ABSTRACT: This paper compares management of mastitis on organic dairy farms with that on conventional dairy farms. National standards for organic production vary by country. In the United States, usage of antimicrobials to treat dairy cattle results in permanent loss of organic status of the animal, effectively limiting treatment choices for animals experiencing bacterial diseases. There are no products approved by the US Food and Drug Administration that can be used for treatment of mastitis on organic dairy farms, and usage of unapproved products is contrary to Food and Drug Administration guidelines. In general, organic dairy farms tend to be smaller, produce less, and more likely to be housed and milked in traditional barns as compared with conventionally managed herds. It is difficult to compare disease rates between herds managed conventionally or organically because perception and detection of disease is influenced by management system. To date, no studies have been published with the defined objective of comparing animal health on organic dairy herds with that on conventional dairy herds in the United States. European studies have not documented significant differences in animal health based on adoption of organic management. Few differences in bulk tank somatic cell counts have been identified between organic and conventional herds. Farmers that have adopted organic management consistently report fewer cases of clinical mastitis, but organic farmers do not use the same criteria to detect clinical mastitis. European dairy farmers that adopt organic management report use of a variety of conventional and alternative therapies for treatment and control of mastitis. In the United States, organic farmers treat clinical mastitis using a variety of alternative therapies including whey-based products, botanicals, vitamin supplements, and homeopathy. Organic farmers in the United States use a variety of alternative products to treat cows at dry-off. Virtually no data are available that support the clinical efficacy of any of the alternative veterinary products used for treatment or prevention of mastitis. Some associations between organic management and antimicrobial susceptibility of gram-positive mastitis pathogens have been noted, but overall, few mastitis pathogens from both conventional and organic dairy herds demonstrate resistance to antibiotics commonly used for mastitis control.

Key words: dairy, ecological, management, mastitis, organic, treatment

INTRODUCTION

Many consumers are increasingly skeptical about conventional methods of food production, and food marketers are increasingly looking to differentiate their products in the market. In 2007, the Organic Trade Association reported that sales of organic foods grew 18% to represent $20 billion in consumer sales (about 2.8% of total US food sales). Dairy products (16%) are second only to fruits and vegetables (40%) as a proportion of overall organic food purchases (Organic Trade Association, 2007). Increased consumer demand for organic dairy products has resulted in increased numbers of dairy farms that have converted to organic status. Between 2000 and 2005, the number of certified organic cows in the United States increased from 38,196 to 87,082 (USDA, 2006), and continued growth is expected. Much of this growth is expected to result from transition of existing conventional dairies to organic management. In 2005, 61% of all organic dairy cows were located in 5 states: Wisconsin (19%), California (17%), Oregon (9%), Texas (9%), and Pennsylvania (7%).

Consumer demand for organic foods is partly driven by perceived concerns about the safety of foods produced using conventional farming systems. A survey commissioned by an organic cooperative indicated that 70% of US consumers expressed at least moderate concern about health risks associated with use of pesticides and antibiotics in food production (Roper Public Affairs, 2004). Organic dairy products are marketed to
lessen these concerns by requiring that dairy cattle are raised using a whole systems approach that includes the use of organic feeds (grown without use of pesticides or synthetic fertilizers), no usage of antibiotics or GH, and emphasis on husbandry practices that limit stress and promote health. Restrictions imposed by the organic certification process result in reduced options for mastitis control programs. The objective of this paper is to present the management restrictions confronted by organic dairy farmers and to review and contrast mastitis management practices used on organic and conventional dairy farms.

**REQUIREMENTS FOR ORGANIC CERTIFICATION**

The process of organic certification is becoming increasingly codified and regulated. Countries have differing standards regarding organic production practices. These practices vary tremendously regarding the acceptability of substances used for animal health management. Canadian standards were defined in 2006 (Canadian General Standards Board, 2006), and organic rules for countries in the European Union (EU) were first implemented in 1991 and last revised in 2007 (EC 837/2007). Within the EU, the application of organic standards governing the treatment of sick animals may be affected by local animal welfare or veterinary regulations (Kijlstra and Van der Werf, 2005).

Since October 2002, the National Organic Program within the USDA Agricultural Marketing Service has defined the US standards for organic production and handling (USDA, 2008). Only farms that meet USDA standards can legally produce certified organic food; however, the certification process itself is performed by a variety of USDA-accredited private certifying agencies.

The national organic standards address the methods, practices, and substances used in producing and handling crops, livestock, and processed agricultural products. The requirements apply to the production process but not to properties of the food itself. A comprehensive listing of organic standards for livestock production can be found at the USDA Web site (USDA, 2008). The requirements state that dairy products must be from animals that have been under continuous organic management for at least 1 yr, except during the transition period when entire dairy herds are being converted to organic production. During the first 9 mo of the year of transition, the producer may feed the herd a minimum of 80% organic feed. After the transition period has been completed, and the herd has been converted to organic production, all dairy animals must be under organic management and receiving organic feed from the last one-third of gestation onward.

Like the organic standards of Canada and the EU, the US organic standards for health management of livestock emphasize preventive health management. Producers are encouraged to “establish and maintain preventive animal health care practices” and to “establish appropriate housing, pasture conditions, and sanitation practices to minimize the occurrence and spread of diseases and parasites” (USDA, 2008). Emphasis is placed on reducing stress: “Animals in an organic livestock operation must be maintained under conditions which provide for exercise, freedom of movement, and reduction of stress appropriate to the species. Additionally, all physical alterations performed on animals in an organic livestock operation must be conducted to promote the animals’ welfare and in a manner that minimizes stress and pain” (USDA, 2008).

