overall cost effectiveness of a procedure. In this study, although the washing procedure was the slowest to perform, it did effect the greatest cleaning. This procedure was considered by milkers to be practical in the herringbone parlours, but to be too time consuming for use in the rotaries. Consequently, the quicker, although slightly less effective medicated wipe may be more suited to rotary parlours.
CONCLUSIONS

The pre-milking teat cleaning procedures investigated reduced the potential sources of bacterial raw milk contamination and mastitis-causing pathogens.

ACKNOWLEDGEMENTS

The work was funded by the Food Standards Agency.
A COMPARISON OF SOMATIC CELL COUNTS BETWEEN FIRST AND SECOND LACTATION HOLSTEIN-FRIESIAN AND NORWEGIAN DAIRY COWS, ON NORTHERN IRELAND DAIRY FARMS

J.A. McKeague, C.P. Ferris, D.C. Patterson and H.C.F. Wicks
Agricultural Research Institute of Northern Ireland, Hillsborough, Co. Down BT26 6DR

SUMMARY

Somatic cell counts (SCC) for Norwegian (NRF) and Holstein-Friesian (HF) dairy cattle were compared during their first and second lactations, in a study conducted on 19 Northern Ireland dairy farms. NRF dairy cattle had significantly lower SCC during each lactation. The large weighting for mastitis resistance within the NRF breeding programme is likely the key reason for this difference in SCC.

INTRODUCTION

In contrast to the Holstein-Friesian (HF) breed, Norwegian dairy cattle (NRF) have been selected using a multi-trait selection programme for approximately 25 years. For example, the current weighting for mastitis resistance within the NRF breeding programme is 22%. As the incidence of mastitis within Norway continues to decline, there is increasing interest in the NRF breed as a means of overcoming some of the health problems experienced within the HF population. For this reason, NRF dairy cattle are currently being evaluated on Northern Ireland dairy farms in a study that involves a comparison with animals of the HF breed. This paper examines the effect of dairy cow breed on SCC during lactations 1 and 2.

MATERIALS AND METHODS

Two hundred and fifteen NRF dairy cattle were imported into Northern Ireland as maiden heifers (3–15 months old), and placed on 19 commercial dairy farms (11 or 12 animals/farm). These animals had a mean total merit index (TMI) of 10.1. An equal number of ‘home bred’ HF animals of similar ages were selected on each farm. More than 25 sires were represented within each breed. On each individual farm, animals of both breeds were subject to the same rearing and management regimes post-calving. However, each farm followed its own rearing, feeding and management regime. The 19 participating farms were selected to cover a range of production systems, and represented both spring and autumn calving herds. A total of 178 HF and 194 NRF animals have now completed their first lactation, while a further 125 HF and 147 NRF animals have completed their second lactation. SCC data presented here came from monthly milk
recording data obtained from official milk recording schemes. Monthly SCC data were statistically analysed using repeat measure ANOVA.

RESULTS AND DISCUSSION

First lactation 305-day milk yields were 5632 and 5894 kg for NRF and HF animals respectively (P>0.05), while second lactation 305 day milk yields were 6208 and 6661 kg respectively (P>0.05). Throughout each of lactations 1 (Figure 1a) and 2 (Figure 1b), animals of the NRF breed produced milk with a significantly lower SCC count than animals of the HF breed (P<0.001). The effect of stage of lactation was also significant within each of the two lactations, with SCC increasing as each lactation proceeded. A significant (P<0.001) breed x time interaction was observed in lactation 1. The lower SCC with the NRF breed is likely a reflection of the multi-trait selection programme that has been used in Norway for approximately 25 years.

Figure 1 Changes in SCC with NRF (■) and HF (□) dairy cows during their first (a) and second (b) lactations

CONCLUSION

When compared with animals of the HF breed, NRF dairy cattle produced milk with a significantly lower SCC during both their first and second lactations. This difference is likely due in part to the very different breeding programmes within which the two breeds have developed.

ACKNOWLEDGEMENT

This study was co-sponsored by DARDNI and AgriSearch.
RELATIONSHIP BETWEEN MILK FLOW RATE AND SOMATIC CELL COUNTS IN TWO BREEDS OF DAIRY CATTLE

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INTRODUCTION

First lactation Holstein-Friesian (HF) dairy cows have higher milk somatic cell counts (SCC) compared with Norwegian (NRF) dairy cattle; the latter also having significantly slower milk flow rates (MFR) (5). However, it was difficult to assess whether the lower SCC in NRF cattle was due to lower milk production capacity, or as a result of the inclusion of health traits in the selection criteria for NRF cattle. The aim of the current work was to examine the relationship between MFR and SCC in HF and NRF dairy cattle in an attempt to explain the reasons for the differences in SCC observed.

