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P. L. Ruegg

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P. L. Ruegg[1]

Department of Dairy Science, University of Wisconsin, Madison, 53706

[1] Corresponding author: plruegg@wisc.edu



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**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 U.S., 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 U.S. Food and Drug Administration (FDA) that can be used for treatment of mastitis on organic dairy farms and usage of unapproved products is contrary to FDA guidelines. In general, organic dairy farms tend to be smaller, lower producing 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 U.S. 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 both conventional and alternative therapies for treatment and control of mastitis. In the U.S., organic farmers treat clinical mastitis using a variety of alternative therapies including whey based products, botanicals, vitamin supplements, and homeopathy. Organic farmers in the U.S. use a variety of alternative products to treat cows at dry-off. Virtually no data is available that supports 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 2006, the Organic Trade Association reported that sales of organic foods grew 21% to represent $16.7 billion in consumer sales (about 2.8% of total U.S. 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 (**ORG**) cows in the U.S. 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 (**CON**) dairies to organic management. In 2005, 61% of all ORG 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 U.S. consumers expressed at least moderate concern about health risks associated with use of pesticides and antibiotics in food production (Roper, 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 growth hormone 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 U.S. 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 website (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 third of gestation onward.

Like the organic standards of Canada and the EU, the U.S. ORG 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).

While 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, U.S. organic standards contain a unique and rigorous prohibition against use of most conventional veterinary treatments. While 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 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 U.S. 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 U.S. is considerably altered in order 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 U.S. 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 cwt but also reported production costs of about $5 to $7 per cwt greater than CON dairy farms (McBride and Greene, 2007). However, the price paid for ORG milk is generally more stable and small dairy farms that have no desire to expand may consider conversion to ORG status as a way to profitably maintain a traditional dairy farm. As a consequence, housing, production, and management of most ORG dairy farms tend to be similar to management and housing of traditional small dairy farms of years past. In two separate studies conducted using Wisconsin dairy herds, there were significant differences between ORG and CON herds in the proportion of herds that used freestall housing (19% ORG vs. 61% CON and 3% ORG vs. 27% CON for Zwald et al., 2004 and Sato et al., 2005, respectively). While exceptions exist, dairy farms managed organically tend to be smaller, lower producing, and are more likely to be milked in stanchion or tie stall barns as compared to CON 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 CON and ORG 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 CON dairies fed lactating cows a total mixed ration, and more pre-parturient cows received a transition ration and anionic salts as compared to ORG herds (Zwald et al., 2004). Others have noted that ORG cattle were fed much less concentrate as compared to cattle in CON herds (Hardeng and Edge, 2001; Roesch et al., 2005). In the U.S., organic production practices require access to pasture suitable to stage of production, climate and environment. Sato et al. (2005) reported that while 76% of CON herds included in his study had some access to grazing, 50% of the ORG herds utilized intensive rotational grazing, in contrast to only 7% of the neighboring CON herds. Few studies have evaluated overall management differences of ORG and CON 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 ORG or CON 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 ORG dairy farms, there would be an increased probability of several age-related disorders, such as milk fever, mastitis, cystic ovaries, and lameness (Dohoo et., 1984).  Housing is an important risk factor for disease and many ORG 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 CON and ORG 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 originates in different countries.  Pooling of data collected from farms operating under differing certification standards or comparison of studies conducted in the U.S. 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 CON and ORG system (Vaarst and Enevoldsen, 1997; Rekson 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., 2007) 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 U.S. ORG farms. Hamilton et al. (2002) compared the health status of cows in ORG (n = 25) and CON (n = 1102) dairy herds in Sweden. Herd sizes were similar (32 to 33 cows/herd) but production was less for ORG (6,213 kg milk) as compared to CON (7,572 kg milk). This analysis was likely biased by the use of health records that were retrieved from different systems. Veterinarians recorded treatments for ORG dairy herds whereas treatments for animals on CON 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 were not significantly different based on management system. There was a significant association of herd management system with the incidence of retained placenta [0.1 (ORG) and 2.3 (CON) cases per 100 cow-years], mastitis treatments [9.1 (ORG) and 14.7 (CON) cases per 100 cow-years], and trodden teats [0.3 (ORG) and 1.8 (CON) cases per 100 cow-years].

