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A study of mastitis in two small experimental dairy herds managed either organically or conventionally, during one year

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ABSTRACT

Mastitis infection status of two small herds located at the Dairy Cattle Research Unit of Massey University was assessed. Single quarter milk samples from 45 cows under organic production (first and second year of organic certification) and 50 cows under a conventional system were taken on four occasions: mid lactation (these samples were frozen); prior to the last milking before dry-off (season 2003/2004); before the first milking after calving and 14 days post calving (season 2004/2005). Milk samples were cultured for bacterial analysis. Somatic cell counts (SCC) from monthly herd tests, and clinical mastitis cases were recorded and analyzed.

The percentages of quarters with positive bacterial growth, and SCC, were generally higher in the organic herd, but differences were only significant for *Staphylococcus aureus* in all four sample periods, and for *Streptococcus spp.* 14 days post calving. The results suggest that in organic herds *Staphylococcus aureus* infections could become an important concern, because of constraints on the use of antibiotic treatments. Effective prevention of infections by this organism will be essential, in order to prevent high culling rates.

Keywords: mastitis; organic dairy; New Zealand.

INTRODUCTION

Interest in organic milk production systems is growing in New Zealand (NZ), with Fonterra Cooperative Dairy Company now seeking an increase in organic milk supply, for which it is offering a premium milk price.

Mastitis, probably the most costly disease in dairy cattle, represents a particularly important ongoing problem in organic herds, because use of antibiotics is prohibited or tightly circumscribed in these herds. There is little information about mastitis in organic herds in NZ and most of the available research data comes from the Nordic countries and the United Kingdom, where infection patterns and common treatments have been analyzed (Vaarst & Enevoldsen, 1997, Busato *et al.*, 2000, Hardeng & Edge, 2001).

In conventional herds in NZ, mastitis is managed on the seasonal basis of calving in spring and drying-off in autumn, where most of the infections through the dry period and at calving are due to *Streptococcus uberis* (Woolford, 1997). Data from recent trials give importance to coagulase negative staphylococcus (CNS) and *Staphylococcus aureus* infections (Williamson *et al.*, 1995, McDougall, 1998)

The present study analyzed data from two small research herds, on two separated farmlets located side by side at Massey University; one was managed conventionally and the other was in its first and second year as a fully certified organic system, from mid lactation until the early stages of the following lactation.

The aim was to provide a detailed and comprehensive description of the mastitis status of cows in the two herds over the critical periods of lactation.

Results from the previous year, before full certification, showed a slightly higher somatic cell count for the organic herd, but with no significant differences between herds. In addition, prevalence of clinical mastitis was similar in both herds with 16% in the organic and 14% in the conventional herd, but with no bacteriological data (Lopez-Villalobos *et al.*, 2003).

MATERIALS AND METHODS

The herds

The farmlets were located at the Dairy Cattle Research Unit, Massey University, on Tokomaru silt loam soils. The two herds were predominantly Holstein Friesian cows of mixed ages (4.3 and 4.9 years average for the organic and conventional herd respectively in season 2003/2004). These were divided at the end of season 2000/2001 based on breeding worth, age, size, SCC and production into two even herds. The organic farmlet has been managed according to organic principles since July 2001 and achieved full Agriquality certification in August 2003. Homeopathic remedies were used to assist in the control of mastitis, and persistent clinical cases were treated with antibiotics and then quarantined as required before allowing their production into the vat. At times, the milk from cows or quarters that were known to have a high SCC was not allowed to enter the milk vat, in order to prevent the

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herd's bulk milk SCC rising to levels above 400,000 cells/ml, the penalty level.

The conventional farmlet was managed according to conventional best practices, including antibiotic treatments for clinical mastitis during lactation, and dry cow therapy given after dry-off to those cows which had clinical mastitis and/or high SCC during lactation (22 after season 2003/2004). In the organic herd, 15 cows with no signs of clinical mastitis and SCC below 200,000 cells/ml were treated with a bismuth in oil sealant (Teatseal., Pfizer Animal Health Group, Auckland, NZ)

Both herds were milked by the same milking machine and by the same staff using conventional best practices, with the organic herd always being milked first at each milking. Teats of cows in both herds were sprayed immediately after each milking, with a sanitizer containing sodium iodide (Teat Guard, Ecolab, Hamilton, NZ). During the lactation that began in August 2004, the teat cups were rinsed with acid sanitizer after the organic herd had been milked.

Milk samples from individual quarters

Milk samples were taken on four occasions between November 2003 and November 2004: During mid lactation (November 2003); at the last milking before dry-off (April to May 2004); at the first milking or within 24 hours of calving (July to October 2004) and again 14 days post calving (August to November 2004).