MATERIALS AND METHODS

Records from a three year study (1, 2, 3 and 4) of spring calving cows that were either on low, moderate or high input systems, were used to investigate the relationship between MFR and SCC for HF and NRF dairy cattle. Milk yield, MFR, SCC, parity and stage of lactation data from 312 cows were collated. Multiple regression analysis was undertaken to quantify the effects of MFR and milk yield on SCC and to investigate any significant interactions between breed and MFR or breed and milk yield. SCC were transformed to the natural logarithm (lnSCC). Average (a) and peak (p) MFR (kg/min) were included in the model in sequence and the model was developed for 1-100, 101-200, 201-305, 1-200 and 1-305 days of lactation.

RESULTS

Mean 305-day milk yields for the HF and NRF cattle were 6939 (3760 to 11376) kg and 5977 (2892 to 8374) kg (s.e.d. 128.9) respectively. NRF dairy cattle had significantly lower lnSCC compared with HF cattle for the first and second trimesters of lactation and over 1 to 305 days. However, there was no effect (P>0.05) of breed on lnSCC for the third trimester of lactation (Table 1), furthermore lnSCC increased with parity (P<0.001). There was no interaction (P>0.05) between breed and parity. LnSCC was correlated with milk yield (P<0.001), peak MFR (P<0.01) and average milk flow rate (P<0.05) (Table 2). The relationships between lnSCC and milk yield, breed and MFR were more significant in later lactation. No significant interactions (P>0.05) were found between breed and milk yield or MFR.
**DISCUSSION AND CONCLUSIONS**

The relationships between MFR, expressed as either peak or average, and SCC were similar for both HF and NRF dairy cattle. NRF cattle had lower lnSCC compared with HF cattle, even when the effects of yield and MFR were taken into consideration. Consequently it appears that the lower lnSCC in NRF dairy cattle may be due to genetic selection for reduced incidence of mastitis in NRF dairy cattle.

### Table 1  Effect of breed (B) and parity (P) on the natural logarithm of somatic cell count (lnSCC)

<table>
<thead>
<tr>
<th>Stage of lactation (days)</th>
<th>Breed</th>
<th>Parity 1</th>
<th>Parity 2</th>
<th>Parity 3</th>
<th>Sig.†</th>
<th>B</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holstein-Friesian</td>
<td>4.199</td>
<td>4.044</td>
<td>4.007</td>
<td>3.954</td>
<td>4.503</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Norwegian</td>
<td>0.0541</td>
<td>0.0468</td>
<td>0.0959</td>
<td>0.0429</td>
<td>0.0656</td>
<td></td>
</tr>
<tr>
<td>1-100</td>
<td></td>
<td>4.802</td>
<td>4.515</td>
<td>4.164</td>
<td>4.473</td>
<td>5.233</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0438</td>
<td>0.0389</td>
<td>0.0811</td>
<td>0.0352</td>
<td>0.0531</td>
<td></td>
</tr>
<tr>
<td>101-200</td>
<td></td>
<td>5.247</td>
<td>5.143</td>
<td>4.470</td>
<td>5.016</td>
<td>5.936</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0319</td>
<td>0.0305</td>
<td>0.0585</td>
<td>0.0270</td>
<td>0.0402</td>
<td></td>
</tr>
<tr>
<td>201-305</td>
<td></td>
<td>4.807</td>
<td>4.628</td>
<td>4.214</td>
<td>4.538</td>
<td>5.318</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0244</td>
<td>0.0222</td>
<td>0.0444</td>
<td>0.0200</td>
<td>0.0299</td>
<td></td>
</tr>
</tbody>
</table>

†No significant breed by parity interactions

### Table 2  Models to predict somatic cell count (lnSCC) for Holstein-Friesian and Norwegian dairy cattle (1-305 days of lactation, peak milk flow rate model)

<table>
<thead>
<tr>
<th></th>
<th>Holstein-Friesian</th>
<th>Norwegian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parity 1</td>
<td>+ 3.8690</td>
<td>+ 3.6904</td>
</tr>
<tr>
<td>Parity 2</td>
<td>+ 4.1929</td>
<td>+ 4.0143</td>
</tr>
<tr>
<td>Parity 3</td>
<td>+ 4.9732</td>
<td>+ 4.7956</td>
</tr>
<tr>
<td>LnSCC</td>
<td>= 0.005737LD - 0.0000929MY + 0.0356pMFR</td>
<td>Model R² = 0.28 (P&lt;0.001)</td>
</tr>
</tbody>
</table>