The impact of organic management on reproductive performance has not been well defined. Rekson et al. (1999) evaluated the reproductive performance of ORG (n = 29) and CON (n = 87) dairy herds in Norway over a period of three years (i.e., 1994 to 1996). The unit of study was the cow over one 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 ORG and CON, respectively). The annual rate of replacement was 23% (ORG) and 35% (CON, $P < 0.01$). It is not likely that results of this study can be extrapolated to the U.S. situation because of differences in reproductive management between cattle in the U.S. and Norway.

Disease detection and definition appear to be associated with management system and should be accounted for in future studies. While 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 impacted by management system. For example, Norwegian researchers (Harding and Edge, 2001) reported that the risk of mastitis (OR = 0.38), milk fever (OR = 0.33), and higher somatic cell count (OR = 0.60) were reduced for ORG (n = 31 herds) as compared to CON (n = 93 herds) dairy herds. They attributed the reduction in disease to more access of ORG cattle to pasture but failed to address whether differing attitudes about disease 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 CON and ORG, respectively), respiratory disease [3.3 and 0.8 cases/(100 cow-years) for CON and ORG, respectively] and metritis [15 and 9 cases/(100 cow-years) for CON and ORG, respectively] were reported for ORG dairy farms in Wisconsin (Pol and Ruegg, 2007a). It is impossible to determine if the observed differences were attributable to adoption of ORG 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 U.S., adoption of ORG management appears to result in reduced consultation with veterinarians regarding animal health. Organic farmers in the U.S. report less dependence on veterinarians, more dependence on the opinion of other ORG farmers and fewer regularly scheduled veterinary services as compared to CON farmers (Zwald et al., 2004; McBride and Green, 2007). It is possible that restrictions on treatments inherent in the U.S. 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 ORG and CON dairy farmers.

## MILK QUALITY AND MANAGEMENT OF MASTITIS

***Milk Quality.*** While consumers may perceive the milk from ORG herds is higher quality than milk from CON herds, there is a pervasive myth among dairy professionals that quality of milk produced on ORG dairy farms is considerably less than quality of milk produced on similar CON dairy farms. Neither argument are supported by the available data does not support that belief (Table 2). Although small differences in bulk tank SCC (**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 U.S. and it is difficult to separate the confounding effect of herd size from the potential effect of management system. In one study in Wisconsin, ORG dairy herds had slightly greater BTSCC but the ORG herds also contained fewer cows (Zwald et al., 2004). While 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 CON and ORG herds, Pol and Ruegg (2007b) recovered more contagious pathogens from individual quarter milk samples obtained from cows on ORG farms (n = 2334 quarters; 5.4% *Staphylococcus aureus* and 2.3% *Streptococcus agalactiae*) compared with samples obtained from cows on CON farms (n = 3338 quarters; 2.9% *Staphylococcus aureus* and 0.8% *Streptococcus agalactiae*). While these small differences were statistically significant, the overall prevalence of these contagious pathogens was surprisingly small and probably accounted for by the inability of ORG 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 two separate studies, the proportion of animals culled due to mastitis was not associated with herd type (about 8 to 9% of both ORG & CON 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 ORG as compared to CON 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 UK 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 ORG herds, 26 to 37 treatments per 100 cow-years for ORG herds interested in reducing antimicrobial usage, and 0 to 3 per 100 cow-years for ORG herds that had an explicit policy of non-use of antimicrobials, respectively (Vaarst et al., 2006).

Pol and Ruegg (2007a) identified philosophical differences between ORG and CON farmers in the detection of mastitis and perception of cure after treatment and it is possible that more diseases were noted on CON farms simply because of more treatment options (Table 3).