Although both Canadian and EU organic standards discourage the use of antibiotics or prohibited synthetic compounds, both standards contain provisions that allow limited usage of antibiotics, without loss of organic status of the animal, under strictly defined conditions and with extended withholding periods. In contrast, US organic standards contain a unique and rigorous prohibition against use of most conventional veterinary treatments. Whereas use of veterinary biological compounds (e.g., vaccines) is encouraged, only compounds that are specifically included on the list of synthetic substances can be used to treat sick animals. The regulation states in part:

The producer of an organic livestock operation must not treat an animal in that operation with antibiotics, any synthetic substance not included on the National List of synthetic substances allowed for use in livestock production, or any substance that contains a nonsynthetic substance included on the National List of nonsynthetic substances prohibited for use in organic livestock production. The producer must not administer any animal drug, other than vaccinations, in the absence of illness. The use of hormones for growth promotion is prohibited in organic livestock production, as is the use of synthetic parasiticides on a routine basis. The producer must not administer synthetic parasiticides to slaughter stock or administer any animal drug in violation of the Federal Food, Drug, and Cosmetic Act. (USDA, 2008)

Unfortunately, there are no Food and Drug Administration (FDA)-approved antimicrobial compounds on the USDA-approved list of organic treatments, and FDA guidelines do not allow for the use of unapproved drugs, regardless of whether or not the substance is a botanical, homeopathic remedy or food supplement, for treatment of food-producing animals even under the supervision of a veterinarian. Organic producers in the United States face a confusing paradox regarding the provision of treatments to sick animals. The regulations require them to provide appropriate medical treatment for sick cows, but those animals that receive that care are permanently disqualified from organic production, thereby effectively providing a strong economic disincentive against the provision of necessary treatments.
The producer must not withhold medical treatment from a sick animal to maintain its organic status. All appropriate medications and treatments must be used to restore an animal to health when methods acceptable to organic production standards fail. Livestock that are treated with prohibited materials must be clearly identified and shall not be sold, labeled, or represented as organic (USDA, 2008).

Management of infectious diseases, such as mastitis, on organic dairy farms in the United States is considerably altered to comply with these organic regulations, and the impact of these regulations on animal health has not been well documented.

**MANAGEMENT DIFFERENCES BETWEEN ORGANIC AND CONVENTIONAL SYSTEMS**

Like other dairy farms, organic dairy farmers utilize a variety of housing and management strategies and vary in farm size. A comprehensive assessment of management of US organic dairy farms has not yet been published but several papers include some comparative data about organic and conventional dairy farms (Table 1). Farmers received an average price premium for organic milk of $6.69 per 45.4 kg of milk but also reported production costs of about $5 to $7 per 45.4 kg of milk greater than conventional dairy farms (McBride and Greene, 2007). However, the price paid for organic milk is generally more stable, and small dairy farms that have no desire to expand may consider conversion to organic status as a way to profitably maintain a traditional dairy farm. As a consequence, housing, production, and management of most organic dairy farms tend to be similar to management and housing of traditional small dairy farms of years past. In 2 separate studies conducted using Wisconsin dairy herds, there were significant differences between organic and conventional herds in the proportion of herds that used free stall housing (19% organic vs. 61% conventional and 3% organic vs. 27% conventional for Zwald et al., 2004, and Sato et al., 2005, respectively). Although exceptions exist, dairy farms managed organically tend to be smaller, produce less, and are more likely to do milking in stanchion or tie stall barns as compared with conventional dairy herds (Table 1).

Regardless of country, nutritional management is associated with management system and is the likely explanation for the greater milk yields consistently noted in studies comparing conventional and organic herds (Hardeng and Edge, 2001; Zwald et al., 2004; Roesch et al., 2005; Sato et al., 2005; Hamilton et al., 2006; Ellis et al., 2007; Pol and Ruegg, 2007a; Rozzi et al., 2007). In Wisconsin, significantly more conventional dairies fed lactating cows a total mixed ration, and more preparturient cows received a transition ration and anionic salts as compared with organic herds (Zwald et al., 2004).

![Table 1. General production and demographic data for studies including data about organic (Org) and conventional (Con) dairy herds in the United States](image-url)

| Study            | Site         | Herd selection criteria                  | Org | Con | Number of herds | Milk/cow, kg | Culling rate, % | Milk/cow, kg | Culling rate, % |
|------------------|--------------|------------------------------------------|-----|-----|-----------------|--------------|----------------|--------------|----------------|----------------|
| Zwald et al., 2004 | MI, MN, NY, WI | Random within herd size strata           | 32  | 99  | 91              | 192*         | 23*           | 17           | 18*           |
| Sato et al., 2005 | WI           | Geographically matched volunteers        | 30  | 51  | 51              | 72*          | 20*           | 21*          | 24*           |
| McBride and Green, 2007 | WI        | Representative sample                    | 325 | 72 | 82              | 1,162        | 21*           | 21*          | 21*           |
| Pol and Ruegg, 2007a | WI      | Volunteer herds with BTSCC > 250,000 cell/mL | 320 | 1,462 | 8,629* | 6,182* | 331* | 18* | 17 |

*Denotes statistically significant difference between organic and conventional herds at P < 0.05.
Others have noted that organic cattle were fed much less concentrate compared with cattle in conventional herds (Hardeng and Edge, 2001; Roesch et al., 2005). In the United States, organic production practices require access to pasture suitable to stage of production, climate, and environment. Sato et al. (2005) reported that whereas 76% of conventional herds included in his study had some access to pasture, 50% of the organic herds utilized intensive rotational grazing, in contrast to only 7% of the neighboring conventional herds. Few studies have evaluated overall management differences of organic and conventional herds; however, no significant differences in cow cleanliness scores (Ellis et al., 2007) or environmental cleanliness of the facilities (Sato et al., 2005) have been noted based on adoption of organic or conventional management systems.