Where LD = day of lactation; MY = 305-day milk yield (kg); pMFR = peak milk flow rate (kg/min)
REFERENCES

WHY DO BULK MILK SOMATIC CELL COUNTS INCREASE IN SUMMER? A preliminary report

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² Department of Clinical Veterinary Science, University of Bristol, Langford House, Langford, Bristol BS40 5DU

SUMMARY

To investigate possible reasons for the reported summer increase in national herd bulk milk somatic cell count (SCC), statistical models were constructed using 41,726 individual cow SCC recordings. The results indicated that more chronic infections (fewer cures) and a small general upward creep in SCC were responsible for the rise in SCC. An increase in summer bulk milk SCC being caused by an increase in apparent new infections was not seen, in fact this occurred more in winter.

INTRODUCTION

For many years there has been a trend in the UK for dairy herd bulk milk SCC to rise in the summer months. This is illustrated in Figure 1 using data from the MDC website (www.mdcdatum.org.uk).

Figure 1  MDC National Dairy Herd bulk milk SCC date

WHY DOES THIS OCCUR?

Suggestions have been made, including:

- An increased incidence of new infections in summer
- A calving pattern effect – more cows in late lactation (with higher SCC) in summer
- A general rise in all SCC because of some ‘stress’ (e.g. heat, nutritional or behavioural) associated with being at pasture

**MATERIALS AND METHODS**

The aim of the study was to investigate patterns of cow SCC in herds that fitted the typical pattern of bulk milk SCC described above, and to identify the reason for the summer rise. A total of 41,726 SCC records from 5,386 cows in 33 herds were used for statistical analysis. Monthly milk records from April 03 to March 04 were used for analysis. The total number of cells produced by each cow at each monthly recording was estimated as:

- Total number cells = Somatic cell concentration (per ml) x Milk Yield (ml)

At each monthly recording, cow SCC were categorised into nine categories that described the change from the previous SCC. These categories are shown in Table 1, below:

**Table 1**  SCC recordings defined according to the change from previous SCC

<table>
<thead>
<tr>
<th>Previous Recording SCC (per ml)</th>
<th>Current Recording – SCC (per ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-100,000</td>
<td>LL</td>
</tr>
<tr>
<td>101-200,000</td>
<td>ML</td>
</tr>
<tr>
<td>&gt;200,000</td>
<td>HL</td>
</tr>
<tr>
<td>1-100,000</td>
<td>LM</td>
</tr>
<tr>
<td>101-200,000</td>
<td>MM</td>
</tr>
<tr>
<td>&gt;200,000</td>
<td>HM</td>
</tr>
<tr>
<td>1-100,000</td>
<td>LH</td>
</tr>
<tr>
<td>101-200,000</td>
<td>MH</td>
</tr>
<tr>
<td>&gt;200,000</td>
<td>HH</td>
</tr>
</tbody>
</table>

Bayesian hierarchical statistical models were used to analyse the data.

**RESULTS AND CONCLUSIONS**

The model results are illustrated in the figure below. Summer months were defined as May to September inclusive. After accounting for effects of stage of lactation and parity, the number of cells contributed to the bulk tank in summer was higher than in the winter for cows with readings in the HH, HM, MH and LM groups.
The greatest difference between summer and winter was the number of cells contributed by the HH group and this indicates chronic infections were the largest contributor to higher bulk milk SCC in summer.

- Fewer cells came from cows in the LH group in summer than winter and this shows that new infections were less influential on bulk milk SCC in summer.
- Fewer cells came from cows with a large reduction in SCC (HL group) in summer than winter
- More cells came from cows with a small increase in SCC in summer (more cells from the LM and MH groups)

These results are consistent with more chronic infections (and fewer cures) and a small general upward creep in SCC in summer months compared to winter. An increase in summer bulk milk SCC was not caused by low SCC cows moving to become high SCC cows, in fact this occurred more in winter months. These SCC changes were identified after accounting for the effects.
DETAILED ANALYSIS OF SOMATIC CELL COUNTS FROM ROUTINE MILK RECORDING DATA

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² Vale Veterinary Centre, Tiverton, Devon

More than 40% of dairy herds in Great Britain participate in monthly milk recording schemes which provide somatic cell counts (SCC) for individual cows. These data are now commonly available to the farmer and veterinarian, via Email or the internet for importation into herd management software.