Of CON farmers, 90% reported that they identified mastitis based on observation of milk, which was in contrast to only 45% of ORG 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 CON and ORG 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 (**CMT**) compared with CON 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 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 ORG herds were generally representative of smaller dairy herds located in Wisconsin. The most common active ingredients used in pre- and post-milking teat dips (i.e., iodine, chlorhexadine, and several chlorine-based products) are allowed for use under U.S. organic standards.

***Treatment of Clinical Mastitis.*** The U.S. national list of substances approved for use by

ORG farmers includes several compounds that could be used in mastitis treatment protocols. Vaccines, anti-inflammatory drugs (e.g., aspirin and flunixin), electrolytes, and furosemide (with double the milk withholding period) are all permitted substances under U.S. organic standards. Oxytocin is approved for postpartum therapeutic usage only but no antimicrobials can be used without disqualifying the cow from ORG production.

It is well known that mastitis treatments account for the majority of antimicrobial usage on CON 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 CON dairy farms was by intramammary infusion for treatment or prevention of mastitis (Figure 1; Pol and Ruegg, 2007b). In this group of herds, cephapirin, pirlimycin, and amoxicillin were the most common compounds used for intramammary treatment of clinical mastitis but data was collected before approval of a newer intramammary antimicrobial that has been widely adopted. Extra-label treatments via intramammary infusion were reported by 11 of 20 CON farmers, while 2 CON 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 CON farmers (Zwald et al., 2005; Pol and Ruegg, 2007b).

In the EU, ORG 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 ORG (n = 16) and CON (n = 7) farms in the United Kingdom, Hovi (2001) reported that antibiotics were used to treat clinical mastitis by 100% and 41% of CON and ORG farmers, respectively. The duration of treatment was similar for both management systems but ORG farmers reported significantly longer milk withhold periods (11.2 and 5.5 d for ORG and CON, respectively). Homeopathy was the most common alternative treatment (reported by 51% of ORG farmers) but other treatments included the use of udder linament, frequent milking and intramammary infusion of aloe (Hovi, 2001). More than 50% of the products administered on Dutch ORG 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 Kingdom, 56% of cases of clinical mastitis were treated using alternative therapies including homeopathy (Weller and Bowling, 2000). In Denmark, some ORG farmers that were trying to reduce antimicrobial usage, adopted the use of nurse cows and dry-off of chronic mastitis quarters to manage mastitis (Vaarst et al., 2006).

In the U.S., cows that receive any antimicrobial treatments are disqualified from ORG production and ORG farmers in the U.S. 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 ORG farmers (95%) used some non-antimicrobial 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 health products and, therefore, extra-label usage is not allowed under FDA guidelines. Organic farms in the U.S. have also reported the use of approved anti-inflammatory 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 CON herds with low BTSCC and ORG 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 ORG dairy herds (28.9 cases per 100 cow-years) as compared to CON dairy herds (9.2 cases per 100 cow-years) (Hovi and Roderick, 2000).

In the U.S., use of long acting intramammary antibiotics is heavily adopted by CON dairy farmers but is not allowed under the national organic standards and is rarely used by ORG farmers (Zwald et al., 2004; Rodrigues et al; 2005; Sato et al., 2005; Pol and Ruegg, 2007a). Approximately one-half of ORG dairy farms reported that they administered a variety of non-antimicrobial ORG products to improve udder health at dry-off (Pol and Ruegg, 2007a). Of data collected from 20 Wisconsin ORG dairy farms, ultra-filtered bovine whey products were the most common dry-off treatment (Table 4). Other products used by ORG farmers included vitamin supplements, microbial supplements, and vitamin C (Table 4). Both CON and ORG 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 ORG farmers reported use of intermittent milking as compared to CON herds (Table 3). There is 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 to cows dried off abruptly (i.e., 15%) (Natzke et al., 1975).