**HEALTH MANAGEMENT OF COWS ON ORGANIC DAIRY FARMS**

It is very difficult to separate potential effects of confounding risk factors for disease unrelated to organic management from the effect of management changes that have been adopted by dairy farmers using organic production systems. Many risk factors that are not specific to organic production, such as age, production level, genetics, environmental conditions, nutrition, and housing, can influence animal health. For example, if longevity was greater for cattle on organic dairy farms, there would be an increased probability of several age-related disorders, such as milk fever, mastitis, cystic ovaries, and lameness (Dohoo et al., 1984). Housing is an important risk factor for disease, and many organic cattle are housed in older facilities for part of the year and grazed during appropriate seasons. Environmental conditions are known to influence the risk of disease, and heat stress is known to influence health and reproductive performance. These confounding differences have influenced almost every study that has attempted to compare disease rates between cows in conventional and organic herds, and it is premature to draw overly broad conclusions about this issue. Future studies should be designed to account for confounding factors that are not directly associated with the organic production process.

Considerable regional and national differences in organic certification standards and enforcement of those standards must be accounted for when summarizing animal health data that originate in different countries. Pooling of data collected from farms operating under differing certification standards or comparison of studies conducted in the United States with studies conducted in Europe should be avoided because the current standards are not comparable. Previous studies from Europe have reported the health status of cattle managed using conventional and organic systems (Vaarst and Enevoldsen, 1997; Reksen et al., 1999; Weller and Bowling, 2000; Hardeng and Edge, 2001; Hoglund et al., 2001; Hamilton et al., 2002, Regula et al., 2004; O’Mahony et al., 2006; Ellis et al., 2007; Fall et al., 2008), but it is important to recognize that organic standards in the EU can vary by certifying agency and most do not prohibit the use of antibiotics and other synthetic medications that are prohibited from use on US organic farms. Hamilton et al. (2002) compared the health status of cows in organic (n = 25) and conventional (n = 1,102) dairy herds in Sweden. Herd sizes were similar (32 to 33 cows/ herd), but production was less for organic (6,213 kg of milk) as compared with conventional (7,572 kg of milk). This analysis was likely biased by the use of health records that were retrieved from different systems. Veterinarians recorded treatments for organic dairy herds, whereas treatments for animals on conventional herds were accessed from the national disease recording system. Mean disease incidence per 100-cow years was corrected for milk yield, herd size, breed, and lactation number and were compared between management system. The incidence of milk fever, ketosis, and hoof disorders was not significantly different based on management system. There was a significant association of herd management system with the incidence of retained placenta [0.1 (organic) and 2.3 (conventional) cases per 100 cow-years], mastitis treatments [9.1 (organic) and 14.7 (conventional) cases per 100 cow-years], and trodden teats [0.3 (organic) and 1.8 (conventional) cases per 100 cow-years].

The impact of organic management on reproductive performance has not been well defined. Reksen et al. (1999) evaluated the reproductive performance of organic (n = 29) and conventional (n = 87) dairy herds in Norway over a period of 3 yr (i.e., 1994 to 1996). The unit of study was the cow over 1 lactation period. A numerical difference was observed in the percentage of cows that conceived through natural breeding based on management system (19 to 27% and 3 to 5% of pregnancies for organic and conventional, respectively). The annual rate of replacement was 23% (organic) and 35% (conventional, P < 0.01). It is not likely that results of this study can be extrapolated to the US situation because of differences in reproductive management between cattle in the United States and Norway.

Disease detection and definition appear to be associated with management system and should be accounted for in future studies. Although researchers have compared rates of selected diseases, the results of most published research cannot be used to arrive at a conclusion about the impact of management system on animal health because case definitions have not been standardized across studies and there is considerable evidence that perception of disease is affected by management system. For example, Norwegian researchers (Hardeng and Edge, 2001) reported that the risk of mastitis (OR = 0.38), milk fever (OR = 0.33), and greater somatic cell count (OR = 0.60) were reduced for organic (n = 31 herds) as compared with conventional (n = 93 herds) dairy herds. They attributed the reduction in disease to more access of organic cattle to pasture but failed to address whether differing attitudes about dis-
ease management resulted in less disease reporting for herds that adopt organic husbandry.

Fewer cases of clinical mastitis (41 and 21 cases per 100 cow-years for conventional and organic, respectively), respiratory disease [3.3 and 0.8 cases/(100 cow-years) for conventional and organic, respectively], and metritis [15 and 9 cases/(100 cow-years) for conventional and organic, respectively] were reported for organic dairy farms in Wisconsin (Pol and Ruegg, 2007a). It is impossible to determine if the observed differences were attributable to adoption of organic management because a standardized definition of each disease was not used and it is likely that the criteria for diagnosis and culling varied based on management system. Differences in detection and perception of mastitis were especially evident and are discussed later in this review.

In the United States, adoption of organic management appears to result in reduced consultation with veterinarians regarding animal health. Organic farmers in the United States report less dependence on veterinarians, more dependence on the opinion of other organic farmers, and fewer regularly scheduled veterinary services as compared with conventional farmers (Zwald et al., 2004; McBride and Green, 2007). It is possible that restrictions on treatments inherent in the US organic standards reduce producer willingness to call veterinarians because Hamilton et al. (2006) reported that the readiness to call the veterinarian was similar among Swedish organic and conventional dairy farmers.

