# Master's thesis in Veterinary Science

Camilla Solgaard VMK08090



# Udder Health in Organic Dairy Herds in the US with a Strategy of Non-use of Antimicrobial Drugs

- Evaluated on the basis of systematic clinical examinations, test day results, bulk tank milk samples, treatment protocols and interviews



# Academic advisor:

Ilka Christine Klaas
Department of Large Animal Sciences
Faculty of Life Science
University of Copenhagen
Grønnegårdsvej 2
1870 Frederiksberg C

Torben Werner Bennedsgaard
Department of Animal Health and Bioscience
Faculty of Agricultural Sciences
Aarhus University
Blichers Allé 20
8830 Tjele

Submitted: February 16th 2011

# **Preface**

This study was conducted with the purpose of increasing the knowledge of udder health of dairy cows from antibiotic-free farms and learning from the practice of such farms in the US. It is also intended as an inspiration and help for organic dairy farms in Denmark, who wishes to practice without the use of antibiotics. A description of US organic dairy herds and an assessment of udder health in these herds will be conducted by means of systematic clinical examination of udders, treatment protocols filled in by the farmer, test day results, bulk tank milk samples and interviews with the farmers about mastitis management.

This work was a part of a DARCOF3 research program and an ECOVIT-project aimed at increasing the integrity in organic dairy production through natural resources of vitamins and minerals and non-antibiotic health control. The project is funded with grants from The Ministry of Food, Agriculture and Fisheries, Denmark.

This thesis was written as a mandatory part of the Danish Veterinary Master's Degree Program and leads to the degree of Doctor of Veterinary Medicine. The project was composed in collaboration with the Department of Large Animal Sciences, Faculty of Life Sciences at the University of Copenhagen, Denmark and the Department of Animal Health and Bioscience, Faculty of Agricultural Sciences at Aarhus University, Denmark.

I wish to thank Torben Werner Bennedsgaard at Faculty of Agricultural Sciences at Aarhus University and Ilka Christine Klaas at Faculty of Life Sciences at the University of Copenhagen for their guidance during the making of this thesis, their aid in collecting of data, their help with the process of planning and general commitment to this project. I also wish to thank Kellie Cicconi, graduate student of Cornell University, and VMD Hubert Karreman from Penn Dutch Cow Care for assisting with the selection of farms in respectively NY and PA. Furthermore I wish to give special thanks to the 18 individual farmers in WI, PA and NY for greeting us welcome, taking their time and putting an effort into filling out the different treatment protocols, allowing us access to their periodic milk records and moreover for sharing their knowledge and experience with us and eliciting patience when we delayed their day.

Last but not least/Finally I wish to thank my family and friends for providing great support and encouragement during the entire working process.

This research paper is addressed to farmers, veterinarians, veterinary students, scientists, and others who share an interest of organic farming, udder health, and/or non-antibiotic strategies.

VMK 08000	Camilla Solgaard

### Abstract

Mastitis is often considered the most common production disease in organic and conventional dairy herds and most antibiotic treatments in cattle are due to mastitis. Moreover, mastitis is of great importance for animal welfare.

One of the main goals in organic livestock farming is the promotion of health and welfare. Use of antimicrobial drugs to treat sick animals are considered to be in controversy with the organic aims of a production based on naturalness and the risk of antimicrobial resistance has been a major concern in recent years. However, one concern related to a non-antibiotic treatment strategy is the risk of reduced animal health and welfare.

A description of eighteen US organic dairy herds and an assessment of udder health in these herds was conducted using the results from of a systematic clinical examination of 802 cows udders, treatment protocols filled in by the farmer during a two-month period, test day results from a twelve-month period, bulk tank milk samples and interviews with the farmers.

Many different approaches to the management of mastitis were identified in this study. In general, the US organic farmers focused on prevention of disease rather than treatment and examples of common preventive approaches were: Good milking routine and hygiene, identification of problem cows, not pushing the cows for high milk production and offer feeding supplements to the cows. Promptness with reference to identification and intervention was considered as one of the main success criteria for mastitis treatment and the most commonly used treatment types were udder liniment or ointment, herbal products, stripping, homeopathic remedies, immune stimulants and drying off quarters.

Three different types of mastitis treatment strategies related to the type of mastitis and the farmers performing the treatments were identified in the US organic dairy herds: 'The quick and simple strategy', 'The time consuming and advanced strategy' and 'The mixed strategy'.

It is difficult to evaluate the overall udder health situation of the eighteen US dairy herds based on udder health indicators mainly obtained during one visit but none of the results from the PCR analysis, the systematic clinical examination, the test day results and the treatment protocols indicated a low udder health status. This was supported by the comparison to Danish organic low-antibiotic herds and other organic herds from Denmark, which also did not indicate the presence of a low udder health status.

When the above-mentioned results are held up against each other it can be suggested that organic farmers manage to successfully control udder health indicators despite having a strategy of non-use of antimicrobial drugs.

Keywords: Organic dairy farming, mastitis, udder health, medical treatment

# Resumé

Mastitis betragtes ofte som den hyppigst forekommende produktionssygdom i økologiske og konventionelle malkekvægsbesætninger, og mastitis er årsag til hovedparten af antibiotikabehandlingerne foretaget hos kvæg. Endvidere er mastitis af stor dyrevelfærdsmæssig betydning.

Et at de vigtigste mål for økologisk husdyrsproduktion er at fremme sundhed og velfærd. Anvendelse af antibiotika til behandling af syge dyr anses for at være i strid med de økologiske mål om en produktion baseret på naturlighed, og risikoen for antibiotikaresistens har været årsag til stor bekymring i de senere år. Der er dog blevet udtrykt bekymring for, at en antibiotika-fri behandlingsstrategi kan medføre forringet dyrevelfærd og sundhed på kort sigt.

En beskrivelse af atten amerikanske økologiske besætninger og en vurdering af yversundhed i disse blev udført ved hjælp af resultaterne fra en systematisk klinisk undersøgelse af yvere på 802 køer, behandlingsprotokoller udfyldt af landmanden i løbet af en to måneders periode, test dages resultater fra en tolv måneders periode, tankmælkprøver og interviews med landmændene.

I denne undersøgelse blev mange forskellige tilgange til management af mastitis identificeret. Generelt fokuserede amerikanske økologiske landmænd på forebyggelse af sygdom frem for behandling og eksempler på hyppigt anvendte præventive metoder var: God malkerutine og hygiejne, identifikation af problemkøer, ikke presse køerne til en høj mælkeproduktion og tilbyde fodertilskud til køerne. Nogle af de vigtigste kriterier for succesfuld mastitisbehandling er hurtig identifikation og intervention og de hyppigst anvendte behandling typer blev yvercreme, urte-baserede præparater, udmalkning, homøopatiske midler, immunstimulerende præparater og afgoldning af kirtler.

Tre forskellige typer mastitisbehandlingsstrategier relateret til mastitistype og typen af behandlere blev identificeret i de amerikanske økologiske malkekvægsbesætninger: 'Den hurtige og enkle strategi', 'Den tidskrævende og avancerede strategi' og 'Den blandede strategi'.

Det er vanskeligt at vurdere den samlede yversundhed i de atten amerikanske malkekvægsbesætninger, baseret på yversundhedsindikatorer hovedsagelig indsamlet i løbet af ét besøg, men ingen af resultaterne fra PCR-analysen, de systematiske kliniske undersøgelser, celletalsopgørelserne og behandlingsprotokollerne tyder på en dårlig yversundhedsstatus. Dette blev understøttet af, at sammenligningen med danske økologiske lav-antibiotika besætninger og andre økologiske besætninger fra Danmark heller ikke indikerede forekomsten af en dårlig yversundhed.

Når de ovenfor nævnte resultater holdes op mod hinanden kan det tyde på, at økologiske landmænd formår at kontrollere yversundhedsindikatorerne til trods for deres antibiotika-fri behandlingsstrategi.

Nøgleord: Økologiske malkekøer, mastitis, yversundhed, medicinsk behandling

# **Abbreviation key**

BTSCC Bulk tank somatic cell count

DHIA Dairy Herd Information Association

ECM Energy-corrected milk

E. coli Escherichia coli

PCR Polymerase Chain Reaction

S. aureus Staphylococcus aureus

SCC Somatic cell count

S. agalactiae Streptococcus agalactiae

S. dysgalactiae Streptococcus dysgalactiae,

S. uberis Streptococcus uberis

# 1. Introduction

# 1.1 Background

In the modern dairy industry, the cows are out under great pressure as they are bred and fed to produce large quantities of milk every day and there is a challenge to keep cows healthy while still maximizing the milk yield. Cows can adapt very well but they are kept under conditions that mainly meet production demand and not necessarily the cows' need. Therefore it is very difficult to keep them healthy all the time. Mastitis is often considered the most common production disease in organic and conventional dairy herds worldwide and it has important effects on the milk production (Pol & Ruegg 2007; Seegers *et al.* 2003; Weller & Bowling 2000). In addition, most antibiotic treatments in cattle are due to mastitis (Bennedsgaard 2003) and this disease is, in general, the most economically important disease of dairy cattle (Seegers *et al.* 2003). Moreover, mastitis is of great importance for animal welfare (Fitzpatrick *et al.* 1998; Milne *et al.* 2003).

One of the main goals in organic livestock farming is the promotion of animal health and welfare and a key aspect of this is production methods based on naturalness and disease prevention. Use of antimicrobial drugs is a very controversial topic in organic research. Consumption of antimicrobial drugs is prohibited in the organic production in the US since antimicrobial drugs are affecting the natural balance of living organisms and any use will result in loss of the organic status of the animal. However, in Europe, restrictive use of antimicrobial drugs is allowed in organic production to avoid compromising animal welfare (EC 2007; USDA 2011). Use of antimicrobial drugs to treat sick animals are considered to be in controversy with the organic aims of a production based on naturalness and the risk of antimicrobial resistance in animal pathogen and the potential transfer of resistant microbials to humans has been a major concern in recent years. Furthermore, the risk of residuals in milk and meat products and the environmental impact of antimicrobial drugs have brought into focus the promotion of non-antibiotic treatment policies in organic farming. However, one concern related to a non-antibiotic treatment strategy is the risk of reduced short-term animal health and welfare (Vaarst et al. 2006).

# 1.2 Objectives

Two very important questions in the debate of pros and cons of organic principles are:

Are organic farmers so dedicated to the organic goal of promoting health and welfare, that disease to a great extent will be prevented, and thus few cases will need antimicrobial treatment? Or will some of the cows requiring treatment not be treated, treated with inappropriate medicine or treated too late in order to preserve the animal's organic status?

More information on health in organic dairy herds having a non-antibiotic strategy is needed in order to be able to work diligently towards the organic goal of a combination of high animal health and welfare and reduction in antimicrobial consumption. Therefore, the objective of this descriptive study is to investigate the effects of an explicit non-antibiotic policy on health, in particular focusing on udder health since

mastitis as previously mentioned is one of the most prevalent production disease in dairy cows. Furthermore, another objective of this study is to gain knowledge of the practical management of mastitis without the use of antimicrobial treatments.

A description of US organic dairy herds and an assessment of udder health in these herds will be conducted using the results from of systematic clinical examination of udders, treatment protocols filled in by the farmer, test day results obtained from the Dairy Herd Information Association (DHIA), bulk tank milk samples and interviews with the farmers. The experience of the US farmers and the results of the data collection in this study will contribute to increased knowledge about udder health in antibiotic-free farming and thus elucidate the strengths and weaknesses of this strategy, making it possible to work towards minimizing the weaknesses and to further enhance the benefits. Furthermore, it might encourage and help guide Danish organic farmers towards a successful strategy of non-use of antimicrobial drugs.

In order to describe and assess the effects of a non-antibiotic treatment policy on the udder health answers to following questions will be sought:

- 1) What are the main characteristics of the US organic dairy herds having a strategy of antimicrobial drugs?
- 2) What is the udder health status in antimicrobial-free organic dairy herds, based on evaluation of the udder health indicators:
  - a) Somatic cell count, milk yield and milk sample PCR analysis?
  - b) Systematic clinical examination of udders?
  - c) Applied mastitis treatment and prevention strategies?
- 3) How do organic farmers handle mastitis cases in antimicrobial-free farming?
- 4) Is it possible to identify a link between different types of mastitis, treatment strategies and farmers performing the treatments?
- 5) Does the same level of udder health exist in the US organic dairy herds with a non-antibiotic strategy as in Danish organic dairy herds having a strategy of phasing out antimicrobial drugs when comparing results from the milk sample PCR analysis and data from test day results?