***Cost of Treatments.*** McBride and Green (2007) did not observe a statistically significant difference in overall veterinary and medical costs based on management system. While numerical differences were noted, the estimated cost of treatments administered at dry-off (intramammary and systemic) was not significantly different for CON farms ($13.30) compared with ORG farms ($7.43) (Pol, 2005). However, the estimated cost of medications given for treatment of clinical mastitis was more than two times greater for CON farms ($28.48) as compared to ORG 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). While 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 have 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 to 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 (CNS) and micrococci were the most common pathogens isolated from one 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 (**IMM**) 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 IMM 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 a number of 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 *Staphylococcus aureus* (Hu et al., 2001, Hu et al., 2003). The use of ginseng extracts as an adjuvant for a *Staphylococcus 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 *Staphylococcus 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 U.S. 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 either bacteriological cure rate or SCC. The mean linear somatic cell scores were 6.6 (pre-treatment) and 6.7 (post-treatment) and 1.9 (pre-treatment) and 2.1 (post-treatment) for quarters infected with *Staph aureus* or other pathogens, respectively.

Among Wisconsin ORG dairy farmers, a bovine whey product was the most common compound administered for systemic treatments of clinical mastitis and at dry-off. Ultra-filtered 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 ORG farmers are non-antimicrobial products that have recognized anti-inflammatory uses in conventional medicine. Experimental intramammary administration of an anti-inflammatory 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 ‘squeezejets' with labels indicating topical usage of 'non-food producing animals.' It is important to recognize that the use of non-approved intramammary compounds, such as *aloe vera*, is prohibited by FDA regulations.

While data on efficacy is lacking, the perception of cure after treatment of clinical mastitis was not significantly different between CON and ORG farmers (Table 3, Pol and Ruegg, 2007a). Approximately one-half of CON and one-third of ORG 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 ORG farmers (74%) were satisfied or very satisfied with the results of compounds used to treat clinical mastitis compared with CON farmers (40%) providing the same response ($P = 0.03$). It is interesting that ORG and CON farmers perceived the same cure rate yet ORG 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 ORG farmers had lower expectations. Prospective studies recording clinical outcomes of mastitis treatments used on both ORG and CON 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, CMT, 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 homoeopathic 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. While 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 appears 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). While 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 ORG farms, few differences in the proportion of resistance have been noted based on management system (Bennedsgaards, et al., 2006; Roesch et al., 2006). While resistance does not seem to be an emerging problem, surveillance for potential antimicrobial resistance of mastitis pathogens remains important. Methicillin resistance of *Staphylococcus aureus* is a growing problem for human medicine and methicillin-resistant *Staphylococcus epidermidis* were recently recovered from milk of cows located on a Swiss ORG dairy farm (Walther and Perreten, 2007).

In the U.S., reduced **MIC** or zones of inhibition of penicillin and pirlimycin have been noted for *Staphylococcus aureus* recovered from ORG dairy farms as compared to isolates recovered from CON farms (Tikofsky, et al., 2003; Pol and Ruegg, 2007b;). Pol and Ruegg (2007b) also reported reduced MIC values of penicillin, pirlimycin, ampicillin, erythromycin, and tetracycline for CNS recovered from ORG farms compared with isolates recovered from CON farms. While 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 ORG 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 U.S. organic standards has not been adequately assessed and future research in this area is needed.

Organic dairy farms tend to be smaller, lower-producing, and 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 ORG herds are likely a result of less concentrated diets. The observation that fewer incidents of nutritionally related diseases have been reported in ORG relative to CON 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 (as based on SCC and bacterial counts) produced on ORG or CON dairy farms. Organic dairy farmers consistently report fewer cases of clinical mastitis as compared to conventional farmers but the impact of philosophical differences in disease detection, use of veterinarians and treatment requires more investigation. Organic dairy farmers in the U.S. utilize a variety of non-traditional treatments. While organic dairy producers pay less for treatments and seem satisfied with non-traditional therapies, there is very little 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.