Existing milk recording reports describe the current cell count status of cows and highlight problem animals. More detailed analyses are required to extract information that can identify the key areas of infection, monitor cell count trends and highlight those cows requiring assistance at the earliest opportunity. A database application has been developed using Microsoft Access and InterHerd. The objective was to provide a practical system that supports the farmer and veterinarian to identify key problem areas and develop appropriate protocols for improvement.

Great emphasis is placed on comparing the latest SCC level of a cow with previous values. Four separate categories of cows with a “high” (normally >200,000 cells/ml) SCC reading have been produced:

- **New**: The first milk recording with a high SCC level in the current lactation (all previous SCC in the current lactation were below the threshold)
- **First**: The first milk recording in the lactation AND at a high SCC level
- **Repeat**: The SCC level is above the threshold level, not for the first time in the current lactation although the previous SCC was below the threshold.
- **Chronic**: The SCC level is above the threshold level, as it was at the previous milk recording

The system generates a series of reports and graphs describing the affected animals (Table 1 and Error! Reference source not found.). Further reports and graphs analyse the SCC levels at key times:

- **Dry period**: Comparison of the SCC at the end of the previous and start of the current lactation show the effectiveness of existing dry cow management.
- **Recovery**: The SCC level at the milk recording following a high reading can indicate levels of self-cure or persistence of infection.

## TABLE 1  Report detailing cows by SCC status at the milk recording

<table>
<thead>
<tr>
<th>Cows with SCC values &gt;200</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recording date:</strong> 28/7/04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Cow</th>
<th>SCC</th>
<th>(Previous SCC)</th>
<th>Parity</th>
<th>Day pp</th>
<th>Milk records &lt;200,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>This parity (to date) Last parity</td>
</tr>
<tr>
<td>(a) New</td>
<td>668</td>
<td>275</td>
<td>(104)</td>
<td>4</td>
<td>55</td>
<td>1 of 2</td>
</tr>
<tr>
<td></td>
<td>688</td>
<td>201</td>
<td>(124)</td>
<td>3</td>
<td>350</td>
<td>1 of 11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total (a) New: 2 (7%)</td>
</tr>
<tr>
<td>(b) First infected</td>
<td>177</td>
<td>2299</td>
<td>(na)</td>
<td>1</td>
<td>4</td>
<td>1 of 1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>482</td>
<td>(na)</td>
<td>4</td>
<td>15</td>
<td>1 of 1</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>207</td>
<td>(na)</td>
<td>1</td>
<td>8</td>
<td>1 of 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total (b) First infected: 3 (11%)</td>
</tr>
<tr>
<td>(c) Repeat</td>
<td>751</td>
<td>495</td>
<td>(64)</td>
<td>2</td>
<td>287</td>
<td>3 of 10</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>354</td>
<td>(79)</td>
<td>1</td>
<td>279</td>
<td>4 of 10</td>
</tr>
<tr>
<td></td>
<td>692</td>
<td>220</td>
<td>(181)</td>
<td>3</td>
<td>127</td>
<td>3 of 5</td>
</tr>
<tr>
<td></td>
<td>1006</td>
<td>205</td>
<td>(68)</td>
<td>1</td>
<td>602</td>
<td>4 of 19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total (c) Repeat: 4 (14%)</td>
</tr>
<tr>
<td>(d) Chronic</td>
<td>635</td>
<td>3068</td>
<td>(4839)</td>
<td>4</td>
<td>238</td>
<td>8 of 8</td>
</tr>
<tr>
<td></td>
<td>671</td>
<td>2606</td>
<td>(2225)</td>
<td>4</td>
<td>32</td>
<td>2 of 2</td>
</tr>
<tr>
<td></td>
<td>555</td>
<td>2026</td>
<td>(700)</td>
<td>5</td>
<td>216</td>
<td>7 of 7</td>
</tr>
<tr>
<td></td>
<td>698</td>
<td>1597</td>
<td>(4901)</td>
<td>3</td>
<td>37</td>
<td>2 of 2</td>
</tr>
</tbody>
</table>
Figure 1  Longitudinal display of SCC status of cows by milk recording date

[Diagram showing longitudinal display of SCC status by milk recording date]
HEALTH AND WELFARE OF DAIRY COWS IN ORGANIC MILK PRODUCTION SYSTEMS

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SUMMARY

We have recently started a new research project investigating the health and welfare of organic dairy cows. A major focus of this research will be on mastitis treatment and prevention in both organic and non-organic herds.

INTRODUCTION

In recent years there has been a large increase in the output and consumption of organically farmed dairy produce. The principles of organic farming are that animal health and welfare are promoted primarily by good management and care of animals. However, some of the regulations placed on organic farming may be compromising welfare, particularly those restricting use of veterinary medicines and levels and type of concentrate feed. Little information exists on the impact of the organic regulations on welfare that would allow organic farmers to respond to consumer concern and improve the well-being of their cows. If good management techniques and quality of care can reduce the incidence of disease, this information is also relevant to conventional management of dairy cows.