Protocols from the National Mastitis Council (NMC) were followed (Hogan *et al.*, 1999), where a few milliliters of fore milk were taken in a single sample using aseptic sampling methods and then cultured at the laboratory within hours after sampling. All cows from both herds were sampled in each period (50 in the conventional herd and 45 in the organic herd) and results recorded.

Samples from mid-lactation were taken before the morning milking, frozen after sampling (November 2003) and kept at -20°C until July-October 2004, when they were cultured. Samples were thawed at 37°C and cultured with the same NMC procedures as for the other sampling periods. 0.01 ml of milk were streaked on an aesculin blood agar plate (Fort Richards, Auckland) and incubated at 37°C for at least 18 hours and then re-checked within 48 hours after plating. Colonies were identified by the catalase test and a Gram stain to differentiate streptococci from staphylococci. Aesculin reaction, inulin, bagg broth and CAMP test were used to differentiate *Streptococcus uberis*, *agalactiae* and *spp.* (*Enterococci*, *dysgalactiae* and others). Rabbit plasma coagulase (Ngaio Laboratories, Nelson, New Zealand) was used to identify *Staphylococcus aureus*. In cases of doubtful growth, (except for dry-off samples), a second confirmatory sample was taken on the following day.

Dry-off samples were taken at the morning milking before the animals were milked for the last time before the dry period. Calving samples were taken before the animal was milked for the first time or, in a few cases, within 24 hours of calving.

Results were analyzed with the PROC GENMOD procedure of SAS 8.02 (2001) using a logit

function, considering the effect of the herd (organic or conventional) and age, which was divided in three groups: 2-3 years, 4-5 years, > 5 years old. At the quarter level the effect of quarter location was included in the model as well.

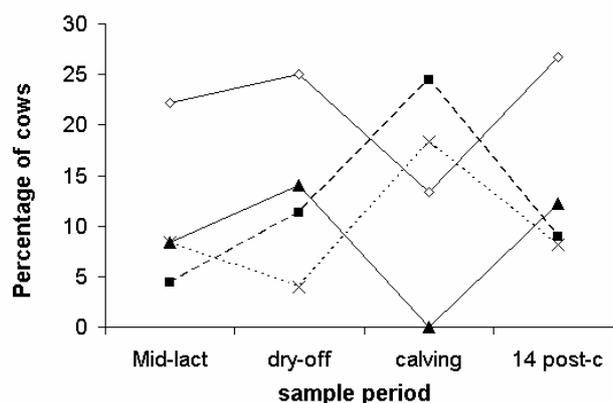
Due to culling of some cows (6 conventional and 10 organic) and the introduction of replacement heifers (8 conventional and 11 organic) into the herd at the start of the next lactation, not all animals were sampled during all four sampling periods. Therefore, data were analyzed for each sampling period separately for both cows and quarters.

Monthly somatic cell counts (SCC) from herd tests were recorded for each herd and analyzed using the PROC GLM procedure of SAS 8.02 (2001) after a natural logarithmic transformation, through a repeated measurement analysis, considering the effect of the herd and the herd test. In addition, clinical cases recorded for both farmlets were analyzed for each month through a chi-square using the PROC FREQ procedure of SAS.

RESULTS

The results of bacteriological analysis of the quarter samples are shown in Table 1. In addition, the general patterns of growth by *Staphylococcus aureus* and *Streptococcus uberis* in cows of both herds across all four sampling periods are shown in Figure 1. The percentage of quarters and cows with positive growth were generally higher in the organic herd.

FIGURE 1: Patterns for *Staphylococcus aureus* and *Streptococci uberis* infections in cows for both herds during the four sampling periods (▲-conventional *S. aureus*) (◇-organic *S. aureus*) (×-conventional *S. uberis*) (■-organic *S. uberis*)



At mid lactation the differences were significant for *Staphylococcus aureus* ($P < 0.001$) with a higher prevalence in the organic herd than in the conventional herd (8 vs 2%; $P < 0.001$). Cows over 5 years showed a higher percentage of quarters with growth of *Staphylococcus aureus* ($P < 0.01$) than animals between 2-5 years old (data not shown).