# 2. Literature review

#### 2.1 Mastitis

Mastitis is defined as inflammation of the mammary gland and it is a multifactorial disease resulting from the introduction and multiplication of pathogenic microorganisms in the udder. The incidence rate of mastitis and the magnitude of the inflammatory response is influenced by the causative pathogen, genetics, management, stage of lactation, parity, and immune status of the cow. Clinical mastitis is characterized by abnormal milk with changed composition and occurrence of bacteria; decreased milk production; swollen, warm and often painful quarters and it is sometimes associated with systemic clinical signs. No visible external changes indicate the presence of subclinical mastitis but as in clinical cases abnormal milk and a lower milk vield are found. In general, two types of mastitis are found; contagious mastitis mainly involving S. agalactiae, S. aureus and Mycoplasma; and environmental mastitis associated with Gram-positive bacteria as S. bovis, S. uberis, S. dysgalactiae, Enterococcus spp., other Staphylococcus spp. or Gram-negative coliforms as E. coli, Klebsiella spp. and Enterobacter spp. Environmental pathogens are found in the surroundings of the cows in particular in the bedding, manure, soil and on the teat skin. Contagious pathogens have their reservoir in the infected udder and infections are spread from cow to cow or between quarters and are often expressed as chronic and subclinical infections with periodic clinical episodes (Harmon 1994).

Mastitis is the most economically important disease of dairy cattle (Seegers *et al.* 2003). Costs can be divided into direct and indirect costs; Withdrawal of milk and increased veterinary costs are examples of the former, while decreased milk yield during the rest of the lactation, the reduction of the price premium of quality milk due to increased somatic cell counts and changed milk composition, penalties due to antibiotic residues in the milk, higher culling and replacement rates, increased labor requirements, and death cows are examples of the latter (Blowey & Edmondson 2010). In a Swedish study of organic dairy production it has been estimated that the average cost per case of clinical mastitis and subclinical mastitis is €278 and €60 respectively (Nielsen *et al.* 2010). Sørensen *et al.* (2010) estimated the economic losses of specific mastitis pathogens in conventional primiparous Danish Holstein cows to range from €149 to €570 per mastitis case, highest for *S. aureus* and Coagulase-negative staphylococci and lowest for *S. dysgalactiae* and *S. uberis*.

Fitzpatrick *et al.* (1998) and Milne *et al.* (2003) have shown that moderate clinical mastitis alters the cows' normal behaviors, and causes systemic physiological changes, such as significantly higher heart rates, rectal temperatures and respiratory rates, and larger hock-to-hock distances when compared to cows with mild clinical mastitis and normal cows; all of these are findings indicative of pain and is considered to compromise the welfare of the cow.

Prevention is the key to controlling mastitis in conventional as organic dairy herds and the National Mastitis Council has developed a ten-point program "the NMC international Recommended Mastitis Control Program" for the prevention of mastitis based on basic management procedures, which have been shown to have the greatest effectiveness in

preventing mastitis. The ten points are: 1) Establishment of goals for udder health, 2) Maintenance of a clean, dry, comfortable environment, 3) Proper milking procedures, 4) Proper maintenance and use of milking equipment, 5) Good record keeping, 6) Appropriate management of clinical mastitis during lactation, 7) Effective dry cow management, 8) Maintenance of biosecurity for contagious pathogens and marketing of chronically infected cows, 9) Regular monitoring of udder health status, 10) Periodic review of mastitis control program (NMC 2006).

According to Tikofsky (2005) realistic, achievable goals for udder health in the majority of farms are: 0% *Streptococcus agalactiae* and *Mycoplasma*, <5% *Staphylococcus aureus*, bulk tank SCC < 200,000 cells/ml, fewer than 5% new infections each month, 5-7% or less chronic infections and 2-3% clinical mastitis.

#### 2.2 Evaluation of udder health status

#### 2.2.1 Indicators for udder health

In the dairy world udder health is often defined as the absence of clinical signs of mastitis, by the quality of the milk and the occurrence of mastitis pathogens (IDF 1997). As previously mentioned mastitis is the most prevalent and economically important production diseases of dairy cattle and therefore the knowledge of indicators for udder health and mastitis is very important in order to be able to prevent new infections from occurring and reducing the number of existing infections. The identification and monitoring of mastitis depends on the various definitions and thresholds used for mastitis and the methods used to diagnosis. Methods for direct and indirect measures of udder health status and milk quality are numerous and some of the most frequently used methods are somatic cell counts, bacterial counts, bacteriological culturing of milk samples, and incidence of clinical mastitis recorded by the farmer or veterinarian (Ruegg & Reinemann 2002). These factors can be valuable in the evaluation of udder health but it is important to have in mind that there are limitations in the diagnostic capabilities and practical application of these tests for dairy farm problem solving. It can be difficult to compare udder health measures between herds and within herds between samplings due to different farm management approaches and treatment strategies. recording efficiency, intermittent shedding of some bacteria and failure to isolate pathogens and discard of milk with high SCC (Ruegg 2009; Ruegg & Reinemann 2002).

# 2.2.2 Somatic cells

Somatic cells are a reflection of the inflammatory response to an intramammary infection or another trigger of the immune system and an increased SCC can be used as an indicator of udder infection. It has been reported that uninfected quarters have a mean SCC of approximately 70,000 cells and the mean increases with age, decreasing milk production and days in milk. In order to use SCC to distinguish between cows having healthy udders and mastitis a cut-off value has to be chosen (Schukken *et al.* 2003). Thresholds between 100,00 and 500,000 cells/mL has been found in different studies but a SCC of approximately 200,000 has been suggested as the optimal cut-off with regard to reduction of diagnostic error (Harmon 1994; Schmidt *et al.* 2001; Schukken *et al.* 2003). The sensitivity and specificity of using a SCC threshold of 200,000 cells/mL as the cut point for infection have been reported to range from 73 – 89% and 75 – 85%, respectively when compared to bacterial culture as "the gold standard test"

(Ruegg & Reinemann 2002). SCC can be used as an indicator for udder health on quarter, cow and herd level and the most common used SCC test are the California Mastitis Test (CMT), test day results (DHIA) and bulk tank SCC.

The California Mastitis Test (CMT) is an inexpensive cow-side diagnostic mastitis test based on the degree of reaction between a CMT-detergent and the DNA of cell nuclei as a measure of the number of somatic cells in the milk. CMT can be useful as a screening test identifying cows having a quarter with an elevated SCC but does not give a precise measure of SCC values and it is based on subjective interpretation of the degree of color change (Ruegg & Reinemann 2002).

A single SCC record has some limitations as an indicator of udder health since the SCC is influenced by normal fluctuation throughout the course of an infection, diurnal variations, stress, breed, parity and stage of lactation. However, test day results (DHIA) can be useful in the monitoring for udder health on cow and herd level, in particular in herds experiencing infections from contagious pathogens because infections by these pathogens tend to be of longer duration than with environmental pathogens and thus a greater probability for identifying the related rise in SCC exist (Harmon 1994). The most accurate relationship between mastitis and SCC exists at quarter level, but test day results (DHIA) are based on composite milk samples of the four quarters with dependent but separate infection status and inflammatory response. Repeated records is a relative cheap and practical method to obtain information on new infections and monitor infected cows (Schukken *et al.* 2003). However, it is important to keep in mind that test day results does not account for the fact that some farmers controls SCC by drying of quarters in chronic cases (Vaarst *et al.* 2006).

Bulk tank somatic cell count (BTSCC) is the most frequent reference point for milk quality but it is a questionable monitoring tool for udder health since the content of somatic cells in the bulk tank can be controlled by avoiding the access of high SCC milk to the bulk tank by means of discard of milk, culling strategies, blinding quarters etc.

# 2.2.3 Mastitis pathogens

Bacteriological culture is a valuable but time-consuming and expensive monitoring tool for infection dynamics monitoring (Schukken *et al.* 2003). It can be used on cow level for surveillance to detect the presence of new or emerging pathogens, in specific control programs e.g for contagious pathogens, to evaluate treatment efficacy and to establish susceptibility patterns to aid in the development of rational treatment strategies. The usefulness of bacteriological cultures varies depending upon the type of organism, sampling and laboratory procedures and the sensitivity of individual cow cultures has been found to vary between 58-97% for different pathogens. Bulk tank cultures are used as an inexpensive screening test for mastitis pathogens at herd level but isolates can arise from either intramammary infections or environmental contamination and the number of organisms isolated does not correspond to the prevalence of infected cows in the herd making it an impractical test of udder health monitoring (Ruegg & Reinemann 2002).

Polymerase chain reaction (PCR) assays are reported to be a rapid, sensitive, specific, and reliable test for milk sample detection of the most common bovine mastitis

pathogens. PCR assays have been suggested to potentially complement or replace the "gold standard test", conventional bacterial culture methods, which are labor-intensive and time-consuming. The PCR test has the advantage of being targeted for specific pathogens, allow for rapid screening of a large number of pathogens simultaneously, and provide definitive confirmation of pathogens and antibiotic resistance genes. Furthermore, it can be used to detect growth-inhibited and dead bacteria (Gillespie & Oliver 2005; Koskinen *et al.* 2009; Riffon *et al.* 2001).

#### 2.2.4 Treatment of mastitis cases

Treated cases of mastitis can be used as an indicator of the occurrence of mastitis within a herd. The treatment of clinical mastitis can be reported in farm records, veterinary records or in national databases and used for comparison within and between farms but this is only a reliable tool if all cases are reported, definitions and disease detection strategies are standardized, and if all treatments approaches, antimicrobial drugs, alternative treatment strategies and blinding quarters, are recorded, which is not the case in most dairy herds. The decision to treat a diseased cow is highly dependent on the individual farmers definition of mastitis and treatment strategy. In a study on farmer's choice of treatment of mastitis Vaarst et al. (2002) found four levels of decision-making used in the herd: Symptom level (the severity of the mastitis), cow level (single cow historical and present characteristics), herd level (the situation of the herd, e.g. bulk tank somatic cell count) and level of alternatives (drying off quarters as a treatment option). The abovementioned factors is highly indicative of the fact that treated cases of mastitis can be considered to reflect different management strategies rather than the actual health status of the cow and therefore it is not a valuable tool for udder health monitoring when used alone.

#### 2.2.5 Systematic clinical examinations

Systematic clinical examinations of udders have been suggested as an easy, inexpensive and reliable tool for the evaluation of udder health status in dairy cows (Klaas *et al.* 2004; Fossing *et al.* 2006). The systematic clinical examination includes inspection and palpation of udder and teats and the assessment of milk secretion and reveals information on udder health by means of changes in udder and teats related to

- 1) morphologic features, as the shape, position and size of udder and teats is found to be related to the SCC level and occurrence of mastitis
- 2) milking or environmental changes, as an increased risk of intramammary infection is found in herd having poor milking routines, malfunction of milking equipment and suboptimal environmental conditions
- 3) pathologic changes associated with infection, the clinical signs found in acute mastitis cases beeing pain, heat, swelling, redness and loss of function with an outcome of either resolution or chronic infection characterised by destinct nodes or diffuse knotty tissue in the quarter, fibrous tissue or atrophy of the quarter (Klaas 2006).

The examination reveals a varity of clinical findings that have to be assessed and interpretted in order to make a diagnosis. Systematic clinical examinations can be useful in the assessment of udder health if carried out on a well-defined sample of cows using a standardized clinical protocol and if the sampling and clinical examination is carried out consistently. Selection of cows for clinical examination should either be a random sample of cows representative for the study population with regard to breed, parity and

stage of lactation or a sample of cows considered in high risk of having udder health problems, e.g. cows in specific parities or in early lactation. Systematic clinical examination provides information of the udder health situation within and between herds over time and can be useful in the identification of udder-related problems and management and environmental risk factors in the herd (Klaas 2006).

# 2.3 Organic farming standards

One of the main goals in organic livestock farming is the promotion of animal health and welfare and a key aspect of this is production methods based on naturalness and disease prevention. The producer must establish and maintain preventive livestock health care practices, with focus on appropriate breed selection, sufficient nutritional provision, selection of housing and pasture conditions that minimize the occurrence and spread of diseases and parasites and minimize pain and stress in the animal (EC 2007; USDA 2011).