Mastitis is a major disease and welfare problem in dairy cattle. It has been estimated that about 25% of cows in dairy herds at any one time are affected by mastitis (3). A UK survey reported a high incidence of dry period mastitis and sub-clinical mastitis in organic herds in comparison with matched conventionally managed herds (2). Mastitis is also considered a major problem for organic herds in other European countries (1, 4). Mastitis is normally treated with antibiotics, with alternative means being less effective and often slower to take effect. Furthermore, routine antibiotic treatment of dairy cows at drying off is not permitted under the organic standards, but is one of the strategies used as part of the ‘Five Point Plan’ to control mastitis in conventional dairy herds.

To investigate the issue of cow health and welfare on organic farms, we will focus on 3 main issues:

- Prevention and treatment of disease (principally mastitis and lameness): Is disease risk higher in organic or non-organic systems? Is there a difference in recovery rate? Are some treatments or management practices more effective than others in controlling disease?
Is there evidence that modern dairy cows are metabolically less well adapted to organic than conventional dairy systems?

Are housing or husbandry conditions better in either system?

**METHODS**

Forty organic and forty non-organic farms from around the UK will be involved in the study, focusing on farms with Holstein-Friesian cows. Organic and non-organic farms will be matched into pairs based on genetic merit of cow, type of housing, geography and herd size.

A number of measures of health and behaviour will be taken on each farm:

- Incidence of mastitis and treatment given will be taken from farmer health records and somatic cell counts from milk recorder data.
- Cows will also be scored for lameness, presence of injury, skin disease and/or parasites.
- Metabolic profiles will be taken, along with an assessment of feed composition, cow body condition and farmer records of fertility.
- Levels of cow aggression, behavioural time budgets and response to an unfamiliar handler will be observed on farm.
- Measures of housing quality (e.g. bedding type, cleanliness), stockhandling and management practices will be taken to assess how these impact on cow health and behaviour.

**Outcomes**

The project will run until September 2006. It will provide information on the standards of welfare on both types of farms and the efficacy of the common forms of treatment. It will also give information on best practice on both organic and non-organic farms with respect to cow welfare.

**ACKNOWLEDGEMENTS**

This project is funded by DEFRA and is run in collaboration with the Soil Association, OMSCo, the University of Reading, Kingshay Farming Trust, and the Royal Agricultural College.

**REFERENCES**


COMPARISON OF HOMOEOPATHIC AND ANTIBIOTIC TREATMENT OF CLINICAL MASTITIS

K. Mueller
Queen’s Veterinary School Hospital, University of Cambridge, Cambridge CB3 0ES

SUMMARY

Eighty dairy cows with clinical mastitis received either antibiotic or homoeopathic treatment in a blind, randomised study. There was no significant difference between the two treatments in clinical cure after 14 milkings, at a follow-up examination one week later, cure rates were similar. Homoeopathy was significantly less likely to achieve a bacteriological cure compared to antibiosis. Subsequent udder health and milk quality were not affected by treatment.

INTRODUCTION

Organic herds are strongly encouraged to use, so-called, alternative medicines, and homoeopathy is one of the main therapies being used. Currently, there is little information on the effect and efficacy of homoeopathy. Reviews of human and veterinary studies suggest that there is a positive effect, but too little evidence for definite conclusions (1, 2, 3, 4) exists. Treatment with unproven therapies has potential welfare implications and economic consequences.

MATERIALS AND METHODS

Cows with clinical mastitis, but without signs of systemic illness, were selected from a 165-cow herd with a history of environmental mastitis. Homoeopathic remedies were administered as intra-nasal spray (dilution and dose calculated to give five drops of remedy) at milking time. Cows received the combination remedy BBU 30c (belladonna, bryonia, urtica urens) during the acute phase (usually once only), followed by phytolacca 10M at the next three milkings. The control group was treated with intramuscular ampicillin for three days. All cows were milked twice daily, with no additional stripping.