Similarly at dry-off, the organic herd had a significantly higher percentage of quarters with growth

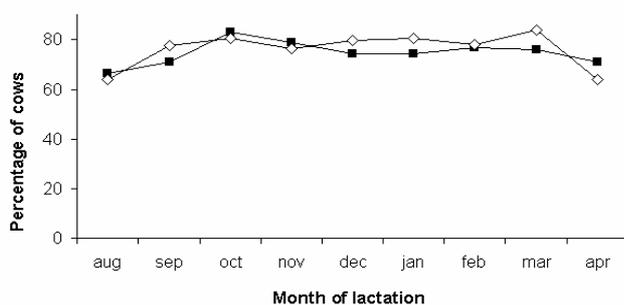
of *Staphylococcus aureus* ($P < 0.05$) than the conventional herd (10% vs 3% respectively). Again, animals older than 5 years showed a higher percentage of quarters with growth ($P < 0.01$) of *Staphylococcus aureus* than animals from 2 to 5 years old.

At calving, there was again a significant difference between herds ($P < 0.01$) only for *Staphylococcus aureus*, with no quarters showing positive cultures in the conventional herd and 6% of quarters with positive cultures in the organic herd. However, both herds showed a higher percentage of quarters with *Streptococcus uberis* at this period (9% and 7% for organic and conventional respectively) than in the other sample periods (Table 1). Gram negative organisms were isolated in this period, but no significant differences between herds were recorded. Two animals were positive for *Proteus* in the organic herd and one in the conventional herd (3 and 1 quarters respectively). In addition, one animal in the organic herd was positive in one quarter for *Escherichia coli*.

At 14 days post calving there was a significantly higher percentage of both *Staphylococcus aureus* ($P < 0.01$) and *Streptococcus spp.* ($P < 0.05$) positive cultures in the organic herd. Growth of *Staphylococcus aureus*, was recorded in 11% and 3% of quarters in the organic and conventional herds respectively, while the corresponding values for *Streptococcus spp.* were 4% and 1%. In the organic herd *Proteus* was isolated in one quarter of one animal and the same occurred for *Escherichia coli*.

Individual SCC values were recorded at the monthly herd tests throughout the season 2003/2004, giving totals of 371 and 404 records in the organic and the conventional herd respectively. Of these, 75% and 77% were below 200,000 cells/ml (Figure 2) for the organic and conventional herd respectively. There were no significant differences between herds, with mean values for the organic herd and conventional herd of 116,000 cells/ml and of 102,000 cells/ml respectively (calculated as the antilogarithm of the mean values of the data transformed to natural logarithms). Milk solid (MS) yields, from monthly herd tests, were 412 kg MS/cow in the organic herd and 430 kg MS/cow in the conventional herd.

FIGURE 2: Somatic cell counts (SCC) at each herd test in 2003/2004 ; percentages of cows in both herds with values below 200,000 cells/ml (■-organic ▲-conventional)



Results from the first part of the second season (August to December 2004) provided 178 and 207 SCC records in the organic herd and the conventional herd respectively. Of these, 74% in the organic herd and 83% in the conventional herd were below 200,000 cells/ml. There were no significant differences between herds, although the organic herd showed a mean value of 91,000 cells/ml compared with 67,000 cells/ml in the conventional herd.

During the 2003/2004 season, 33 and 19 cases of clinical mastitis were recorded in 16 and 14 cows in the organic and conventional herds respectively, with about 80% of the cases occurring in the first two months of lactation for both herds. In addition, in the organic herd, five animals required treatment with antibiotics and were quarantined as required. There were no significant differences in clinical cases between herds, except in the second month of lactation, when the organic herd showed a higher incidence of infections ($P < 0.001$) with 17 clinical cases compared with 6 in the conventional herd. During the first part of the season 2004/2005 (August to December 2004) 10 clinical mastitis cases were recorded in each of the herds, in 7 and 8 cows for the organic and conventional herds respectively, with 5 animals in the organic herd treated with antibiotics and quarantined.

DISCUSSION

The present results come from two small groups of cows, both of which were milked through the same milking machine, and from measurements over only one year. However they represent the only comparative bacteriological data presently available for cows in an organic herd in NZ.

A significantly higher proportion of quarters showed positive cultures of *Staphylococcus aureus* in the organic herd than in the conventional herd at all four sample periods. In addition, the organic herd had a slightly higher proportion of positive cultures of *Streptococcus spp.* but this was significant only at the 14 days post-calving sample.

However, there were no significant differences between the two herds in the prevalence of clinical mastitis, nor in the SCC of individual cows, although the organic herd had higher values for both. These results agree with analysis of the previous season (Lopez-Villalobos *et al.*, 2003).

In the present study, the lowest number of positive cultures of *Staphylococcus aureus* infections was recorded at calving (6% and 0% in the organic and conventional herd respectively) and these increased as lactation advanced, in agreement with results for conventional herds in NZ, where the incidence of *Staphylococcus aureus* has been shown to increase from mid lactation until dry-off (Pankey *et al.*, 1996). Similar results have also been reported for organic herds in Denmark (Vaarst & Enevoldsen, 1997).