Use of antimicrobial drugs for organic dairy cows are prohibited in the US since antimicrobial drugs are affecting the natural balance of living organisms. However, the organic farmers are not allowed to withhold treatment of a sick or injured animal in order to preserve its organic status but an animal treated with prohibited medication may not be sold as organic, nor may the milk or beef from this animal (USDA 2011). According to the European organic legislation sick animals shall be treated immediately to prevent them from suffering and antimicrobial drugs may be used in organic production in the European Union where necessary and under strict conditions, when the use of phytotherapeutic, homeopathic and other products is inappropriate to maintain the animal welfare (EC 2007). Additional regulations on antimicrobial drugs has been implemented in Denmark and some of these provisions are that antimicrobial drugs can only be used on organic dairy cows when the veterinarian has made a diagnosis, prophylactic use of antimicrobial drugs are prohibited and the animals treated with antimicrobial drugs have twice the non-organic withdrawal period. Furthermore, the farmer must re-convert animals if they are treated with veterinary drugs more than tree times within one year and the re-conversion period is six months for dairy products and twelve months for meat (Vejledning om økologisk jordbrugsproduktion, April 2010, stk. 12 og 15).

# 2.4 Management of mastitis in organic herds

As mentioned above, an increasing concern about antimicrobial resistance has lead to a critical antimicrobial strategy in organic as well as conventional herds during the last years. Studies on farmers phasing out antimicrobial drugs in their herds have been conducted in order to gain knowledge about non-antimicrobial treatment strategies. Vaarst *et al.* (2006) found that farmers phasing out antimicrobial drugs changed their perception of disease over time from something that was unavoidable to something that could and should have been avoided. The restrictions on antimicrobial drugs made the farmers focus on selection criteria for treatment and disease prevention. The main tool in this process was improvement of the herd health and welfare through optimization of the housing conditions, milking routines, focus on the individual cow and early intervention in case of disease.

Organic dairy farmers in Europe use antimicrobials as well as alternative treatment strategies when treating cases of mastitis. In a study conducted in the UK antimicrobials were used in 41% of the mastitis treatments on organic dairy farms and homeopathic remedies accounted for 51% of these alternative treatments. Other alternative therapies were used in 8% of the cases and these included udder liniments and frequent stripping. cold-water massage and intramammary infusion of aloe vera (Hovi 2001). In another UK study 56% of the cases of mastitis were reported to be treated using alternative treatments (Weller and Bowling, 2000). As mentioned above, treatment with antimicrobials are prohibited in the US organic production making alternative treatment strategies widely used in US organic dairy herds. In a study from the US less than 10% of the organic dairy farmers reported antibiotic treatments of the milking cows and none of these used antimicrobial drugs to treat mastitis (Zwald et al. 2004), which is in accordance with findings by Pol & Ruegg (2007) and Sato et al. (2005a). Pol & Ruegg (2007) reported use of a variety of nonantimicrobial compounds for treatment and prevention of mastitis in organic dairy herds in Wisconsin, including whey-based products, garlic tincture, aloe vera, vitamin supplements, aspirin, homeopathy, vegetable or olive oil, corticosteroids, microbial supplements and electrolytes. Sato et al. (2005a) reported alternative treatment strategies comparable to the study conducted by Pol & Ruegg (2007) and furthermore reported the use of frequent stripping and nursing cows as mastitis treatment strategies.

# 2.5 Udder health in organic and conventional dairy herds

The udder health in conventional and organic herds with or without having a strategy of phasing out antimicrobial drugs has been compared in several studies conducted in Europe and the US. Many of these comparison studies show no significant difference in udder health indicators. Sato et al. (2005a) showed no significant difference in incidence of clinical mastitis, bulk tank somatic cell count, bulk tank bacterial count and average annual cull rate when comparing geographically matched organic and conventional herds in Wisconsin. Bennedsgaard et al. (2010) reported that Danish organic farmers managed to reduce the use of antimicrobial drugs by approximately 50% without an apparent negative effect on somatic cell count, production level, mortality rate, calving number and the incidence of treatment of mastitis or other diseases. This is in accordance with Vaarst et al. (2006) who found that Danish organic herds having significant fewer mastitis treatments per 100 cow-year than other organic herds do not have significant different bulk tank somatic cell count, culling rate and number of cows with chronic or acute elevated somatic cell count. Bennedsgaard et al. (2003b) found that Danish herds converted to organic milk production before 1990 had lower milk yield, lower somatic cell count and less use of antibiotic treatment for mastitis compared to conventional herds and herds converted later than 1990. Little difference was found in somatic cell count and mastitis treatment between newly converted herds (converted in 1999-2000) and conventional herds. Vaarst (2001) compared udder health parameters in Danish organic and conventional herds in three different studies and reported no difference in SCC, the same level of udder health and a better health in organic herds compared to conventional herds. In contrast to this some studies have found the SCC to be significant higher in organic than conventional herds (Ellis et al. 2007; Hardeng & Edge 2001; Zwald et al. 2004). However, when comparing results from different studies on udder health it is important to keep in mind that it is difficult to separate potential effects of confounding factors for disease such as herd size, housing, nutrition, production level, genetics and longevity from the effect of management. Factors, which further complicate the comparison, are differences in disease detection, definition and treatment criteria (Ruegg 2009).

In general, the US organic herds have significantly fewer cows, the average daily milk production per cow is lower, they are more likely to be housed in older traditional facilities as tie stalls or stanchions and use intensive rotational grazing as compared with conventional herds (Pol & Ruegg 2007; Sato et al. 2005a 2005; Zwald *et al.* 2004). This should be kept in mind when organic herds are compared to conventional herds.

### 3. Materials and methods

A cross-sectional observational study was conducted in Wisconsin, Pennsylvania and New York in the US in October 2010.

#### 3.1 Selection of herds

Eighteen certified organic dairy farms in Wisconsin, Pennsylvania and New York were visited once in October 2010. The study population was selected as a convenience sample based on geography and willingness to participate in the project. Four of the herds in Wisconsin were found on a list of organic farmers and two were found subsequently with help from the farmers visited in Wisconsin. The geographical selection was based on the fact that the climate conditions in the chosen states are somewhat comparable to the Danish conditions and because of an already existing collaboration between the Faculty of Agricultural Science and Cornell University. The herds were selected to represent a broad spectrum of milk production units in Wisconsin, Pennsylvania and New York with regards to herd size, period as certified organic dairy herd, different milking systems and management levels.

#### 3.2 Selection of cows

The aim was to examine a systematic random sample of approximately 50 cows from each farm. Seven of the eighteen farms had less than 50 cows and thus all cows were examined in these herds. In the remaining eleven farms the cows were selected as a random sample of the lactating cows. The randomization was done by examining cows at pre-selected and fixed positions in the tie stall or the milking parlor, e.g. every second or fifth cow depending on the total number of cows in the herd. It was taken into account that cows were selected from the front, middle and back of the parlor/barn and that cows from both sides were examined.

# 3.3 Interviews

All farmers were interviewed twice during the visit in October 2010. The first interview was conducted by the use of a questionnaire interview, defined as an interview based on predetermined questions. The interviewee was asked questions from the questionnaire by the interviewer and unclear answers were further investigated. The questionnaire interview was mainly conducted by the author but a PhD student at the Faculty of Agricultural Sciences, Tjele, Denmark, conducted the interviews in herds where the owner or the herd manager did not participate in the milking procedure. This interview was dealing with general management and production conditions on the farm such as number of cows, grazing routines, reproduction strategy, feeding, number of dead, slaughtered, sold and purchased animals etc. (appendix 1).

The second interview was a qualitative semi-structured research interview, dealing with treatment strategies, practical management of sick cows and disease prevention on the farm. The qualitative semi-structured interview is a method based on predetermined thematic questions within a chosen focus area. The interviewer does not have to ask the questions the same way each time and the interviewees have the freedom to answer questions as they prefer and to focus on those aspects most relevant to them. The interviewer ensures that the themes of the interview are kept in focus (Aagaard-Hansen & Yoder 2007). The interviews, which were conducted by a PhD student at the Faculty of Agricultural Sciences, Tjele, Denmark, had an approximate duration of two hours. The farmers' answers were written as field notes and verbatim quotations. The interview

focused on the management and treatment of common diseases including udder, leg/hoof and reproduction related problems as well as the prevention of diseases in general.

# 3.4 Systematic clinical examinations

The systematic clinical examinations were conducted based on inspiration from methods used by Klaas et al. (2004) and Fossing et al. (2006). The author carried out all the examinations and the four quarters of the selected cows were examined visually and palpated immediately after either the morning or evening milking. The examinations were performed from the side or from behind the cow depending on the milking facilities and deep palpation of the udder was carried out using both hands. Udder and teat characteristics were recorded, as well as the degree of manure soiling on the body, udder and teats. In case of abnormal findings in more than one quarter during inspection or palpation, the worst case was recorded. Definitions of the characteristics are described in Table 1.

Variable	Scale	Additional guidelines
Soiling of the body	0: no soiling with manure, 1: slight soiling around tail/hooves, 2: slight soiling on thigh and tail, 3: soiling on bigger parts of the rear end, 4: marked soiling on rear end and parts of front end/abdomen, 5: whole body soiled with layer of manure	Visual inspection just after milking
Soiling of the udder	0: No soiling, 1: slight soiling, 2: marked soiling on bigger parts of the udder	Visual inspection just after milking
Soiling of the teats	0: No soiling, 1: slight soiling, 2: marked soiling on bigger parts of the teats	Visual inspection just after milking
Udder size	1: < halfway towards hooks, 2: halfway towards hooks – hooks, 3: at the level of the hooks, 4: Lower than the hooks	Visual inspection just after milking from side and/or back
Asymmetry between front and rear	0: no, 1: slight, 2: marked, 3: complete atrophy	Visual inspection just after milking
quarters Asymmetry between left and right	of one quarter 0: no, 1: slight, 2: marked, 3: complete atrophy	from side and/or back Visual inspection just after milking
side quarters	of one quarter	from side and/or back
Blind quarters <sup>1</sup>	0: no, 1: Yes	Palpation just after milking
Distinct nodes in the udder	0: no, 1: yes	Palpation just after milking
Diffuse knotty tissue in the udder	0: no, 1: yes	Palpation just after milking
Udder edema	0: no, 1: slight, 2: larger area of the udder, 3: most of the udder	Palpation just after milking – especially lower part of the udder
Clinical mastitis	0: normal, 1: swelling, warmth, pain, redness, 2: cow generally affected	Palpation of normal quarters (with no signs of atrophy or mastitis) just after milking
Udder tissue condition	1: Soft (fingers easily palpate deep in the gland), 3: firm (general firm, fingers palpate 3-5 cm into the tissue), 5: hard (fingers cannot palpate into the tissue)	Palpation just after milking
Warts on teats	0: no, 1: small (1-2mm), 2: medium (3-8mm) 3: large (≥8mm), 4: wounds on warts	Visual inspection just after milking and before post teat dipping
Teat end callosity	0: no; 1: slight ( $\leq$ 1mm); 2: marked (2-3mm);	Visual inspection just after milking
•	3: Pronounced (≥3mm) with crusts	and before post teat dipping

<sup>&</sup>lt;sup>1</sup> A blind quarter is defined as a quarter not being milked for the rest of the lactation e.g. due to udder suckling as calf, mastitis, trauma or selective drying quarters with chronically high somatic cell count or recurrent mastitis.

# 3.5 Treatment protocols

The farmers were asked to fill out a treatment protocol (appendix 2) for each case of mastitis occurring during a two-month period. The farmers received the protocols either prior to the visit by e-mail or during the visit in paper form. Because of the short

recording period of only two months duration they were allowed to start recording cases two or tree weeks back in time from the visit if they considered themselves able to remember details of the cases. The farmers were contacted approximately halfway in the recording period to make sure that the recording had begun and that no questions had arisen about the recording. Further reminders were given in cases where the treatment protocols had not been received approximately two months after the visit.

### 3.6 Test day results

Monthly test day results from the DHIA program were available at cow level from twelve out of the eighteen farms from the Lancaster DHIA, Dairy One Cooperative Inc. and AgSource Cooperative Services and included data on herd size, calving interval, milk production, somatic cell count and culling rate. The data were collected for a twelve-month period. Information about herd average milk production and number of cows sold, dead or culled was obtained from the farmers during the questionnaire interview and these information's were used as approximations of the test day results at the five farms not having monthly test day recordings and for one herd that had unreadable DHIA data. Danish test day results for comparison to the US herds were collected from January to December 2010.