Clinical cure was defined as physically normal milk and a normal mammary gland, and bacteriological cure as the absence of any growth of the pathogen isolated from the pre-treatment sample.
RESULTS

Cure rates achieved by the two treatments are shown in Table 1 below. The odds ratio for homeopathy to achieve a cure was 0.43 (95% CI 0.17- 1.1) for clinical cure, and 0.33 (95% CI 0.12-0.9) for bacteriological cure.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Homeopathy</th>
<th>Antibiosis</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical cure (%)</td>
<td>14th milking</td>
<td>48</td>
<td>68</td>
<td>&gt;0.07</td>
</tr>
<tr>
<td></td>
<td>28th milking</td>
<td>56</td>
<td>69</td>
<td>&gt;0.3</td>
</tr>
<tr>
<td>Bacteriological cure (%)</td>
<td>14th milking</td>
<td>50</td>
<td>75</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td></td>
<td>28th milking</td>
<td>65</td>
<td>74</td>
<td>&gt;0.5</td>
</tr>
</tbody>
</table>

*Chi-Square

For pathogens other than *Streptococcus uberis*, the two treatments showed no significant difference in cure rates. For *S. uberis*, cure rates were significantly lower in the homoeopathy group.

No deterioration was evident in cows treated with homoeopathy based on clinical examination. There was no difference between the two groups in quarter recurrence rate, or number of cows with SCC exceeding 200,000 cells/ml at the next herd test.

DISCUSSION

The study deviates from classical homeopathy by applying a standardised treatment regime based on proven indications. This closely reflects the approach to homeopathy by an inexperienced person. The remedies used have been advocated as useful treatments for mastitis in literature available to farmers. No conclusions can, or should, be drawn on the efficacy of classic homeopathy based on the simile principle.

Without a negative or placebo group, it is not possible to assess the contribution of self-cure to the observed cure rates. Reported self-cure rates vary widely from marked deterioration to rates above those achieved by either homeopathy or antibiosis in this study.

Clinical observations did not give rise to welfare concerns for cows treated with homeopathy in this study.
REFERENCES


THE CALIFORNIA MASTITIS TEST – REAGENT AND OPERATOR VARIABILITY

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SUMMARY

To investigate possible variation between reagents and differences in user interpretation of the California Mastitis Test (CMT), eight operators, using four commercially available detergents and a bespoke CMT fluid, were compared in their ability to detect quarters with a cell count above a certain threshold. The results indicate that the sensitivity and specificity of the test was affected by the concentration and type of surfactant in the detergent, as well as by user interpretation.

INTRODUCTION

The California Mastitis Test (CMT) was developed in the mid 1950s as a refinement of the Whiteside Reaction. The test involves mixing detergent in equal quantity with raw milk – the mixture is then gently agitated and the reaction scored for gel formation. The surfactant present in the detergent results in lysis of the membranes of somatic cells in the milk; the subsequent release and denaturation of the DNA is responsible for the formation of the gel.

Commercially-produced CMT reagent has been available for many years. However, household detergents are commonly substituted on the basis of convenience and cost. The purpose of this study was to validate the use of different detergents and to investigate the influence of operator interpretation.

MATERIALS AND METHODS

Four, commercially available, ‘washing up’ detergents were mixed with water to achieve a consistency similar to that of raw milk. This involved diluting the detergents by between 1:4 and 4:1 (Reagent:Water). Red food colouring was added to aid visibility of the gelling reaction (0.5% vol/vol).

The four preparations were compared to a commercially available CMT reagent by assessing their reaction against a panel of 160 quarter milk samples from 40 cows. Eight operators scored the reaction on a scale of 0-3
(0 = no gelling, 1 = slight thickening, 2 = unmistakable gel formation, 3 = very marked gel formation (cannot be poured)). Five of the operators were experienced in the use of the CMT whereas three had no previous experience and worked from a standard operating procedure (SOP) provided. The four quarter samples from individual cows were always presented together in the same paddle, and were scored simultaneously by all operators. Both sample sets and reagents were randomised and all operators were blinded to sample identity and reagent. All samples were prepared for assessment by a third party. Data were analysed by categorising CMT scores as positive (score 2 or 3) or negative (score 0 or 1) and comparing their ability to discriminate correctly a sample as having a cell count above or below a threshold. Two SCC thresholds were assessed – ≥200,000 and ≥400,000 cells/ml, for the data overall and also for operator and reagent variability. SCC were determined by an accredited laboratory using the Fossamatic method. A general linear mixed model was used to compare the effects of reagent and operator.

**PRELIMINARY RESULTS AND DISCUSSION**

Across all reagents and operators the sensitivity and specificity of the CMT Test for detecting SCC above or below different thresholds is illustrated in Table 1.