In contrast, the highest growth of *Streptococcus uberis* (9% of quarters for the organic and 7% for the conventional herd) was recorded in both herds around

TABLE 1: Results for quarter samples at all four sample periods, in both herds. Total number of quarters sampled, with no growth or positive growth; and LS mean values of these numbers expressed as a % of the total number of quarters sampled in each herd, with the significance of differences between herds

Quarters	Mid- lactation			Dry-off			Calving			14 days post calving		
	Org	Conv	Sig	Org	Conv	Sig	Org	Conv	Sig	Org	Conv	Sig
Total	177	191		173	198		177	196		177	196	
LS means as a percentage of total sampled quarters (<i>Number of quarters</i>)												
No growth	64.16 (116)	73.77 (139)	NS	34.10 (66)	33.02 (68)	NS	53.59 (100)	55.93 (109)	NS	59.46 (109)	68.62 (136)	NS
Positive growth	35.84 (61)	26.23 (52)	NS	65.90 (108)	66.98 (130)	NS	46.41 (81)	46.07 (87)	NS	40.54 (72)	31.38 (60)	NS
Bacteria	LS means as the number of quarters positive for each type of bacteria expressed as a percentage of the total quarters sampled (<i>Number of positive quarters</i>)											
Staph. aureus	7.87 (19)	1.72 (6)	***	9.88 (19)	3.15 (9)	*	5.87 (9)	0.00 (0)	** *	11.04 (16)	3.13 (6)	**
Strep. uberis	1.71 (3)	2.12 (4)	NS	2.63 (5)	0.83 (2)	NS	9.03 (15)	7.07 (11)	NS	2.65 (4)	2.13 (4)	NS
Staph non-c.	24.15 (41)	21.86 (41)	NS	54.59 (94)	61.64 (122)	NS	33.46 (57)	38.51 (74)	NS	25.58 (41)	25.87 (49)	NS
Strep. spp	1.17 (2)	0.54 (1)	NS	7.68 (13)	3.12 (7)	NS	4.51 (8)	2.55 (5)	NS	4.24 (9)	1.31 (3)	*
Strep. agalactiae	0.00 (0)	0.00 (0)	-	2.69 (1)	0.90 (2)	NS	0.00 (0)	0.51 (1)	NS	2.56 (4)	0.53 (1)	NS
Proteus	0.00 (0)	0.00 (0)	-	0.00 (0)	0.00 (0)	-	1.69 (3)	0.51 (1)	NS	0.58 (1)	0.00 (0)	NS
<i>E. coli</i>	0.00 (0)	0.00 (0)	-	0.00 (0)	0.00 (0)	-	0.56 (1)	0.00 (0)	NS	0.58 (1)	0.00 (0)	NS

NS= Non significant; * = P < 0.05, ** = P < 0.01, *** = P < 0.001

calving, in agreement with results for conventional herds in NZ (Pankey *et al.*, 1996, McDougall, 1998).

The percentage of clinical cases in both herds was higher than the 10% reported by McDougall (1998) for the first 6 weeks of lactation in conventional NZ herds. The percentage of clinical cases in the organic herd was also higher than the 19% reported for six organic herds in United Kingdom (UK). However, the mean somatic cell count of 116,000 cells/ml presented by the organic herd in the present study was lower than the 244,070 reported for six organic herds over a six year period in UK (Weller & Davies, 1998). Animals showing a high somatic cell count in the latter herds were positive for *Staphylococcus aureus*, which agrees with the results obtained in the present study, where in season 2003/2004, 74% and 52% of the high SCC (> 400,000 cells/ml) records were from animals showing positive cultures by *Staphylococcus aureus* for the organic and the conventional herds respectively. Data from previous studies have shown that herds with low prevalence of clinical mastitis but high levels of somatic

cell counts are related to contagious pathogens rather than to environmental pathogens (Hogan *et al.*, 1999).

In addition, Weller and Bowling (2000) showed a similar prevalence of clinical mastitis in organic herds (34%) and in conventional herds (37%) in UK. The prevalence of clinical mastitis was higher than in the present study, but in both studies there was no difference between herds.

The elimination of *Staphylococcus aureus* infections in conventional herds has proven to be difficult, even with the use of antibiotics (Kerro Deogo *et al.*, 2002). In organic herds, failure to control this pathogenic organism could allow it to spread through the herd and to increase the number of chronically infected cows. Results for further seasons should be evaluated to analyse the impact of this contagious pathogen over the time. Effective preventive and control measures to avoid the spread of contagious pathogens are required in all herds, but are especially important under organic conditions.

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