# 3.7 Milk samples

Bulk tank milk samples were collected from each herd during the visit. The samples were collected in tubes containing Bronopol for conservation and stored in the refrigerator at 4°C for one day to three weeks from herd one to eighteen, respectively. The samples were sent to the laboratory 'Lancaster DHIA PCR DNA Mastitis Diagnostics', Manheim, Pennsylvania, at the end of the three-week study period. A Real-Time quantitative Polymerase Chain Reaction-based DNA Mastitis Testing Assay was performed on a PCR1 (Stratagene Mx3000P/Mx3005P QPCR System, Agilent Technologies, Inc., Santa Clara, California). A Full Panel Analysis was ordered (included Staphylococcus contagious pathogens: Streptococcus agalactiae, uberis, Streptococcus environmental pathogens: Streptococcus dysgalactiae, Staphylococcus spp., E. coli, Enterococcus spp., Klebsiella spp., Serratia marcescens, Corynebacterium bovis, Arcanobacterium pyogenes and Peptococcus indolicus, and Staphylococcal beta-lactamase gene). Danish Mastitis PCR Assays for comparison to the US herds were available from October 2009.

# 3.8 Data handling and statistical analysis

Collected data were proofread twice to correct incomplete or incorrect data entry and no data were excluded as being unreasonable or unreadable. All of the eighteen US dairy herds were included in the analysis of the data obtained from the questionnaire and the semi-structured interview, the systematic clinical examination, and the bulk tank milk PCR assay. Seventeen treatment protocols were received in time to be analyzed. The test day recordings were analyzed for the twelve US dairy herds having available monthly registration. The difference between bulk tank milk PCR bacteriological findings as well as the test day recordings for the US dairy herds and the Danish organic dairy herds, was analyzed using the GENMOD and the GLM procedure in the SAS computer software (Statistical Analysis System, SAS Institute Inc, Cary, NC, version 9.2) on the single test day and during a twelve-month period, respectively.

# 3.8.1 Analyses of qualitative semi-structured and questionnaire interviews

The part of the unprocessed transcribed data from the qualitative interview dealing with mastitis treatment and prevention was evaluated for types of strategies identified across the eighteen herds. The treatment data was divided into different categories based on the purpose or the properties of the treatment. The categories were identified without considering which treatment was used for what type of mastitis and if treatments were combined. Data categorization was performed systematically from one end and categories were added as new types of treatment were identified. The identified categories were presented in a table and the types of these treatment categories used in each herd were recorded. The preventative strategies were identified and farmers using each approach were recorded. The main characteristics of the herds obtained from the questionnaire interview were presented in a table. Only information related to udder health and mastitis treatment and prevention was used for further analysis.

# 3.8.2 Analyses of herd prevalence of clinical findings

The prevalence of clinical findings was calculated and the variables having  $\leq 2$  possible scoring opportunities were presented in a table, while the variables with > 2 scoring opportunities were presented in a graphical depiction in order to illustrate the distribution of the various values. The distribution of each score value in each of the eighteen herds was presented as the prevalence of cows with each score value of the total number of cows (100%) for each herd. Variables that proved virtually not to be present in the eighteen herds were excluded from further analysis. The variable *udder tissue condition* was presented in a graph as percentage of the 802 cows having a particular score from 1-5. This was not considered to be an udder health indicator but rather a tool to assess how easy it was to perform a thorough deep palpation of each udder.

### 3.8.3 Analyses of incidence of mastitis treatment

Treatment protocols recorded during a two-month period were available from seventeen farmers. Protocols, completed for more than two months, were limited to contain data from only two months at some point during the autumn to synchronize the registration period duration in all herds. The earliest data was removed in herds with a too long period of registration. Treatment within ten days from the last treatment was considered as a treatment of the same case of mastitis and these treatments were excluded from further analysis. To get an overview of the data, it was summarized into one table. The incidence, of the different types of mastitis (mild, moderate, severe and E. coli) and the various types of treatment strategies associated with these types of mastitis, were recorded for each farm. The treatment strategies were recorded without regard to which treatment was used for a particular case. Treatment approaches were presented as they were received from the individual farmers, thereby illustrating the products used and the administration strategy. Treatment outcomes were recorded as the possible outcomes observed for each type of mastitis after treatment without regards to the individual case.

#### 3.8.4 Transformation and analyses of test day results

Transformation of the unprocessed US Test day results (DHIA) into data comparable to Danish test day results from the Central Danish Cattle Database was performed by

Torben Werner Bennedsgaard, Ph.D at Faculty of Agricultural Sciences, Tjele, Denmark, as described in Bennedsgaard *et al.* (2010).

Herd size was calculated as cow-years including only cows postpartum. Calving interval of the cows was calculated in days. Culling and mortality rates were not available from the US herds but culling rates, including dead, culled and sold cows, were either available or calculated for the US and Danish herds based on the test day results. An estimation of lactation curves for the individual cows was performed using a piece-wise linear regression model with intercept (expected peak) at 60 days postpartum. This was used to assess the production level of the cows. Included in the analysis were cows with at least one milk record before day 60 postpartum and the last test day later than day 180. Milk production was calculated as energy-corrected milk (ECM) of 305 days production. The production of cows of the Jersey breed was multiplied by 1.11 before calculations based on data of the national average production of all Holstein Friesian and Jersey cows in Denmark from 1994 to 2005 (Danish Cattle Federation 2007). This was done to be able to identify differences between breeds other than the general production potential. The same correction was used in earlier studies (Bennedsgaard 2003; Bennedsgaard et al. 2010).

Calculated BTSCC was calculated as the sum of individual SCC and milk yield divided by the daily milk yield at test day. The proportion of cows with an acute rise in SCC (defined as the percentage of cows at each recording that had a sudden, significant rise in SCC) and the proportion of cows with chronically elevated SCC (defined as the percentage of all cows within parity with an increased SCC) was estimated based on individual cow SCC at each test day. These calculations were performed according to Rasmussen et al. (2001).

The significance of differences in herd size, calving interval, culling rate, production level, calculated BTSCC, acute rise in SCC and chronically elevated SCC between 16 Danish herds from a organic dairy in Thise having a low antimicrobial consumption, 33 other organic herds supplying milk to the Thise Dairy, 123 Danish organic herds from other parts of Denmark and the 18 US study herds were evaluated using the GLM procedure in the SAS computer software (Statistical Analysis System, SAS Institute Inc, Cary, NC, version 9.2). 95% confidence intervals for the mean predicted values were calculated for each of the variables.

#### 3.8.5 Analyses of Mastitis PCR Assay

In a real time PCR assay a positive reaction is detected by accumulation of a fluorescent signal. The cycle threshold (Ct) specifies the number of amplification cycles required for the fluorescent signal to cross a specific threshold, which means that the lower the Ct-level the greater the amount of target nucleic acid in the sample (Eurofins Steins Laboratory 2011). The Ct-ranges for a positive or negative test measured at 'Lancaster DHIA PCR DNA Mastitis Diagnostics' for analysis of samples from US herds as well as the Ct-ranges from the Danish 'Eurofins Steins Laboratory', Holstebro, Denmark for analysis of samples from Danish herds, differed between bacterial species but the upper and lower limits for each quantity class are presented in Table 2.

**Table 2.** Ct-ranges for Mastitis PCR Assay at 'Lancaster DHIA PCR DNA Mastitis Diagnostics' for analysis of samples from US herds as well as the Ct-ranges from the Danish 'Eurofins Steins Laboratory' for analysis of samples from Danish herds.

	Negative	Low	Medium	High
US herds	>37	37-28	34-22	<33 - <22
Danish herds	>37	37-33	32-29	<29

Data on Mastitis PCR Assays were available for 17 Danish herds from the organic Thise Dairy having a low antimicrobial consumption, 34 other herds supplying milk to the Thise Dairy, 119 organic herds from other parts of Denmark and the 18 US study herds. Each of the US and Danish herds were classified as positive or negative for the bacterial targets measured in the laboratories. A positive test sample was defined as either low, medium and high Ct-values because it was impossible to compare the results for the quantity classes separately between countries due to different Ct-cut-off values used at the different laboratories. The difference in the Mastitis PCR Assay results between the US and the three Danish dairy herd groups was analyzed in a logistic analysis with the GENMOD procedure in the SAS computer software (Statistical Analysis System, SAS Institute Inc, Cary, NC, version 9.2). Odds rations and 95% confidence intervals were calculated for the four above mentioned herd groups.

### 4. Results

#### 4.1 Main herd characteristics

The main characteristics of the participating herds, based on information from the questionnaire interviews, are presented in Table 3.

Table 3. Herd characteristics of the eighteen dairy herds selected for systematic clinical examination. The average of the variable is

presented in the bottom row.

Herd ID	State <sup>1</sup>	Certified organic, (year) <sup>2</sup>	Breed <sup>3</sup>	Cows per Year <sup>4</sup>	Housing system <sup>5</sup>	Breeding goals	Farmers	Culling rate (%) <sup>11</sup>	Mortality rate(%) <sup>12</sup>
1	WI	13	H-BS - J-SH -DB	413	Loose (C)	Healthy cows, A2A2	-	36	1
2	WI	11	H-BS - (J-GU)	29	Tied	Exterior	-	15	0
3	WI	3	Н	100	Loose (C)	-	-	1	0
4	WI	10 (57)	H-J	17	Tied	-	Biodynamic	0	0
5	WI	8 (20)	H-J-BS	137	Loose (DL)	-	-	15	1
6	WI	4	H-J-BS -(N-GV-SR)	105	Loose (DL)	-	-	11	0
7	PA	23	J-(H-GU)	75	Tied	Longevity, fat:protein	Biodynamic	25	1
8	PA	10 (25)	Н	39	Tied	Healthy exterior	Old order mennonite	20	0
9	PA	8	Н	30	Tied	Healthy cows	Old order amish	27	3
10	PA	$\frac{1}{12}$ (20)	Н	34	Tied	Longevity, yield	Old order amish	15	3
11	PA	10	Н-Ј	101	Loose (DL)	Longevity, low SCC	Conservative mennonite	6	2
12	NY	10	Н	327	Loose (C)	Longevity, SCC, A2A2	-	21	4
13	NY	10	H-(BS-NR)	98	Loose (C)	Balance in the cow	-	33	4
14	NY	3.5 (17)	Н	40	Tied	Healthy cows	-	15	3
15	NY	12	H-(BS-J-GU-A-NR)	132	Loose/ tied (C)	Yield, fat:protein	-	3	3
16	NY	4	H-BS-J-N-A-SH-DB	70	Loose (DL/C)	Yield and beef	-	6	6
17	NY	3	H-(J-BS)	301	Loose (C)	Yield, low SCC	-	29	7
18	NY	3	H, BS, J, A	36	Tied	Balance in the cow	-	8	6

Not reported or unknown

The period as certified organic dairy herd varied widely between farms, the shortest period being one month and the longest being 23 years, and on average 8.1 year. Five of the farmers had farmed their land and/or rest of the farm according to organic principles for additionally 10-47 years without having their herds certified organic during that period. The mean herd size was 116, ranging from 17 to 413 cows. Eleven different breeds were used in the organic herds and a preference for mixed breeds was found. Twelve of the farmers used mixed breeds; some had a strategy of systematic

<sup>&</sup>lt;sup>1</sup> WI = Wisconsin, PA = Pennsylvania, NY = New York

 $<sup>^2</sup>$  Years as certified organic dairy herd. If the land and/or rest of the farm has been farmed organically without certification as organic the

number of years is recorded in brackets.

<sup>&</sup>lt;sup>3</sup> H = Holstein Friesian, J = Jersey, BS = Brown Swiss, SH = Shorthorn, DB = Dutch Belted, GU = Guernsey, GV = Gelbvieh, N = Normandy, SR = Sweedish Red, A = Ayshire, NR = Norwegian Red. "Dash" between breeds = mixed breeds or systematic cross-breeding. "Comma" between breeds = several breeds in the herd but no mixed breeds.

<sup>&</sup>lt;sup>4</sup> Herds with DHIA: herd size, cow years. No DHIA: Number of lactating and dry cows in the herd per year according to the farmer.

<sup>&</sup>lt;sup>5</sup> Loose (C) = Loose housing with cubicles and concrete floor, Loose (DL) = Loose housing with deep litter system, Tied = Tie stall or stanchion

<sup>&</sup>lt;sup>6</sup> Number of cows culled within the last year calculated as a percentage of total number of cows per year (numbers according to the farmer).