MILK QUALITY AND MANAGEMENT OF MASTITIS

Milk Quality

Although consumers may perceive that the milk from organic herds is better quality than milk from conventional herds, there is a pervasive myth among dairy professionals that quality of milk produced on organic dairy farms is considerably less than the quality of milk produced on similar conventional dairy farms. Neither argument is supported by the available data (Table 2). Although small differences in bulk tank somatic cell count (BTSCC) have been noted in some European studies, it is unlikely that these differences are biologically significant when milk is consistently produced with BTSCC < 150,000 cells/mL. No truly comparative studies have been conducted in the United States, and it is difficult to separate the confounding effect of herd size from the potential effect of management system. In one study in Wisconsin, organic dairy herds had slightly greater BTSCC, but the organic herds also contained fewer cows (Zwald et al., 2004). Whereas numerous small herds produce very high quality milk, when viewed on a population basis, BTSCC of smaller dairy herds of all farm management systems tends to be greater (Rodrigues et al., 2005). Pol and Ruegg (2007a) did not assess differences in BTSCC because having BTSCC > 250,000 cells/mL was one criterion for study participation. In spite of similar BTSCC in conventional and organic herds, Pol and Ruegg (2007b) recovered more contagious pathogens from individual quarter milk samples obtained from cows on organic farms (n = 2,334 quarters; 5.4% Staphylococcus aureus and 2.3% Streptococcus agalactiae) compared with samples obtained from cows on conventional farms (n = 3,338 quarters; 2.9% Staph. aureus and 0.8% Strep. agalactiae). Whereas these small differences were statistically significant, the overall prevalence of these contagious pathogens was surprisingly small and probably accounted for by the inability of organic farmers to use routine mastitis control strategies such as administration of long-acting intramammary antibiotics at dry-off.

No differences in bulk milk bacterial counts based on management system have been reported (Sato et al., 2005; Pol and Ruegg, 2007b). In 2 separate studies, the proportion of animals culled due to mastitis was not associated with herd type (about 8 to 9% of both organic and conventional herd types; Hamilton et al., 2006; Pol and Ruegg, 2007a).

Identification and Management of Mastitis

In contrast to some inconsistencies among studies comparing BTSCC, virtually all studies have reported fewer cases of clinical mastitis for organic as compared with conventional farms (Table 2). In most field-based research, enumeration of clinical mastitis has the potential to be severely affected by reporting bias. Detection of mastitis is affected by the intensity of surveillance and case definition and most field studies have not standardized these factors.

Farmers converting to organic status in the United Kingdom were less likely to report cases of clinical mastitis (Berry and Hillerton, 2002). A study conducted in Denmark (Vaarst et al., 2006) provided strong evidence that the rate of mastitis treatments was associated with a desire to reduce overall antimicrobial treatments. Reported mastitis treatments were approximately 41 to 45 treatments per 100 cow-years for general organic herds, 26 to 37 treatments per 100 cow-years for organic herds interested in reducing antimicrobial usage, and 0 to 3 per 100 cow-years for organic herds that had an explicit policy of nonuse of antimicrobials, respectively (Vaarst et al., 2006).

Pol and Ruegg (2007a) identified philosophical differences between organic and conventional farmers in the detection of mastitis and perception of cure after treatment, and it is possible that more diseases were noted on conventional farms simply because of more treatment options (Table 3). Of conventional farmers, 90% reported that they identified mastitis based on observation of milk, which was in contrast to only 45% of organic farmers (Pol and Ruegg, 2007a). The assessment of cure after treatment of clinical mastitis was based on observation of normal milk for 75 and 20% of
Table 2. Indicators of milk quality for studies including organic (ORG) and conventional (CON) dairy herds

<table>
<thead>
<tr>
<th>Study</th>
<th>Site</th>
<th>Herd selection criteria</th>
<th>Number of herds</th>
<th>Bulk tank somatic cell count, cells/mL ($\times 10^3$)</th>
<th>Rate of clinical mastitis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>ORG</td>
<td>CON</td>
<td>ORG</td>
</tr>
<tr>
<td>Hardeng and Edge, 2001</td>
<td>Norway</td>
<td>Matched stratified random sample</td>
<td>31</td>
<td>93</td>
<td>79$^{1*}$</td>
</tr>
<tr>
<td>Hovi and Roderick, 2001</td>
<td>United Kingdom</td>
<td>Geographically matched</td>
<td>16</td>
<td>7</td>
<td>135$^*$</td>
</tr>
<tr>
<td>Zwald et al., 2004</td>
<td>MI, MN, NY, WI</td>
<td>Random within herd size strata</td>
<td>32</td>
<td>99</td>
<td>370$^{*}$</td>
</tr>
<tr>
<td>Sato et al., 2005</td>
<td>WI</td>
<td>Geographically matched volunteers</td>
<td>30</td>
<td>30</td>
<td>263$^2$</td>
</tr>
<tr>
<td>Hamilton et al., 2006</td>
<td>Sweden</td>
<td>Volunteers (ORG) and matched on herd size (CON)</td>
<td>26</td>
<td>1,102</td>
<td>173$^3$</td>
</tr>
<tr>
<td>Ellis et al., 2007</td>
<td>United Kingdom</td>
<td>Undefined</td>
<td>14</td>
<td>14</td>
<td>206$^5$</td>
</tr>
<tr>
<td>Fall et al., 2007</td>
<td>Sweden</td>
<td>Single herd with 145 ORG and 151 CON managed cows</td>
<td>1/2</td>
<td>1/2</td>
<td>91</td>
</tr>
<tr>
<td>Pol and Ruegg, 2007a</td>
<td>WI</td>
<td>Volunteer herds with BTSCC$^9$ &gt; 250,000 cell/mL</td>
<td>20</td>
<td>20</td>
<td>305$^7$</td>
</tr>
<tr>
<td>Roesch et al., 2007</td>
<td>Switzerland</td>
<td>Matched volunteers</td>
<td>60</td>
<td>60</td>
<td>53$^{10*}$</td>
</tr>
</tbody>
</table>