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Table 1. General production and demographic data for studies including data about organic (Org) and conventional (Con) dairy herds in the U.S.

| | | | Number herds | | Herd size | | Milk/cow, kg | | Culling rate, % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Study | Site | Herd Selection Criteria | Org | Con | Org | Con | Org | Con | Org | Con |
| Zwald et al., 2004 | MI, MN, NY, WI | Random within herd size strata | 32 | 99 | 91 | 192* | 23[a] | 31[a,]* | 18[c] | 17 |
| Sato et al., 2005 | WI | Geographically matched volunteers | 30 | 30 | 51 | 72* | 20[a] | 24[a,]* | --- | --- |
| McBride and Green, 2007 | 16 to 24 U.S. States | Representative Sample | 325 | 1462 | 82 | 156 | 6,182[b] | 8,629[b,]* | --- | --- |
| Pol and Ruegg, 2007 | WI | Volunteer herds with BTSCC >250,000 cell/ml | 20 | 20 | 72 | 197* | 21 [a] | 33[a,]* | 9[d] | 9 |

* Denotes statistically significant difference between organic and conventional herds at *P*<0.05.

[a] Daily milk production.

[b] Annual milk production.

[c] Overall reported herd culling.

[d] Culling for mastitis related reasons only.

Table 2. Indicators of milk quality for studies including both organic (ORG) and conventional (CON) dairy herds.

| | | | Number of herds | | Bulk tank SCC, cells/mL ($\times 10^3$) | | Rate of clinical mastitis | |
|---|---|---|---|---|---|---|---|---|
| Study | Site | Herd selection criteria | ORG | CON | ORG | CON | ORG | CON |
| Hardeng and Edge, 2001 | Norway | Matched stratified random sample | 31 | 93 | 79[a*] | 74[a] | 14[b*] | 29 |
| Hovi and Roderick, 2001 | UK | Geographically Matched | 16 | 7 | 135[*] | 84 | 37.6[c*]<br>28.9[d*] | 54.5[c]<br>9.2[d] |
| Zwald et al., 2004 | MI, MN, NY, WI | Random within herd size strata | 32 | 99 | 370[e*] | 254 | --- | --- |
| Sato et al., 2005 | WI | Geographically matched volunteers | 30 | 30 | 263 | 285 | 27.7 | 32.0 |
| Hamilton et al., 2006 | Sweden | Volunteers (ORG) & matched on herd size (CON) | 26 | 1102 | 173 | 191 | 9[f*] | 15 |
| Ellis et al., 2007 | UK | undefined | 14 | 14 | 206[g] | 189[g] | 3.5[h*] | 5.6 |
| Fall et al., 2007 | Sweden | Single herd with 145 ORG & 151 CON managed cows | ½ | ½ | 91 | 106 | --- | --- |
| Pol and Ruegg, 2007 | WI | Volunteer herds *with BTSCC >250,000 cell/ml* | 20 | 20 | 305[e] | 335 | 20.5[*] | 40.9 |
| Roesch et al., 2007 | Swiss | Matched volunteers | 60 | 60 | 53[*i]<br>55 | 38<br>48 | --- | --- |

[*] Denotes statistically significant difference between organic and conventional herds at $P$<0.05.

[a] Converted from natural log as reported in study.

[b] Cases per 100 cows per lactation.

[c] Incidence in lactating period.

[d] Incidence in dry period.

[e] Means estimated from distributions presented in study.

[f] Annual incidence density.

[g] Estimated mean from data reported in study.

[h] Cases per 100 cows/month.