<sup>&</sup>lt;sup>7</sup> Number of dead cows within the last year calculated as a percentage of total number of cows per year (numbers according to the farmer).

crossbreeding, others tried to mix new breeds into the herd because other farmers recommended the breeds or because the given breed had qualities that the farmer wanted to introduce into the herd. In general, a consensus was found among the interviewed farmers that mixed breeds have a better longevity and fit well into the organic farming. Three different housing systems were found in the eighteen herds, 44% used a tie stall barn, 28% had loose housing system with cubicles and concrete floor and 17% used loose housing with a deep litter system. Considerable variation was found in the culling rate with values from 0-36% and an average of 16% culled cows per year. The mean mortality rate was 2%, ranging from 0 to 7% dead cows per year.

### 4.2 Mastitis treatment and prevention

Ten different types of mastitis treatment were identified based on the qualitative semistructured research interview of the eighteen farmers' perspectives on mastitis treatment and prevention. The choice of treatment was dependent on the severity of the mastitis case and the individual cow but all treatments mentioned in the interview were registered in table 4 without regard to which treatment was used for a particular type of mastitis and the combination of treatments.

**Table 4.** Types of applied mastitis treatment at the 18 organic dairy herds based on the qualitative semi-structured interview. In the column on the far right the total number of treatment choices for each farm are listed and the bottom row presents the number of farms (%) using the type of treatment in question.

Herd ID	Strip- ping <sup>1</sup>	Liniment/ ointment <sup>2</sup>	Herbal product <sup>3</sup>	Homeo- pathic remedy <sup>4</sup>	Probiotic <sup>5</sup>	Immune stimulant <sup>6</sup>	Fluid therapy <sup>7</sup>	Pain killer <sup>8</sup>	Nutri- tional supple- ment <sup>9</sup>	Blinding quarter <sup>9</sup>	Total no. of treat- ment
1		X	X		X	X		X	X		types
	V	X	Λ		Λ	Λ		Λ	А		4
2	X										2
3	X	X					X				3
4	X	X	X	X						X	5
5		X	X	X		X		X	X		6
6	X	X		X*	X					X	5
7	X	X	X	X		X	X	X	X	X	9
8		X	X		X	X	X		X		6
9	X	X				X	X	X		X	6
10	X	X	X	X		X	X		X		7
11	X	X	X	X		X	X			X	7
12	X	X	X	X	X	X		X			7
13	X	X	X	X					X		5
14	X	X	X	X							4
15	X*	X	X	X		X	X			X	7
16	X									X	2
17		X	X							X	3
18	X	X	X							X	4
%	78	94	72	56	22	50	39	28	33	50	

 $<sup>^{1}</sup>$  Stripping out manually or using quarter milker 2-5 times per day, with or without udder massage and/or oxytocin. \* Uses some cows with

high somatic cell counts and *S. aureus* as nursing cows.

<sup>&</sup>lt;sup>2</sup> Udder liniment/ointment applied topically with or without udder massage: 'Dynamint udder creme', 'Linirub oil', 'Vet liniment', 'Ildder

comfort', 'Udder symptoms'. Main herbs: Camphor, tea tree oil, peppermint

<sup>&</sup>lt;sup>3</sup> Oral, topical, intramuscular, intramammary or vaginal administration of whole/parts of fresh or dried plant/plant substances, also as bolus,

capsule, tincture, tisane and in essential oils: 'Phytomast', 'Phyto-biotic', 'Ex-cell 7000', 'Impro M+R+C capsule'. Main herbs: Aloe vera, garlic,

cayenne, echinacea, rhamnus phurshiana, cumin, canola, ginseng, lobelia, goldenseal, comfrey, olives, oregano, liquorice, cloves, turmeric.

milk thistle, pau d'arco, 'Sweedish Bitter'.

- <sup>4</sup> Oral, nasal or vaginal administration of homeopathic liquids or pills. Main remedies: Urtica, phytolacca, lac caninum, belledonna, bryonia,
- silica, sulphur, carbon, echinacea, lachnesis, arsenicum, hepar sulph, pulsatilla, apis mel, 'Mastoblast', 'staph/strep', 'SCC'. <sup>5</sup> Oral or intramammary administration of microbial products as Lactobacilli and yeast.
- <sup>6</sup> Oral, subcutaneous, intravenous and intramammary administration of liquid or boluses. Main immune stimulants: Colostral whey, 'Impro-
- Whey blend', 'Impro Environ', 'Plasma Gold', 'Immunoboost™, 'Impro Dairy M Power Pak', homeopathic nosodes, antitoxins, hyperimmunized serum/plasma.
- <sup>7</sup> Subcutaneous or intravenous administration. Main fluids: Hypertonic saline solution, calcium, dextrose.
- <sup>8</sup> Subcutaneous or intravenous administration of pain killers/anti-inflammatory drugs: Hypericum, Flunixin Meglumine, acetylsalicylic acid.
- <sup>9</sup> Oral (often free choice feeders in barn/outside), intramuscular, intravenous or intramammary administration. Main supplements: Vitamin
- A, C, D, E, minerals, 'Kelp' (seeweed), buffers (bicarbonate), 'Fast-track' (herb-mix), molasses.
- 10 Avoiding milking the gland, drying off the quarter with medication ('Novalsan') or using a castration band on the teat.

The number of different treatment choices varied considerable between farms, from two to nine different approaches. The treatment types applied the most were stripping, udder liniment or ointment, herbal products and homeopathic remedies.

The qualitative semi-structured interview and the questionnaire interview revealed many different approaches to the management of mastitis. Ten farmers mentioned promptness with reference to identification and intervention as the main success criteria for mastitis treatment. According to thirteen farmers the outcome and duration of each case was closely related to the type of mastitis and the approach to therapy sometimes varied within the herd, depending on the individual cow characteristics. The two interviews revealed that farmers generally had a tendency to focus on prevention of disease rather than treatment and many different approaches were used to reduce the incidence of mastitis and lower the SCC. Examples of preventive approaches are (the following numbers in brackets indicate the number of farmers who have mentioned this as their approach to preventing disease): A balanced and high quality feeding ration (2), grazing (1), feeding crops from a balanced soil (1), cleanliness of the cows and the barn (4), knowledgeable staff (1), the milking routine and hygiene (7), maintenance of milking equipment (5), the milking order: high somatic cell count and S. aureus positive cows identified and milked after other cows (8), identification of problem cows using 'California Mastitis Test' (6), put tape on the teat end of some cows to prevent leaking and transference of bacteria (2), not pushing the cows for yield including feeding a less concentrated diet (5), vaccination against *E. coli* and *S. aureus* (2) and the application of a culling or selling strategy of cows not responding well to treatment, having reoccurring cases or being *S. aureus* positive (9). All farmers used feeding supplements in the mixed ration or in free-choice feeders to meet the cows' nutritional requirements and to prevent diseases. The supplements were 'Kelp' (seeweed) (11), salt (13), other minerals (14), buffer (carbonate) (4), calcium (4) and vitamins (4). In general, the farmers expressed that good milking routines are of great importance and 17 used preand post milking teat dipping, 17 used individual cloths or papers for cleaning the teats, 14 used gloves during milking and 15 used prestripping.

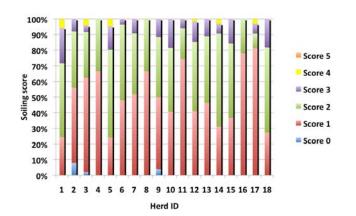
# 4.3 Herd prevalence of clinical findings

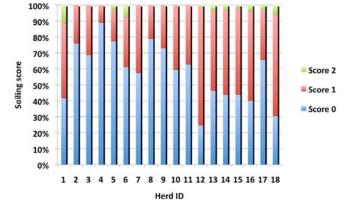
A total of 802 cows were examined during the study period. The results from the systematic clinical examinations in the 18 organic dairy herds are presented in table 5.

7	Րable 5. Ի	Herd preva	lence of clinical find	dings in th	e 18 organic dairy	y herds.
	Hord ID	Millzing	No. of cour	c Blind	Dietinet	Diffuso

Herd ID	Milking	No. of cows	Blind	Distinct	Diffuse
	system	examined	quarters	nodes	knotty
					tissue
1	Carousel	53	0.02	0.36	0.08
2	Tie stall	25	0	0.20	0.20
3	Parallel	48	0	0.19	0
4	Tie stall	9	0.11	0.33	0
5	Parallel	66	0.02	0.14	0.03
6	Parallel	54	0.09	0.07	0.07
7	Tie stall	54	0.13	0.04	0.06
8	Tie stall	33	0	0	0
9	Tie stall	26	0.12	0	0.04
10	Tie stall	27	0.19	0.04	0.04
11	Parallel	51	0.18	0.18	0.12
12	Herringbone	61	0.05	0.13	0.02
13	Herringbone	54	0.17	0.19	0.11
14	Tie stall	32	0.03	0.16	0
15	Tie stall	57	0.12	0.09	0.07
16	Side-by-side	55	0.11	0.07	0.05
17	Parallel	64	0.08	0.09	0.03
18	Tie stall	33	0.33	0.18	0

The herd prevalence of blind quarters varied from 0 to 33% and the mean was 10%. Palpation of the udders showed that distinct nodes were present in 0 to 26% of the cows with an average of 14% of the cows having nodes in the udder. At five farms no cows with diffuse knotty tissue in the udder were found and at other farms up to 20% of the cows had knotty tissue, the mean being 5%. In 98% and 98.5% of the examined cows no udder edema and clinical mastitis were found, respectively. Herd prevalence of the variables manure soiling of the body, udder and teats, udder size, asymmetry between front and rear quarters, asymmetry between right and left side of the udder, teat end callosity and warts on teats are presented in figure 1-8, respectively. For definitions of score-values see table 1.



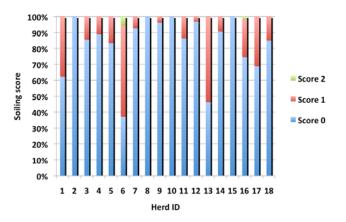


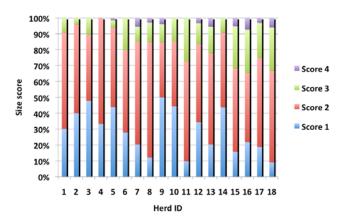
**Fig. 1.** The prevalence of cows with each 'soiling of the body'score value in each of the 18 herds.

**Fig. 2.** The prevalence of cows with each 'soiling of the udder'score value in each of the 18 herds.

As can be seen in figure 1, the prevalence of cows with soiled legs or body varied widely between herds. Slight soiling around hooves, tail and thigh (score 1 and 2) was found in 88% of the 802 examined cows, which means that very few cows were found completely

clean or dirty at bigger parts of the body (score 0, 3, 4 and 5). The mean score was 1.6 (10 and 90% percentiles: 1;3). The prevalence of cows with soiled udders was also found to vary considerable between herds (figure 2). Clean (score 0) or slightly dirty udders (score 1) were found in 55% and 42% of the 802 examined cows, respectively with a mean score of 0.5 (0-1).

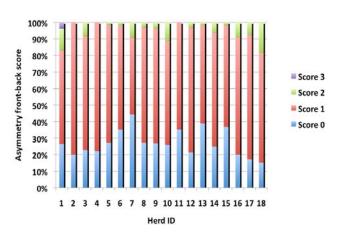


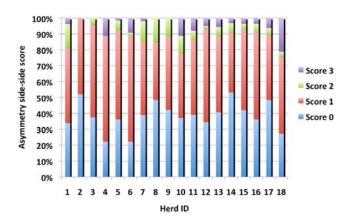


**Fig. 3.** The prevalence of cows with each 'soiling of the teats' score value in each of the 18 herds.

**Fig. 4.** The prevalence of cows with each 'udder size'- score value in each of the 18 herds.

Most of the cows (81%) had a relative tight udder attachment (score 1 and 2) with a mean size score of 1.94 (1;3) but the prevalence of small and deep udders varied considerably between herds (figure 4).





**Fig. 5.** The prevalence of cows with each 'asymmetry between front-rear quarters'- score value in each of the 18 herds.

**Fig. 6.** The prevalence of cows with each 'asymmetry between right-left quarters.' - score value in each of the 18 herds.

No asymmetry (score 0) between front and rear quarters of the udder (figure 5) existed in 28% of the examined cows and 9% had marked or complete atrophy of a quarter (score 2 and 3). The score average was 0.8 (0;1). A larger number of cows (39%) were found not to have any asymmetry (score 0) when comparing the right and left side of the udder (figure 6) but more cows had complete atrophy of on quarter (score 3). The mean score was 0.8 (0;2).