$^1$Converted from natural log as reported in study.
$^2$Cases per 100 cows per lactation.
$^3$Incidence in lactating period.
$^4$Incidence in dry period.
$^5$Means estimated from distributions presented in study.
$^6$Annual incidence density.
$^7$Estimated mean from data reported in study.
$^8$Cases per 100 cows/month.
$^9$BTSCC = bulk tank somatic cell count.
$^{10}$Data analyzed at both 31 and 102 d postpartum.
$^*$Denotes statistically significant difference between organic and conventional herds at $P < 0.05$. 
conventional and organic herds, respectively (Pol and Ruegg, 2007a). Organic farmers reported more reliance on physical signs, such as udder observations, and results of the California Mastitis Test compared with conventional farmers (Table 3). These differences are intriguing and need to be investigated for other diseases and also indicate the need to include severity scores in mastitis recording systems used for research purposes (Wenz et al., 2001; Nash et al., 2002).

Some of these differences may be attributable to differences in herd size rather than management system. In a representative survey of the overall dairy herd population in Wisconsin, the type of treatment records and the information recorded were strongly associated with herd size (Hoe and Ruegg, 2006). Owners of dairy farms containing ≤100 lactating cows were 5 times more likely to not have any record of antibiotic treatments compared with larger herds (Hoe and Ruegg, 2006). Likewise, Rodrigues et al. (2005) reported that only one-half of Wisconsin dairy herds voluntarily participating in a milk quality improvement program recorded data about clinical mastitis, but operators of large herds were 2 times more likely than operators of small herds to record cases of mastitis.

Sato et al. (2005) reported few differences in milking procedures based on herd management system and milking practices of organic herds were generally representative of smaller dairy herds located in Wisconsin. The most common active ingredients used in pre- and postmilking teat dips (i.e., iodine, chlorhexadine, and several chlorine-based products) are allowed for use under US organic standards.

### Table 3. Mastitis management practices on organic (n = 20) and conventional farms (n = 20) in Wisconsin

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Organic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of clinical mastitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observe milk</td>
<td>18 (90.0)</td>
<td>9 (45.0)</td>
<td>0.002</td>
</tr>
<tr>
<td>Other methods (below)</td>
<td>2 (10.0)</td>
<td>11 (55.0)</td>
<td></td>
</tr>
<tr>
<td>Abnormal milk on filter</td>
<td>1 (5)</td>
<td>2 (10)</td>
<td></td>
</tr>
<tr>
<td>CMT positive</td>
<td>0 (0)</td>
<td>2 (10)</td>
<td></td>
</tr>
<tr>
<td>Swollen quarter</td>
<td>1 (5)</td>
<td>6 (30)</td>
<td></td>
</tr>
<tr>
<td>Other method</td>
<td>0 (0)</td>
<td>1 (5)</td>
<td></td>
</tr>
<tr>
<td>Determination of cure after treatment of clinical mastitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observe normal milk</td>
<td>15 (75.0)</td>
<td>4 (20.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other methods (below)</td>
<td>5 (25.0)</td>
<td>16 (80.0)</td>
<td></td>
</tr>
<tr>
<td>CMT negative</td>
<td>2 (10.0)</td>
<td>5 (25)</td>
<td></td>
</tr>
<tr>
<td>Udder looks and feels normal</td>
<td>0 (0)</td>
<td>6 (30)</td>
<td></td>
</tr>
<tr>
<td>Test day SCC</td>
<td>2 (10.0)</td>
<td>3 (15)</td>
<td></td>
</tr>
<tr>
<td>Treatment is completed</td>
<td>1 (5)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0 (0)</td>
<td>2 (10)</td>
<td></td>
</tr>
<tr>
<td>Number of cows culled for mastitis</td>
<td>345 of 3,937²</td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td>Proportion of specific culling reasons for cows culled for mastitis</td>
<td>129 of 1,449³</td>
<td>8.9</td>
<td>0.75</td>
</tr>
<tr>
<td>Repeat clinical case</td>
<td>209</td>
<td>81</td>
<td>9.8</td>
</tr>
<tr>
<td>High SCC</td>
<td>64</td>
<td>23</td>
<td>43.3</td>
</tr>
<tr>
<td>Blind quarter</td>
<td>2</td>
<td>25</td>
<td>3.9</td>
</tr>
<tr>
<td>Chronically infected</td>
<td>53</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other</td>
<td>17</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Culture of some clinical cases of mastitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>16</td>
<td>4</td>
<td>(20.0)</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>16</td>
<td>(80.0)</td>
</tr>
<tr>
<td>Dry-off method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abrupt</td>
<td>19</td>
<td>8</td>
<td>(40.0)</td>
</tr>
<tr>
<td>Intermittent</td>
<td>1</td>
<td>12</td>
<td>(60.0)</td>
</tr>
</tbody>
</table>

¹Data are adapted from Pol and Ruegg (2007a) with some unpublished data (P. L. Ruegg) added. Multiple answers per farm were allowed. CMT = California Mastitis Test; SCC = somatic cell count.
²Number of cows in conventional study herds.
³Number of cows in organic study herds.

Treatment of Clinical Mastitis

The US national list of substances approved for use by organic farmers includes several compounds that could be used in mastitis treatment protocols. Vaccines, antiinflammatory drugs (e.g., aspirin and flunixin), electrolytes, and furosemide (with double the milk withholding period) are all permitted substances under US organic standards. Oxytocin is approved for postpartum therapeutic usage only, but no antimicrobials can be used without disqualifying the cow from organic production.