**Table 1. Sensitivity, specificity, positive predictive value and negative predictive value of CMT score 2 or 3 at identifying quarter SCC above 200,000 or above 400,000 (All reagents, all operators (n = 6400))**

<table>
<thead>
<tr>
<th>SCC Threshold</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>ppv</th>
<th>npv</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;400,000</td>
<td>0.87</td>
<td>0.89</td>
<td>0.48</td>
<td>0.98</td>
</tr>
<tr>
<td>&gt;200,000</td>
<td>0.72</td>
<td>0.95</td>
<td>0.78</td>
<td>0.93</td>
</tr>
</tbody>
</table>

ppv = positive predictive value, npv = negative predictive value

**Operator Variability:** There was significant operator variability with sensitivity and specificity varying between 54% and 89% and 89% and 98% respectively.

**Reagent Variability:** There was significant reagent variability with sensitivity and specificity varying between 57% and 84% and 98% and 91% respectively. When compared to the bespoke CMT reagent, only domestic ‘Fairy’ proved to be not significantly different.
Typically the CMT is used to identify high SCC quarters in high cell count cows. For this reason the sensitivity of the test is probably more important than specificity – this would appear to preclude the use of ‘cheap’ own brand detergents for performing the tests. This study suggests that in order to optimise the detection of high SCC quarters, when in doubt the degree of gelling should be over, rather than under estimated. The cost of using ‘Fairy’ as opposed to CMT reagent was favourable (1p cf 12p per cow).

CONCLUSIONS

This research would appear to lend weight to the claim that Fairy ‘lasts longer’ and ‘performs better’ than cheaper alternatives!

**The Recipe:** Add one part Fairy to 4 parts water, add 0.5 ml of dark food colouring and gently agitate.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Milk Development Council (Project No 03/T2/07), which in part helped to fund the above study.
THE BENEFITS OF SAND BEDDING

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INTRODUCTION

Controlling environmental mastitis has become a priority on many dairy farms, particularly where yields have risen and contagious infections have been controlled, largely through the implementation of the Five Point plan. The Mastitis Management Action Plan acknowledges that limiting the challenge to the cow's udder by environmental pathogens is a major step in preventing environmental mastitis. As a consequence many producers in the UK are looking at bedding their dairy herd on sand, as opposed to organic beddings, such as straw and sawdust. The poster demonstrates the advantages of using an inorganic bedding material and the technical considerations required when using sand for bedding.

SPECIFICATIONS

- Fine, graded, washed sand, especially if it contains much clay
- Must be managed daily, as with any bedding type
- Store outside, on a well-drained site

BENEFITS OF SAND BEDDING

- Inert material, promoting limited bacterial growth
- Maintains teat cleanliness, easy to clean teats at milking
- Less environmental mastitis
- Can be stored outside
- Sand beds can be the most comfortable beds – fewer injuries, particularly trodden teats
- Provides good underfoot conditions - cows more confident and show bulling
- Labour saving – bedding put out 2 times a week
- Reduces the cost of new cubicle housing
LIMITATIONS OF USING SAND BEDDING

- Slurry handling – sand settles out in drains, blocks weeping walls, settles in slurry tankers, wears machinery
- Slurry scraped from passages is less solid
- Finite resource

THE FUTURE

In the US mechanical separators are used to separate sand from slurry, for re-use and for ease of slurry handling. So far this technology has not been perfected.
MILKING MACHINE TEST SURVEY

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² Genus Milking Systems, Stapley

One of the recommendations in the National Institute for Research in Dairying ‘Five Point Plan’ for mastitis control is a regular milking machine test. This is enshrined in good practice such that the National Dairy Farm Assured Scheme stipulates that an annual milking machine test be carried out.

Milking machines are tested by Genus Milking Systems staff throughout England, Wales and Scotland. An analysis was made of test reports for 1000 machines examined between January and April 2004, with no pre selection for machine make, configuration or size. The findings were compared with data collected between November 1996 and February 1997, from 2,500 similar tests in England and Wales. Milking machines were tested to determine compliance with either BS5545 or ISO5707.

In 1997, 70 per cent of machines failed one or more requirements of satisfactory performance compared with 61 per cent in 2004. The main reasons for failure in both surveys were vacuum line losses, inadequate vacuum reserve, inadequate drainage, incorrect site or accuracy of the vacuum gauge and excessive milk line losses. Faults due to pulsation problems were usually corrected at the time of the test and not recorded as a reason for failure.

Despite the National Dairy Farm Assurance Scheme stipulating that the milking machine perform properly as demonstrated in an annual test, most machines fail and it would appear that improvement has been woeful. It is necessary to determine not just that a machine has been tested but also that it complies with the appropriate standards. No farm can claim to be effective in mastitis management or be demonstrating appropriate animal welfare if milking machine performance is below what are only the minimal requirements of the international standards.
FORCES ON THE COW’S TEAT DURING MILKING

D. Boast, D. Turner and J. Allcock
Avon Rubber, Materials Development Centre, Westbury

The forces applied to the cow’s teat must be understood if the factors that control speed of milking and teat damage are to be addressed. If the forces are known then liner design can be improved or an informed choice made as to the best liner to suit particular milking conditions and cows.