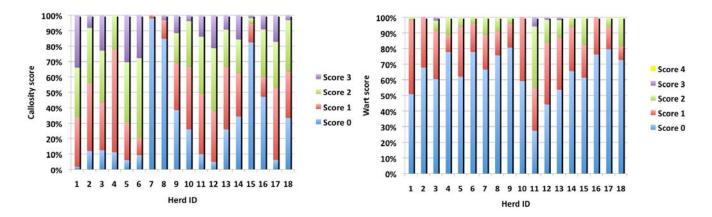


Fig. 7. The prevalence of cows with each 'teat end callosity's core value in each of the 18 herds.

**Fig. 8.** The prevalence of cows with each 'warts on the teats'-score value in each of the 18 herds.

As can be seen in figure 7, the prevalence of cows with teat end callosities varied widely between herds, some herds (7, 8, 15) having almost no callosities and other herds (1, 3, 5, 6, 12) having more than 20% pronounced callosities. The distribution of no, slight and marked callosities (score 0, 1, 2, respectively) was approximately 30% each, with a mean score of 1.3 (0;3). A few herds (1, 11, 12, 13) had a high prevalence of warts on the teats but in general, most cows (63%) had no warts (figure 8). The mean score was 0.5 (0;2).

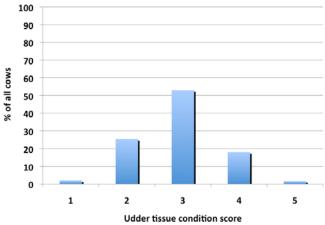


Fig.9. The prevalence of the udder tissue condition scores of the total number of cows.

The prevalence of cows with firm udders (score 3) was 53%. In 27% of the cows a more thorough deep palpation (score 1 and 2) was possible and 20% of the cows had udders difficult to palpate into the tissue (score 4 and 5).

# 4.4 Mastitis incidence and treatments during a two-month period

The treatment protocols filled in by seventeen of the eighteen farmers during a twomonth period is presented in a simplification of the mastitis treatment registration in Table 6.

Herd ID	Cases/2 mo	Dry/lac.	Mastits type	Treatment	Treatment duration	Outcome
1	1	L	Mild	R1: Ex-cell Countdown 7000 (herbs) injected into bad quarter 1-2x + udder mint rub as needed	1	Rec.
	3	L	Moderate	R1 OR R2 (R2: R1 + Aspirin bolus (for discomfort) + power bolus (herb based) + stripping	2+	Rec., bline
	2	L	Severe	severalx/d R2	2+	q. Chr.
2	2	L	Mild	R1: Stripping + mint lotion $2x/d$ + quarter milker <b>OR</b> R2: Stripping + mint lotion + probiotics $2x/d$ for $4-5d$ + Vit. C. $1x$ + quarter milker	3 to 5	Rec.
	3	L	Moderate	R1 for 5-7d $\mathbf{OR}$ R2: Stripping + mint lotion + probiotics $2x/d$ for $4-5d$ + Vit. C. $1x$ + quarter milker	4 to 11	Rec.
3	4	L	Mild	R1: Dynamint udder creme 2x/d for 7d	7	Rec., sold
	4	L	Moderate	R1: Dynamint udder creme 2x/d for 7d	7	Rec., chr.
1	2	L	Mild	R1: Linirub oil on udder + garlic tincture orally 1x/day	3 to 11	Rec.
	2	L	Moderate	R2: Linirub oil on udder + garlic tincture orally $1x/day + SCC$ -homeopatics vaginally $2x/d$ for 5d OR R3: Linirub oil on udder + garlic tincture orally $1x/d + Phytolacca$ -homeopatics vaginally	5 to 12	Blind q.
5	5	L	Mild	R1: Stripping 2x + Dynamint udder creme for several milkings	?	Rec., sold
	2	L	Moderate	R2: Stripping + Dynamint udder creme + Bryonia Alba and SSC-homeopatics x3d	3	Rec., chr.
	1	L	Severe		?	Rec.
5	3	L	Moderate	R1: Rub Vet Linament on quarters + hand strip 2x/d	2	Rec.
7	8	L	Mild	R1: Impro-Whey blend (immunestimulant) SQ 1x/2d> 1x/3d> Staph./Strep. Nosode 2x/14d. + Phyto-Biotic (herb blend) and Water 2x/5d <b>OR</b> Vit. IM C 2x/d for 2.5d + Uddermint cream 2x/2d + 'nosode spray' and SSC-homeopatics 2x/10d <b>OR</b> Vit. C IV/IM 2x/d for 2.5d <b>OR</b> Phyto-Biotic and Water 2x/5d	1 to 14	Rec., sold
	4	L	Moderate	R1: Impro-Whey blend SQ 1x/2d> 1x/3d> Staph./Strep. Nosode 2x/14d + Phyto-Biotic (herb blend) and Water 2x/5d $\mathbf{OR}$ Phytomast tubes- 2 at first treatment, then 1 at each milking for 5 milkings + Vit. C IM 2x/d for 2.5d $\mathbf{OR}$ R1 + Uddermint cream 2x/2d + Blind quarter when dry $\mathbf{OR}$ Experimental Staph. Antitoxin IV (Dr. Karreman trial) + Blind quarter at end of lactation.	2.5 to 14	Rec., blind q., sold, chr.
3	2	L	Mild	R1: Impro M+R+C capsule (herb blend) 1x 3 d + Impro Dairy M Power Pak (immunestimulant) 1x 10 days	10	Rec.
	4	L	Moderate	R2: 'Impro Environ' (immunestimulant) IM 1x 2d + 'Impro Dairy M Power Pak' 1x 10d + udder comfort spray +/- EX.cell 7000 (herb based) $2x$	10	Rec., chr.
)	2	L	Mild	Immunoboost + udder comfort	?	Rec.
	1	L	E.coli	$Hypertonic\ saline\ solution\ +\ plasma\ gold\ (immunestimulant)\ +\ vit.\ C\ IV\ +/-\ calcium,\ +/-\ flunixin$	5	Died
.0	3	L	Mild	R1: Dynamint salve + massage + Phyto-mast (herb based) IMM, Dairy M Power Pak (immunestimulant) x3 orally 2x/d <b>OR</b> R2: Culture and give specific antibodies orally <b>OR</b> Put 2 calves on cow	5	Rec.
11	6	L	Mild	R1 <b>OR</b> Udder mint 2x daily 10d + colostrum whey 4x 1x/d <b>OR</b> None (reoccurring mastitis, chronic)	?	Rec., blind q., sold, chr.
	2	L	Moderate	R1: Colostrum Whey 1x/d 4x, Phytolacca IM 2x/d, udder mint salve 10-14 d	7	Rec., culled
.2						
.3	8	L,D	Mild	R1: Homeopathic SCC + udder symptoms 2x/d until cleared +/- stripping +/- tape on teat end	? to 10+	Rec.
	2	L,D	Moderate	R2: R1 + Vit. C + B12 + garlic + Aspire 2x/d until cleared +/- stripping	? to 10+	Rec., bline
	3	L	Severe	R3: Drench of Echinacea, Goldenseal, Cayenne and lobelia, 2x/d. Sugar + B-complex	10+	q. Sold, died
14	7	L	Mild	R1: Stripping + linamint <b>OR</b> R2: Stripping + linamint + garlic tincture + boluses with liquorice root, Pao D'arco, Astragalus root, turmeric, cloves, cumin, milk thistle <b>OR</b> R3: Mastoblast homeopatic (Preventative)	1 to 3	Rec., sold
	1	L	Moderate	R2	4	Blind q.
.5	9	L	Mild	R1: Phytomast (herb based) IMM for 4 milkings + uddercomfort (creme) <b>OR</b> R2: Abandon persistant clinically infected quarter	3 to 9	Rec., chr.
	2	L	Moderate	R1: Infusion with phytomast for 4 milkings + apply uddercomfort topically $\bf 0R$ R2: Abandon persistant clinically infected quarter	4	Rec., blind
6	2	L	Mild	R1: Mild signs $\rightarrow$ closely observe $\rightarrow$ strip $\rightarrow$ 1) improve or 2) moderate signs $\rightarrow$ routine 2	?	Rec.
	1	L	Moderate	R2: Clinical signs → hand strip/use quarter milker → 1) Dry quarter or 2) Resume marketing milk	?	Sold
7	1	L	Mild	Udder Comfort	?	Rec.
	3	L	Moderate	Phytomast	?	Rec., blin
						q.
10	2	L	Severe	Phytomast or no treatment	?	Rec., chr.
18		L	Moderate	Linirub 2x/d for 6d or as needed	14	Rec.
** 1		L	Severe	garlic 2x/d for 3 d + linirub creme as needed + aspirin 2x/d for 3d	14	Rec.

<sup>&</sup>lt;sup>?</sup> Unknown, due to lack of registration by the herdsmen.

The vast majority of the mastitis cases recorded in the treatment protocols were mild or moderate but five of the farms experienced one or more cases of severe or E. coli mastitis. When using the same categorization of mastitis treatment types as applied in the analysis of the semi-structured interview (table 4), the number of different treatment choices also showed to vary considerable between farms in the treatment records. The individual farm used between one and five different treatment approaches. The treatment types applied the most in the herds were udder liniment or ointment (94%), herbal products (63%), stripping (44%), homeopathic remedies (31%), immune stimulants (31%) and drying off quarters (31%). Different treatment combinations were used by the individual farmer, for example, application of liniment, stripping and homeopathic remedies was counted as one combination, and stripping together with probiotics as another. The individual farmer used between one and seven different combinations of treatment types, but twelve of the farmers used only two or three different combinations to handle all mastitis cases. Within the same treatment combination seven of the farmers used a varying length of the treatment period. The duration of the treatment periods was recorded as being between one and nineteen days for all kind of treatment routines but some farmers reported the treatment as lasting until the cow was considered healthy and did not define when the treatment period was over.

Different farmers had different approaches to treatment of mastitis and based on the results from the treatment protocol three levels of decision regarding treatment strategies were identified. These levels were, with inspiration from Vaarst *et al.* (2002), named disease level, cow level and herd level.

- *Disease level:* Twelve of the seventeen farmers used routine treatments specifically targeted at certain type of mastitis and they seemed to used the same routine mastitis treatment strategies on the same type of mastitis every time.
- *Cow level:* Even though most farmers seemed to have a well-defined and established treatment routine eleven of the farmers deviated one or more times from using the routine approach to the same type of mastitis thereby fitting the treatment to the individual case or cow.
- Herd level: On two of the farms, the same treatment type and duration was applied to all cases of mastitis independently of the type of mastitis and individual cow characteristics.

Based on the results from the treatment protocol three different types of farmer treatment strategies were recognized in the seventeen herds included in the analysis:

- 'The quick and simple strategy' characterized by  $\leq 2$  treatment types,  $\leq 2$  treatment combinations and the same approach to the same type of mastitis. Herd 3, 6 and 16 used this strategy.

<sup>&</sup>lt;sup>1</sup> Recorded cases of mastitis during a two-month period between October 1st 2010 and January 15th 2011. Reoccurring mastitis in the same

cow within 10 days from last case of mastitis is counted as the same case of mastitis. The proportion of mastitis cases per month is presented in the brackets.

<sup>&</sup>lt;sup>2</sup> Effect of the treatment evaluated after last treatment. Rec. = Recovered or recovering (milk is normal, returned to tank, SCC, healthy but

watchful, slowly getting better, Blind q. = Dry off a quarter, inproduction in quarter, Chr. = Chronic high SCC/S.aureus/A.pyogenes.

- 'The time consuming and advanced strategy' characterized by ≥4 treatment types, ≥3 treatment combinations, ≥3 days of difference in treatment duration from the shortest treatment period to the longest. This strategy was used by herd 5, 7, 9, 10, 13 and 14.
- "The mixed strategy" where no common pattern was found in the treatment strategies. This strategy included the remaining herds (herd 1, 2, 4, 8, 11, 15, 17 and 18), which were something between the two above-mentioned strategies. No routine treatments of different types of mastitis were used in three of these herds, seven used individual treatment of the same type of mastitis, they used three to four different types of treatment but only in two or three different combinations and some used different treatment length while others did not.

# 4.5 Comparison of production level and SCC.

Results of production level, SCC and blind quarters in each of the 18 dairy herds are presented in table 7.