It is well known that mastitis treatments account for the majority of antimicrobial usage on conventional dairy farms (Sundlof et al., 1995; Mitchell et al., 1998,
Pol and Ruegg, 2007b). In a recent study, the greatest proportion of antimicrobial administered on conventional dairy farms was by intramammary infusion for treatment or prevention of mastitis (Figure 1; Pol and Ruegg, 2007b). In this group of herds, cepapirin, pirlimycin, and amoxicillin were the most common compounds used for intramammary treatment of clinical mastitis, but data were collected before approval of a newer intramammary antimicrobial that has been widely adopted. Extralabel treatments via intramammary infusion were reported by 11 of 20 conventional farmers, whereas 2 conventional farmers reported intramammary usage of a prohibited compound (sulfamethoxazole and trimethoprim). Parenteral administration of antimicrobials for some treatments of clinical mastitis has been reported by about 70 to 80% of conventional farmers (Zwald et al., 2004; Pol and Ruegg, 2007b).

In the EU, organic dairy farmers continue to use antibiotics to treat clinical mastitis but also adopt alternative treatment strategies. In a study that compared mastitis treatments performed on organic (n = 16) and conventional (n = 7) farms in the United Kingdom, Hovi (2001) reported that antibiotics were used to treat clinical mastitis by 100 and 41% of conventional and organic farmers, respectively. The duration of treatment was similar for both management systems, but organic farmers reported significantly longer milk withholding periods (11.2 and 5.5 d for organic and conventional, respectively). Homeopathy was the most common alternative treatment (reported by 51% of organic farmers), but other treatments included the use of udder liniment, frequent milking, and intramammary infusion of aloe (Hovi, 2001). More than 50% of the products administered on Dutch organic farms were considered to be regular veterinary products, in contrast to 43% of products classified as alternative (Kijlstra and Van der Werf, 2005). The most common alternative product used to treat mastitis was a peppermint ointment (used on 16 of 30 farms), followed by usage of a variety of homeopathic remedies (Kijlstra and Van der Werf, 2005).

In the United States, cows that receive any antimicrobial treatments are disqualified from organic production and organic farmers in the United States consistently report that they do not use antimicrobials to treat mastitis (Zwald et al., 2004; Sato et al., 2005; Pol and Ruegg, 2007a). In a Wisconsin study, almost all organic farmers (95%) used some nonantimicrobial compounds to treat clinical mastitis (Table 4). Use of intramammary compounds, including, isoflupredone, vitamin C, apple cider, aloe vera, and microbial supplements were reported by 7 of 20 farms. None of these products are approved veterinary or human

Figure 1. Proportion of defined daily doses of antimicrobial per cow per year administered on conventional dairy farms in Wisconsin (n = 20) for treatment of selected diseases by route and indication. Data are from Pol and Ruegg (2007a).
health products, and therefore, extralabel usage is not allowed under FDA guidelines. Organic farms in the United States have also reported the use of approved antiinflammatory drugs and frequent milking, as well as the use of calves to suckle mastitic quarters (Sato et al., 2005).

### Treatment of Cows at Dry-Off

The efficacy and importance of antibiotic dry cow therapy (DCT) as part of an udder health management program has been demonstrated (Neave et al., 1966). In both conventional herds with low BTSCC and organic dairy herds, quarters that received antibiotic DCT had fewer cases of clinical mastitis during the dry period and fewer subclinical intramammary infections at calving (Berry and Hillerton, 2002). Routine usage of antibiotic DCT is prohibited under organic standards in the United Kingdom, and one study noted significantly more clinical mastitis during the dry period in organic dairy herds (28.9 cases per 100 cow-years) as compared with conventional dairy herds (9.2 cases per 100 cow-years; Hovi and Roderick, 2000).

In the United States, use of long-acting intramammary antibiotics is highly adopted by conventional dairy farmers but is not allowed under the national organic standards and is rarely used by organic farmers (Zwald et al., 2004; Rodrigues et al., 2005; Sato et al., 2005; Pol and Ruegg, 2007a). Approximately one-half of organic dairy farms reported that they administered a variety of nonantimicrobial organic products to improve udder health at dry-off (Pol and Ruegg, 2007a). Of data collected from 20 Wisconsin organic dairy farms, ultrafiltered bovine whey products were the most common dry-off treatment (Table 4). Other products used by organic farmers included vitamin supplements, microbial supplements, and vitamin C (Table 4). Both conventional and organic farmers had similar appraisal of compounds used for DCT. Regardless of management system, about 80% of farmers were satisfied or very satisfied with the result of the DCT, and 20% were somewhat satisfied (Pol and Ruegg, 2007a).

Differing management strategies are used at dry-off based on management system (Pol and Ruegg, 2007a). More organic farmers reported use of intermittent milking as compared with conventional herds (Table 3). There are data that is somewhat supportive of this approach. An older study reported that prevalence of intramammary infection in cows not treated with antimicrobials at dry-off was slightly less (i.e., 10%) for cows dried off using intermittent milking as compared with cows dried off abruptly (i.e., 15%; Natzke et al., 1975).

### Cost of Treatments

McBride and Greene (2007) did not observe a statistically significant difference in overall veterinary and medical costs based on management system. Whereas numerical differences were noted, the estimated cost of treatments administered at dry-off (intramammary and systemic) was not significantly different for conventional farms ($13.30) compared with organic farms ($7.43; Pol, 2005). However, the estimated cost of medications given for treatment of clinical mastitis was more than 2 times greater for conventional farms ($28.48) compared with organic farms ($11.33; \( P = 0.02 \)).