The poster describes the forces imposed on the teat by the liner. Drawings are used to show the different conditions for open and closed liners. The mouthpiece of the liner is considered separately from the barrel. Understanding how the teat is loaded helps to explain its reaction. The deformations of the teat relate to teat health and the eventual udder health and milk quality.

The poster will also discuss what the forces mean with reference to failure criteria for teat tissue and some failure criteria leading to degeneration of the teat orifice are proposed.

The poster presents a simplified explanation for the relative layman rather than a detailed explanation of large strain elasticity.
ENHANCEMENT OF MILK PROTEOME INVESTIGATION IN DAIRY COWS WITH MASTITIS BY USE OF AN ISOELECTRIC FRACTIONATOR

P. David Eckersall¹, Christopher McComb¹, Caroline J. Hogarth¹,²
¹ Division of Animal Production and Public Health, Institute of Comparative Medicine, University of Glasgow
² Ciphergen Ltd, Guildford, Surrey

The protein component in milk from dairy cows suffering from mastitis is known to change considerably during the course of the disease. The normal components of milk, such as casein, α-lactalbumin and β-λactoglobulin, decrease. Other proteins increase in concentration such as albumin, which leaks from the circulation into the mammary gland, while others such as mammary associated serum amyloid A3 are newly synthesised in the gland. A variety of protein separation methods have been used in attempts to characterise the changes that occur in milk during mastitis and recently analytical tools developed for proteome analysis have been assessed (1). The objective of this study was to enhance the separation of the milk proteome by use of a novel approach to pre-treatment of milk samples.

Recent advances in the methodology to investigate the total protein content (proteome) of cells, tissues and biological fluids have defined the milk proteome. Furthermore, large differences can be observed in the protein separation pattern in milk from healthy cows compared to milk from cows with clinical mastitis (1) using 2-dimension electrophoresis (2-DE). However, when similar methods were used to investigate milk from cows with sub-clinical mastitis, few differences could be seen from samples from healthy cows. The presence of high abundance proteins obscured changes in proteins of similar isoelectric point and molecular weight. In addition, the standard approach to 2-DE is most effective for proteins of neutral or slightly acidic isoelectric point (pI), with changes in proteins and peptides with pI at the extremes of the pH scale being less obvious.

In this study an isoelectric fractionator (Zoom Fractionator™, Invitrogen Ltd, Paisley, UK) was used to pre-fractionate milk from healthy cows and milk from cows with mastitis into five fractions of differing pI prior to 2-DE. The effect of this modification on the investigation of the milk proteome during bovine mastitis was determined.

Samples of skimmed whole-milk from a healthy dairy cow and from a cow with sub-clinical mastitis were separated into isoelectric fractions using the Zoom Fractionator and then subjected to 2-DE over appropriate pH intervals (7cm IPG strips and a 8-16% polyacrylamide gradient (BioRad, Hemel Hempstead, UK), finally stained with Coomassie blue.

The major milk proteins, casein, β-lactoglobulin and α-lactalbumin were confined to two of the five IEF fractions (pH 4.6–5.3 and pH 5.4–6.1). In the
pH 4.6-5.3 fraction, these major proteins were present in both healthy and infected milk. In the pH 5.4-6.1 fraction there was an obvious reduction in milk protein component in the sample from the infected mammary gland. Major differences could be seen at the acidic and basic extremes of the pH range. Figure 1 shows the difference between control and infected milk in the acidic fraction (pH 3.1-4.5) after separation by the isoelectric fractionator and 2-DE over a pH range of pH 3-6. A group of small (<20 kDa) acidic (<pH4.5) peptides (arrows) were found in the acidic fraction of mastitic milk. Differences were also observed in the basic fraction of mastitic milk compared to the basic fraction of control milk with at least 5 extra protein spots appearing in the former.

**Figure 1** 2-DE gels pH 3-6 of acidic (pH 3.1-4.5) Zoom IEF fraction of normal and mastitic milk

This pilot study has demonstrated that pre-fractionation of milk protein prior to 2-DE can improve the separation of the milk proteome and could identify proteins or peptides which may have potential as markers of mastitis. Further investigations are needed to identify these proteins and characterise their appearance in relation to the stage of infection.

**REFERENCE**