**Table 7.** Comparison of production level, SCC and blind quarters in the 18 dairy herds. The rows marked with gray color indicate herds not having monthly test day results and these values are based on information gathered during the farm visit in October 2010.

Herd ID	DHIA	ECM, kg / kg milk per cow <sup>1</sup>	Calculated BTSCC <sup>2</sup>	Acute elevated SCC (%) <sup>3</sup>	Chronic elevated SCC (%) <sup>4</sup>	Blind quarters (%) <sup>5</sup>
1	+	7098	189	4.0	15.4	4.8
2	+	5489	247	7.0	15.0	3.4
3	+	4834	181	3.4	2.9	2.0
4	-	5000-6600				5.9
5	+	5635	292	5.5	15.9	4.4
6	+	6722	197	5.2	7.3	6.7
7	+	5998	328	14.7	36.8	2.0
8	+	9092	241	3.9	16.3	2.6
9	+	9110	353	13.8	25.4	10.0
10	-	6800-8160				8.8
11	+*	6006				15.9
12	+	6467	140	5.6	3.0	1.2
13	+	6391	316	9.1	8.9	18.0
14	-	6350-6800				2.5
15	+	8540	200	9.7	5.6	9.1
16	-	6350				11.4
17	+	6269	264	9.1	7.8	6.6
18	-	4626				31

<sup>\*</sup> Test day results were unreadable.

The milk production measured in kg ECM for 305 days of production or as kg milk delivered per cow to the dairy ranged between 4626 and 9110 kg and the mean yield was 6292 kg. Prevalence of the calculated BTSCC, acute and chronic elevated SCC was presented in order to illustrate individual herd prevalence. Further analysis is performed in table 8. The prevalence of blind quarters in the herd according to the farmer ranged from 2-31%, with a mean of 8.1. Chosen test day results variables

 $<sup>^{\</sup>rm 1}$  ECM = Energy-corrected milk, 305 days production (herds with DHIA), kg milk delivered per cow (no DHIA)

<sup>&</sup>lt;sup>2</sup> Calculated BTSCC (x1000/ml)

<sup>&</sup>lt;sup>3</sup> Prevalence of cows (%) per month with acute elevated somatic cell count

<sup>&</sup>lt;sup>4</sup> Prevalence of cows (%) per month with chronic elevated somatic cell count

<sup>&</sup>lt;sup>5</sup> Prevalence of cows (%) with blind quarters at the visit in October according to the farmer

compared between 16 Danish herds from an organic dairy in Thise having a low antimicrobial consumption, 33 other organic herds supplying milk to the Thise Dairy, 123 Danish organic herds from other parts of Denmark and the 18 US study herds, are presented in table 8.

**Table 8.** Test day results: Herd size, calving interval, culling rate, production level, calculated bulk tank SCC, acute and chronic elevated SCC, comparison between 16 Danish herds from a organic dairy in Thise having a low antimicrobial consumption, 33 other organic herds supplying milk to the Thise Dairy, 123 Danish organic herds from other parts of Denmark and the 18 US study herds.

Variable	Thise low-antibiotic	Other Thise	Other Danish organic	US organic
Herd size, cow year	91 (47;135)	157 (127;188)	149 (134;165)	149 (98;200)
Calving interval, days	426 (412;440)	413 (403;423)	414 (409;419)	412 (396;428)
Culling rate, % of cows/herd	22 (16;27)	20 (17;24)	25 (23;27)	26 (20;32)
Estimated 305d production, kg ECM	7483 (6918;8048)	7918 (7531;8305) a	8353 (8155;8551) b	6803 (6172;7436) a,b
Calculated BTSCC x1000 cells/mL	267 (228;306)	292 (265;319)	296 (282;310) a	246 (201;290) a
Acute SCC % of cows at risk/test day	7.2 (4.9;9.5)	9.9 (8.3;11.5)	10.0 (9.2;10.9)	7.58 (4.9;10.2)
High chronic SCC % of cows at risk/test day	16.3 (12.3;20.2)	17.7 (15.0;20.5)	15.9 (14.5;17.3)	13.4 (8.8;17.9)

<sup>(</sup>i.) 95% confidence interval for mean predicted values.

No significant difference (p<0.05) was found between the four herd groups in herd size, calving interval, culling rate, acute and chronic elevated SCC. The milk production was significantly lower in the US herds compared to the other herds delivering milk to Thise Dairy and a sample of organic herds in other areas of Denmark. The calculated BTSCC was significant higher in the organic herds from rest of Denmark compared to the result obtained from the US herds. The milk yield and calculated BTSCC was lower in the US herds than the values found in the Thise herds having a strategy of low-antimicrobial consumption, however, this difference was not significant.

#### 4.6 Mastitis PCR Assay

Results from the Mastitis PCR Assay on the bulk tank milk samples from the 18 dairy herds are presented in table 9.

**Table 9.** Results from Mastitis PCR Assay on the bulk tank milk samples from the 18 US dairy herds. The bottom row presents the percentage of US dairy farms having that particular bacterial finding on the test day<sup>1</sup>.

Herd ID	S. uberis	S. dysgalac.	S. agalac.	S. aureus	Staph. spp.	Enteroc. spp.	Klebsiella spp.	C. bovis	Beta-lac. gene	A. pyogenes P. indolocus
1	++	+			+					
2	+			+						
3					+	+	+			
4					+*			+		
5	+			+					+	
6	+	+		+						+
7	+	+		+						
8	+			+*				+		
9	+	+		+					+	
10	+*				+					
11	++	+		+				+	+	
12	+	+		+					+	+
13		++*		+				+	+	
14	+				+*					
15	+	+		+				+		
16	++			+						
17	+			+		+	+			
18	+			+	+*			+		
%	83	44	0	72	33	11	11	33	28	11

<sup>&</sup>lt;sup>1</sup> Bacterial findings: Streptococcus uberis, Streptococcus dysgalactiae, Streptococcus agalactiae, Staphylococcus aureus\_Staphylococcus sp.

a,b Statistic significant difference (p<0.05) between the US herds and one of the other herds is indicated by the letters (e.g. USa and Other Thisea indicates significant difference between these two herds).

Enterococcus sp. (including faecalis and faecium), Klebsiella sp. (including oxytoca and pneumonia), Corynebacterium bovis\_Beta-lactamase

gene, Arcanobacterium pyogenes and Peptococcus indolicus

- + Quantity specific to each bacterial target: + Low, ++ Medium, +++ High
- \* Proportion: The percentage of the most abundant bacteria is reported if its proportion is over 90 %.

The most prevalent bacterial findings in the PCR analysis of milk samples from the eighteen herds were *S. uberis* (83%), *S.aureus* (72%) and *S.dysgalactiae* (44%). The sample was negative for *S.dysgalactiae* in all of the herds.

Table 10 presents the comparison of results from the Mastitis PCR Assay on bulk tank milk samples between 17 Danish herds from the organic Thise Dairy having a low antimicrobial consumption, 34 other herds supplying milk to the Thise Dairy, 119 organic herds from other parts of Denmark and the 18 US study herds

**Table 10.** Mastitis PCR Assay results, for *Staphylococcus aureus, Streptococcus agalactiae, Streptococcus uberis, Streptococcus dysgalactiae.* 

The odds ratio of having a negative PCR-result for each of the four bacterial findings is calculated for the 17 Danish herds from the organic Thise Dairy having a low antimicrobial consumption, 34 other herds supplying milk to the Thise Dairy, 119 organic herds from other parts

of Denmark compared to the 18 US study herds.

	Thise low-antibiotic versus US	Other Thise herds versus US	Other Danish organic herds
	herds	herds	versus US herds
S. aureus	6.2 (1.4;27.1) <sup>a</sup>	27.3 (4.6;161.8) <sup>b</sup>	0.9 (0.3;2.8)
S. agalactiae	0.0 (0;0)	0.0 (0;0)	0.0 (0;0) °
S. uberis	0.0 (0;0)	0.0 (0;0)	0.1 (0.0;0.6) <sup>c</sup>
S. dysgalactiae	0.1 (0.0;0.5) a	0.2 (0.1;0.9) b	0.1 (0.0;0.4) °

<sup>(</sup>i.) 95% confidence interval for the odds ratios.

Bacterial findings: Staphylococcus aureus, Streptococcus agalactiae, Streptococcus uberis, Streptococcus dysgalactiae.

The odds of having a PCR-negative result for *S. aureus* were significantly greater in the low-antibiotic Thise herds and other Thise herds compared to the US herds. The odds of having a PCR-negative result for *S. dysgalactiae* are significantly lower in the low-antibiotic Thise herds and other Thise herds compared to the US herds. The odds of having a PCR-negative result for *S. agalactiae*, *S. uberis* and *S. dysgalactiae* were significantly lower in the low-antibiotic Thise herds and other Thise herds compared to the US herds. The US herds, the low-antibiotic Thise herds and other Thise herds were all *S. agalactiae*-negative and thus an odds ratio of zero was found in the comparison between herds. The low-antibiotic Thise herds and other Thise herds were all *S. uberis*-negative.

 $_{a,\,bc}$  Statistic significant difference (p<0.05) between the US herds and one of the other herds is indicated by the letters (e.g. Other Thise herds

<sup>&</sup>lt;sup>b</sup> indicates significant difference between this herd group and the US herds).

### 5. Discussion

# 5.1 Study design and data collection

An observational study design was chosen because the aim of the study was to describe the udder health situation in the US organic dairy herds.

#### 5.2 Selection of herds and cows

The eighteen dairy herds were considered to represent a broad spectrum of milk production units in Wisconsin, Pennsylvania and New York with herd sizes ranging from 9 to 400 milking cows, period as certified dairy herd ranging from 1 month to 23 years, six different milking setups, three different housing systems, eleven different breeds, and farmers managing their herds differently, see table 3, 4 and 6. The study population was selected based on geography, farmers' willingness to participate in the project, farmers' known to keep good records, and they were specifically chosen by their veterinarian, the university or by their neighbor, which may have biased the results. Preferably all herds should have been chosen for example as every tenth on a list of organic farmers in Wisconsin, Pennsylvania and New York, but this was not possible of practical and economical reasons. The fact that the farmers were willing to spend extra time in the milking facilities, being interviewed and keep mastitis treatment records for a two-month period was an important aspect of the selection process. It is likely that the willingness to participate is related to farmers being proud of their farm, having nothing to hide, being open-minded towards new ideas in general and it might be farmers that see it as an opportunity to learn something new. Such farmers may not be representative of the general population of farmers in the three states but the results of this study will mainly be relevant to farmers wanting to phase out antimicrobial drugs and these farmers are also considered to be open minded to new thinking and motivated to learn.

The systematic clinical examination included all cows in the herds having less than 50 lactating cows and therefore no important results were left unnoticed as can be the case with the larger herds were the study unit was selected as a sample of the study population. However, an attempt was made to select a random sample of approximately 50 cows in the remaining farms and due to the systematic sampling approach in all herds, the cows were considered a random sample of cows in all stages of lactation and parity from the selected herds in this particular time of year. A strategy of mainly seasonal calving was found in six herds, tree of the herds trying to have spring calvings and three farmers tried to get the most calvings in the fall because several of the organic dairy cooperatives pays a better price on milk during the fall and cows calving in the fall are dry during summer when it is hot. This may have biased the occurrence of mastitis cases and should be taken into consideration when comparing the treatment rate between herds.

When comparing the main herd characteristics of the eighteen US organic dairy herds to a study performed by Sato et al. (2005a) based on 30 organic dairy herds in Wisconsin many similarities were found. In the following section the average of the eighteen organic herds of this study will be mentioned in brackets for comparison. The 30 Wisconsin herds had an average period as certified organic dairy herd of 8 years (8.1),

herd size of 51 cows (116), 80% of the cows housed in a tie stall (44%), a BTSCC of 263,000 (246,000), an estimated 305 days milk production per cow of 6161kg (6803kg ECM), 47% and 100% using pre- and post milking teat dipping, respectively (94% and 94%) and a preference for mixed breeds as had the 18 study herds. The fact that the two study populations seems quite similar indicates that the sample size of this study can be considered large enough to describe the most common findings in the given area that to some degree share weather conditions, dairies, organic certifiers etc.

It is not recommended to use a too large sample size when dealing with qualitative data because this often will lead to lack of overview of the data, but the sample must not be too small either, as this may lead to important information not being recognized. There is theoretical data saturation when new data no longer provide new knowledge on the subject (Malterud 2003). Data analysis of the qualitative semi-structured interviews were conducted starting from the lowest herd number and after analysis of the fourth farm no new types of treatment was added to Table 4 indicating that there is a theoretical saturation and thus the sample size can be considered large enough to cover important opinions.