### EFFICACY OF ALTERNATIVE THERAPIES

#### Miscellaneous Alternative Therapies

Many alternative therapies used for treatment of mastitis have some theoretical basis for consideration of efficacy, but there are almost no peer-reviewed studies that demonstrate clinical efficacy. A recently published critical review of veterinary usage of botanical and herbal remedies states that “With few exceptions,
controlled studies on the clinical effects of herbal or botanical preparations in veterinary medicine appear to be essentially nonexistent (Ramey, 2007).

Organic producers in Wisconsin reported that they often used garlic tincture or aloe as mastitis remedies (Pol and Ruegg, 2007a). Whereas antimicrobial properties of garlic extracts and aloe vera gels have been reported (Ross et al., 2001; Agarry et al., 2005), the use of these compounds to successfully treat mastitis has not been described. Only one clinical trial has been published that specifically evaluated clinical efficacy of a botanical treatment used for subclinical mastitis (Abaineh and Sintayehu, 2001). Two different doses of a dried leaf powder of an African perennial herb (Persicaria senegalense) were fed for 3 to 5 d to cows infected with subclinical mastitis. Bacteriological cures after treatment were compared with cures experienced by both negative and positive control groups (cows in the positive control group were treated with an intramammary compound containing penicillin, streptomycin, and vitamin A). The distribution of causative pathogens was not reported by group or for the final study population, but coagulase-negative staphylococci and micrococci were the most common pathogens isolated from 1 of 2 farms participating in the trial. In the first trial, bacteriological cure rates at 14 d were 58% for cows treated with Persicaria, 55% for negative control cows, and 78% for cows receiving intramammary antibiotic treatment. In the second trial, bacteriological cure rates were 78% cows treated with Persicaria, 30% for negative control cows, and 70% for cows treated with intramammary antibiotic. The authors concluded that the studies suggested therapeutic efficacy of the treatment but conceded that more research was necessary.

Stimulation of the immune system is the goal of several alternative therapies advocated for treatment of mastitis (Karreman, 2007). Subcutaneous injection of an extract of ginseng has been evaluated as a treatment for cows affected with subclinical mastitis caused by Staph. aureus (Hu et al., 2001, 2003). The use of ginseng extracts as an adjuvant for a Staph. aureus bacterin resulted in enhanced lymphocyte proliferation in response to stimulation and greater antibody production (Hu et al., 2003). However, subcutaneous injections of ginseng given to cows subclinically infected with Staph. aureus did not affect the number of bacteriological cures, milk somatic cell count (SCC), blood leukocyte counts, or the proportion of lymphocyte populations (Hu et al., 2001).

Several products that claim to be immune stimulants are available commercially in the United States, and one product (i.e., Immunoboost, Bioniche Animal Health, Bellville, Ontario, Canada) has a USDA license with an indication for treatment of calf scours caused by Escherichia coli. Immunoboost is a mycobacterium cell wall fraction immunostimulant. A small, randomized, controlled clinical trial was performed to evaluate treatment of subclinical intramammary infections using combined therapy with Immunoboost, a colostrum-whey product (i.e., BiocelCBT, Agri-dynamics, Martins Creek, PA), and homeopathy (Tikofsky and Zadoks, 2005). The authors reported that there were no significant effects of treatment on bacteriological cure rate or SCC. The mean linear somatic cell scores were 6.6 (pretreatment) and 6.7 (posttreatment), and 1.9 (pretreatment) and 2.1 (posttreatment) for quarters infected with Staph. aureus or other pathogens, respectively.

Among Wisconsin organic dairy farmers, a bovine whey product was the most common compound administered for systemic treatments of clinical mastitis and at dry-off. Ultrafiltered bovine whey has been shown to have the ability to enhance in vitro neutrophil activity (Kehrli et al., 1989; Roth et al., 2001). The ability of these products to successfully treat subclinical or clinical mastitis has not been described.

Some medications used by organic farmers are nonantimicrobial products that have recognized antiinflammatory uses in conventional medicine. Experimental intramammary administration of an antiinflammatory steroid drug, isoflupredone, has been found to be effective in reducing swelling of the mammary gland but has the unwelcome side effect of reduced milk production (Carroll et al., 1965). Some antioxidant properties have been identified for vitamin C and its concentration in milk was found to be reduced after induction of clinical mastitis, perhaps because of utilization by neutrophils (Weiss et al., 2004). Clinical trials describing the use of vitamin C for treatment of mastitis have not been published nor have studies been published that support use of apple cider or microbial supplements. Some alternative treatments are not labeled for intramammary treatment but are packaged in squeeze-jets with labels indicating topical usage of nonfood-producing animals. It is important to recognize that the use of nonapproved intramammary compounds, such as aloe vera, is prohibited by FDA regulations.

Whereas data on efficacy are lacking, the perception of cure after treatment of clinical mastitis was not significantly different between conventional and organic farmers (Table 3, Pol and Ruegg, 2007a). Approximately one-half of conventional and one-third of organic farmers estimated that fewer than one-half of clinical mastitis cases were cured as a result of treatment. A separate question in the same survey indicated that more organic farmers (74%) were satisfied or very satisfied with the results of compounds used to treat clinical mastitis compared with conventional farmers (40%) providing the same response (P = 0.03). It is interesting that organic and conventional farmers perceived the same cure rate, yet organic farmers were more satisfied with the results. Pol and Ruegg (2007a) did not collect prospective data about results of mastitis treatments, and it is possible that organic farmers had lower expectations. Prospective studies recording
clinical outcomes of mastitis treatments used on both organic and conventional farms are needed to further define this issue.