[I] Data analyzed at both 31 and 102 days post-partum

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

| | Conventional | | Organic | | |
|---|---|---|---|---|---|
| | Number of herds or cows | % | Number of herds or cows | % | P-value |
| Identification of clinical mastitis | | | | | |
| Observe milk | 18 | (90.0) | 9 | (45.0) | 0.002 |
| Other methods (below) | 2 | (10.0) | 11 | (55.0) | |
| *Abnormal milk on filter* | *1* | *(5%)* | *2* | *(10%)* | |
| *CMT positive* | *0* | *(0%)* | *2* | *(10%)* | |
| *Swollen quarter* | *1* | *(5%)* | *6* | *(30%)* | |
| *Other method* | *0* | *(0%)* | *1* | *(5%)* | |
| Determination of cure after treatment of clinical mastitis | | | | | |
| Observe normal milk | 15 | (75.0) | 4 | (20.0) | < 0.001 |
| Other methods (below) | 5 | (25.0) | 16 | (80.0) | |
| *CMT negative* | *2* | *(10.0)* | *5* | *(25%)* | |
| *Udder looks & feels normal* | *0* | *(0%)* | *6* | *(30%)* | |
| *Test day SCC* | *2* | *(10.0)* | *3* | *(15%)* | |
| *Treatment is completed* | *1* | *(5%)* | *0* | *(0%)* | |
| *Other* | *0* | *(0%)* | *2* | *(10%)* | |
| Number Cows Culled for Mastitis | 345 of 3937[b] | 8.8% | 129 of 1449[c] | 8.9% | 0.75 |
| Proportion of specific culling reasons for cows culled for mastitis | | | | | <0.001 |
| *Repeat Clinical Case* | *209* | *51.7%* | *81* | *9.8%* | |
| *High SCC* | *64* | *26.8%* | *23* | *43.3%* | |
| *Blind quarter* | *2* | *2.6%* | *25* | *3.9%* | |
| *Chronically infected* | *53* | *7.0%* | *0* | *0.0%* | |
| *Other* | *17* | *11.8%* | *0* | *0.0%* | |
| Culture of some clinical cases of mastitis | | | | | |
| Yes | 16 | (80.0) | 4 | (20.0) | < 0.001 |
| No | 4 | (20.0) | 16 | (80.0) | |
| Dry-off method | | | | | |
| Abrupt | 19 | (95.0) | 8 | (40.0) | < 0.001 |
| Intermittent | 1 | (5.0) | 12 | (60.0) | |

[a] Data are adapted from Pol and Ruegg (2007a) with some unpublished data added. Multiple answers per farm were allowed.

[b] Number of cows in conventional study herds.

[c] Number of cows in organic study herds;

Table 4. Reported products used for treatment of cows at dry-off or for clinical mastitis in organic dairy herds in Wisconsin (n = 20)[1].

| | Herds with reported usage of treatment, no. (%) | | |
|---|---|---|---|
| | For dry cow therapy | For clinical mastitis | Routes utilized[a] |
| Whey-based products | 5 (25%) | 9 (45.0) | PO, i.v., i.m., s.q. |
| Garlic Tincture | 0 (0%) | 7 (35%) | PO, in vulva |
| Aloe vera | 2 (10%) | 6 (30%) | PO, i.m., IMM, in vulva |
| Vitamin C | 2 (10%) | 5 (25%) | i.m., IMM, . |
| Multivitamin supplement | 3 (15%) | 4 (20%) | PO, i.m. |
| Aspirin | 0 (0%) | 4 (20%) | PO |
| Homeopathy | 1 (5%) | 4 (20%) | PO, in vulva |
| Vegetable or Olive Oil | 1 (5%) | 4 (20%) | IMM, Topical |
| Corticosteroid | 0 (0%) | 2 (10%) | i.m., IMM |
| Microbial supplement | 2 (10%) | 1 (5%) | IMM |
| Electrolytes | 0 (0%) | 1 ( 5%) | PO |
| Vitamin B | 0 (0%) | 1 (5%) | i.m. |

[1] Data are from Pol and Ruegg (2007a). Multiple answers per farm were allowed.

[a] PO = *per os*, IMM = intramammary.

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).