**Homeopathy**

Homeopathic remedies were first introduced in Germany in the era before microorganisms were identified and gained great popularity as treatments for a variety of human illnesses. A comprehensive review of homeopathy is beyond the scope of this article, but it is not difficult to assess the few articles that specifically address veterinary homeopathy. Egan (1998) described results of an unpublished trial that compared the use of a homeopathic nosode (i.e., a remedy derived from diluted pathogenic materials) or placebo administered for 12 mo to lactating cows (n = 188) located at research stations in Ireland. Clinical mastitis developed in 39 and 35% of cows in the homeopathy and placebo groups, respectively, and there was no significant difference in the frequency of isolation of pathogens from quarters.

Hektoen et al. (2004) reported the results of a randomized clinical trial that compared efficacy of homeopathy, placebo, and antibiotic therapy. This trial enrolled 57 cows from 39 herds and utilized a variety of outcome measures. Along with bacteriological responses, the study used defined scoring systems to evaluate acute changes (0 to 7 d) in clinical symptoms (i.e., body temperature, appetite, inflammation, etc.) and longer term (to d 28) chronic changes (i.e., udder fibrosis, California Mastitis Test, milk production in affected quarter, etc.) after treatment. The authors noted that sample size was small and that overall long-term results of all treatments were relatively poor. However, evidence of efficacy of homeopathic treatment beyond placebo was not evident at any time period.

The ability of a commercially available homeopathic nosode to influence SCC was evaluated in 152 Holstein-Friesian cows located in a single commercial dairy herd in the United Kingdom (Holmes et al., 2005). The nosode or a control solution was administered topically on the mucous membranes of the vulva twice daily for 3 consecutive days. Whereas significant daily variation in SCC was observed over the 28-d follow-up period, no significant differences in SCC were observed based on treatment.

Efficacy data for veterinary homeopathy appear to be almost completely lacking. The author of a recent critical review of veterinary homeopathy stated that “the few well designed trials in veterinary medicine have also failed to demonstrate efficacy of homeopathy, including for the treatment of calf diarrhea, somatic cell counts in milk, bovine mastitis and canine atopic dermatitis” (Rijnberk and Ramley, 2007). Although scientific evidence is lacking, European producers indicated that they chose homeopathy based on personal experience, which they valued more than scientific evidence or approval from the veterinary profession (Hektoen, 2004).

**ANTIMICROBIAL RESISTANCE OF MASTITIS PATHOGENS ISOLATED FROM ORGANIC DAIRY FARMS**

In general, researchers have reported that only a small proportion of gram-positive mastitis pathogens demonstrate resistance to commonly used veterinary antimicrobials (Tikofsky et al., 2003; Sato et al., 2004; Bennedsgaard et al., 2006; Roesch et al., 2006; Pol and Ruegg, 2007b). In Europe, where antimicrobial usage is allowed on organic farms, few differences in the proportion of resistance have been noted based on management system (Bennedsgaard et al., 2006; Roesch et al., 2006). Whereas resistance does not seem to be an emerging problem, surveillance for potential antimicrobial resistance of mastitis pathogens remains important. Methicillin resistance of *Staph. aureus* is a growing problem for human medicine, and methicillin-resistant *Staphylococcus epidermidis* were recently recovered from milk of cows located on a Swiss organic dairy farm (Walther and Perreten, 2007).

In the United States, reduced minimum inhibitory concentrations or zones of inhibition of penicillin and pirlimycin have been noted for *Staph. aureus* recovered from organic dairy farms as compared with isolates recovered from conventional farms (Tikofsky et al., 2003; Pol and Ruegg, 2007b). Pol and Ruegg (2007b) also reported reduced minimum inhibitory concentration values of penicillin, pirlimycin, ampicillin, erythromycin, and tetracycline for coagulase-negative staphylococci recovered from organic farms compared with isolates recovered from conventional farms. Although these results are intriguing, temporal studies that define the relationship between antimicrobial exposure at the animal level and the occurrence of resistance in mastitis pathogens are needed.

**SUMMARY AND CONCLUSIONS**

Consumer preferences for differentiated dairy products have resulted in dramatic growth of the organic dairy sector, and this growth is expected to continue. It is important for researchers to understand that there are large differences in organic standards among countries, and in some countries, differences exist among certifying agencies. One consequence of these differences is that the term organic production does not fully define exposures to antimicrobials or other substances commonly used for management of animal health. Future publications regarding organic production should include information about substances that are allowed for animal health management. The impact of the rigorous prohibition of antimicrobial usage included in the US organic standards has not been adequately assessed, and future research in this area is needed.

Organic dairy farms tend to be smaller, to produce less, and to be housed in older traditional facilities, and these differences need to be accounted for in the design and analysis of future studies. Reduced milk yields
consistently noted for organic herds are likely a result of less concentrated diets. The observation that fewer incidents of nutritionally related diseases have been reported in organic relative to conventional herds support this concept. Researchers have published several studies that compared animal health based on management system, but the results are insufficient to arrive at a conclusive statement regarding differences in animal health that can be attributable to organic management.

It is clear that there is little difference in the quality of milk (based on SCC and bacterial counts) produced on organic or conventional dairy farms. Organic dairy farmers consistently report fewer cases of clinical mastitis compared with conventional farmers, but the impact of philosophical differences in disease detection, use of veterinarians, and treatment requires more investigation. Organic dairy farmers in the United States utilize a variety of nontraditional treatments. While organic dairy producers pay less for treatments and seem satisfied with nontraditional therapies, there are very few efficacy data to support the use of most alternative treatments. There is a profound lack of efficacy data for veterinary homeopathic treatments, and the use of these treatments should not be recommended.

LITERATURE CITED