#### 5.3 Conduction of the interviews

The questionnaire interviews were conducted by two different persons who may have asked the questions differently but in all except three herds both persons were present during this interview and the questions were considered as being relatively straightforward to understand and the fact that the interview was not performed by the same person every time is therefore not perceived as a problem. Recall bias will very likely be present in this type of interview, as farmers among others were asked about how many animals were purchased, culled, sold and slaughtered in the last year.

The qualitative semi-structured interviews were, as previously mentioned, not conducted the exact same way each time since the questions are adjusted according to the interviewee's answers and interests and is based on what the interviewees want the interviewer to know. The interview was not recorded, but transcribe during the interview. It is impossible to manage writing everything down said by the farmer during the interview while listening to the answers and posing new questions and thus the level of detail will necessarily be less than interviews being recorded. Further it is very likely that recall bias will be present since some of the questions required that the farmer could remember cases that happened a while ago. These factors taken into account make it difficult to ensure that all relevant opinions and strategies are covered at all of the eighteen dairy herds and important details may have been left unnoticed. The performance of the clinical examinations and the interviews was quite time consuming and although farmers had been informed about this beforehand, a lot of them were impatient to be finished quickly, which compromised the quality of the research several times.

### 5.4 Categorization of treatment approaches

The different types of mastitis treatment, found in the qualitative semi-structured interview, were categorized in order to form a general view of the different treatment approaches and make it easier to compare the treatment strategies between herds. A rather broad range of different approaches to the treatment of mastitis was reported

and therefore the categories had to be allowed a certain latitude, to avoid too many categories. However, this implies that the level of detail is considerably reduced and thus information of individual treatment choices is left unnoticed. The treatment strategies for mastitis of different severity may range from administration of one product infrequently used to many different products used frequently in many different combinations within the same herd.

The table was used to reveal the types of treatment used and it was obvious that some farmers had a more sophisticated and time-consuming treatment strategy than other farmers. However, one has to keep in mind the risk of prestige bias. This is defined as the interviewees answering questions related to what they in theory would like their strategy to be or what they think they are supposed to answer, instead of telling what they actually do in their herd. It is likely that prestige bias was an issue in this study since the qualitative interview revealed more types of treatment and products used than what was recorded in the treatment protocols. This may reflect that the actual treatment strategy was simpler than revealed in the interview, but the short registration period is also important, as very few cases of mastitis were recorded in some herds during the two-month period and thus few of their possible strategies were recorded. Misclassification bias may also be present since some of the 'ready to use' combination products consisted of ingredients from more of the categories. These products were categorized based on the main ingredients but a content list was not available for all products and therefore these products were categorized based on information from the farmers or catalog definitions found on the Internet.

# 5.5 Collection of treatment protocols

One of the protocols was received very late and thus it was not possible to include results from this in the analysis due to lack of time.

Recall bias is a highly relevant issue for the treatment protocols since more than half of the farmers had not started to fill out the protocol one month after the visit and after getting a reminder many of them filled out the entire 2-month treatment protocol in one day. This was not the intention, but there were no other options due to lack of time and therefore these registrations should be used with some caution. The farmers were told to fill out one row per treatment of the cow and make a short evaluation of the effect of or status after the treatment. Although a detailed description and an example was attached to the treatment protocol, this was not always completed as intended by the farmers. Only eight farmers registered the treatment protocol with all details about treatment type, length and effect. Five of the farmers recorded the type of treatment used but the duration of the treatment or the date of the status registrations were lacking. Four of the treatment protocols lacked considerable amounts of information making it difficult to evaluate the length of the treatment period and to identify possible correlations in the choice of treatment related to the severity of the case and change over time. Some farmers had done a great job in completing the entire protocol very detailed and clearly had read the instructions carefully beforehand while others had recorded very few details and had not completed the requested. To overcome some of these deficiencies farmers, known to answer their emails, were contacted for further clarifications of their recordings. All farmers who had not completed the protocol as desired should probably have been contacted to obtain the missing information, but as a part of the records were received at a late stage of the study period this was not possible.

There are significant limitations in the usefulness of these treatment protocols for evaluation of the general approach to mastitis treatment of different types of mastitis due to the short study period, few cases, and missing registrations but the protocol can be used to obtain an overview of these farmers' strategies with respect to mastitis treatment of the given cases and incidence of mastitis in a given 2-month period. To increase the applicability of treatment protocols these should have been filled out over a longer time period but it is difficult to attain this, since it is highly dependent on the farmers willingness to devote time to do this. Another option could be using already existing treatment protocols from the herd but in general, treatment registration on farm is a questionable indicator of herd health. The individual farmer has different mastitis definition and threshold for treatment of mastitis (Vaarst et al. 2002), the organic certification agencies have different policies regarding registration requirements (Ruegg 2009), subclinical cases of mastitis is not registered in the protocol and the management system on the farm will influence the need for registration to control disease. These factors make underreporting of mastitis seem very likely. Some of the eighteen farmers already had very detailed and precise treatment registrations that could be useful, but others had incomplete or completely lack of records and thus thus the farmers own registrations was not considered an applicable tool to assess udder health in this study.

# 5.6 Management of mastitis

Many different approaches to the management of mastitis were obtained from the two interviews performed in this study. Ten farmers mentioned promptness with reference to identification and intervention as the main success criteria for mastitis treatment and recovery, which is in accordance with recommendations by Kirk *et al.* (1994). In general, the farmers focused on prevention of disease rather than treatment and this strategy was also found among Danish organic farmers phasing out antimicrobial drugs (Vaarst *et al.* 2006). Some of the preventive approaches mentioned where a balanced and high quality feeding ration, grazing, feeding crops from a balanced soil, cleanliness of the cows and the barn, not pushing the cows for yield, vaccination, feeding supplements. These strategies are in accordance with the organic guidelines to successful organic farming focusing on disease prevention through a sufficient nutritional provision, selection of housing and pasture conditions that minimize the occurrence and spread of diseases and minimize pain and stress in the animal (EC 2007; USDA 2011).

Three different types of farmer treatment strategies were identified from the treatment protocols, some using an advanced strategy, some using a simple strategy and the rest of the farmers are something in-between. This seems very reasonable and can probably be recognized in almost all management related strategies. The classification of the farmers may have been quite different if a longer registration period has be used because some of the farmers only had few cases of mastitis during the two-month period making it quite difficult to classify them correctly. However, this would probably not have brought in new treatment types but it would have increased the accuracy and precision of the categorization.

Three levels of decision regarding treatment strategies were identified in the treatment protocols of this study as well as in Danish research on organic farming performed by Vaarst *et al.* (2002). Vaarst *et al.* (2002) reported that severe symptoms of mastitis would always lead to antimicrobial treatment but milder cases had a high degree of individual treatment decisions based on cow characteristics and herd strategies for different categories of cows.

This seemed to be in accordance with findings in this study where the number of treatment combinations often increased with increasing severity of the mastitis case and severe cases also seemed to get more attention in the shape of a higher frequency of treatment and additional supportive therapy such as calcium, glucose and pain killers.

Some farmers seemed to have a treatment strategy based on well-known products used the same way each time. Other farmers seemed to try different preparations from the medicine cabinet somewhat randomly for each case and changed the treatment strategy if they saw no effect of treatment. Both strategies have advantages and disadvantages. A well-known routine is often arisen based on good experience with a particular strategy and the farmer is familiar with the doses and administration methods usually found effective but may not be open-minded to new ideas. In herds where farmers adapt treatment to individual cases there is a good chance of the cow being closely monitored and treatment effectiveness will be evaluated and adjusted accordingly. However, this strategy can be problematic because farmers will probably try a few different strategies, without necessarily having experience with the successful combination and this may be considered problematic from a welfare point of view.

The above-mentioned factors indicates that some farmers are willing to spend lots of time on the individual case and they follow the development of the disease closely and react in accordance with these findings. Ten herds had been certified organic or farmed their land according to organic principles eight ore more years and they seemed to have a tendency to use more advanced treatment strategies than herds being certified organic less than eight years. Five of these herds were categorized as farmers having a time consuming and advanced strategy and five were categorized as having a mixed strategy. This may be due to farmers getting more knowledge about and be more prone to use alternative treatments the longer they have been certified organic. The simpler strategy used in herds having less years as certified organic may also be due to the fact they recently have been used to antimicrobial treatment which are less time consuming than most alternative treatments.

In the following section the prevalence of the most common treatment types will be mentioned in brackets to illustrate the difference in the qualitative interview and the treatment protocol, respectively: Udder liniment or ointment (94% and 94%), herbal products (72% and 63%), stripping (78% and 44%), homeopathic remedies (56% and 31%), immune stimulants (50% and 31%) and drying off quarters (50% and 31%). There seems to be a tendency to administration of fewer types of treatment in practice compared to what farmers have indicated in the interview. The reason may be that farmers have an idea about how they want to treat each cow and this is not done in practice because of lack of time, energy, economy etc but it can also result from the fact that the treatment types found in the interview referred to treatment for all types of

mastitis and not all herds did experience all types of mastitis during the two-month registration period. The prevalence of treatment types for clinical mastitis reported in a study conducted in Wisconsin was: 85% herbal products (garlic, aloe vera, vegetable and olive oil), 55% nutritional supplements (multivitamins, electrolytes), 45% immune stimulants (whey-based), 20% homeopathic remedies, 20% pain killers (aspirin) and 5% probiotics (Pol & Ruegg 2007). These results are somewhat comparable to the ones found in this study. Differences may reflect different strategies between the two study populations but it may also be due to differences in data collection method. None of the farmers reported using antimicrobial drugs to treat mastitis during the study period and this was in accordance with results from previous research (Pol & Ruegg 2007; Zwald *et al.* 2004; Sato et al. 2005a 2005).

A theoretical basis for efficacy of most alternative treatments exist, but almost no peer-reviewed studies have recorded clinical efficacy on alternative treatments. A review of efficacy of alternative treatments performed by Ruegg (2009) reported virtually no clinical effect of successfully treatment of mastitis when using herbal or botanical preparations, homeopathic remedies and colostrum whey products (Immunoboost). It could have been very interesting to know the details about the efficacy of all the specific products mentioned by the farmers in this study but it was very difficult to find information about the products and only few of the search results were peer-reviewed studies or studies having reasonable setups to evaluate the efficacy of the alternative product. Furthermore it could have been very interesting to assess the association between different types of farmer treatment strategies and the individual herd test day results for SCC, production level and incidence of mastitis.

Even though almost no scientific proves exist about the efficacy of alternative treatment it is not necessarily equal to no efficacy of the treatments with these products. Many organic as conventional farmers use application of udder liniments or ointment, stripping and various nutritional supplements. These treatment types are not considered as 'alternative' as e.g. homeopathy. It can be argued that the fact that the farmer select the cow for treatment without regards to if the treatment are considered alternative or scientifically proved, the cow becomes subject to increased monitoring and care which may improve the chances of recovery. Moreover, application of e.g. udder cream may itself have a possible effect of udder inflammation.

Most alternative treatments have not been proved clinically effective but it is important to remember that the use of antimicrobial drugs to treat mastitis are not necessarily equal to a high treatment efficacy either. The success of antimicrobial treatment depends on several factors, including the choice of drug, route of administration, duration of treatment, antimicrobial susceptibility of the pathogen and immune status of the host (Erskine *et al.* 2004). A resent study conducted in Denmark showed that 42% of the milk samples from subclinical mastitis cases treated with antimicrobial drugs were sterile and thus a critical evaluation of the cases chosen for antimicrobial treatment is needed in order to avoid unnecessary antimicrobial treatments (Katholm 2009). An overall spontaneous cure rate of 65% has been found in subclinical mastitis cases compared to a cure rate of 75% after antimicrobial treatment (Wilson *et al.* 1999). Kirk *et al.* (1994) found antimicrobial treatments almost ineffective against *S. aureus* and

non-severe coliforms (Kirk *et al.* 1994), which further supports the need for critical evaluation of cases selected for antimicrobial treatments.

It is very difficult to assess if a non-antimicrobial strategy affects the welfare of the animals based on the information gathered in this study. The udder health indicators seem to be quite similar for the US herds and the Thise herds as well as other Danish organic dairy herds. In Denmark a health advisory service contract is required if the farmers wants to do follow-up treatments himself. As the name of the contract reveals these visits are among others arisen to improve health and welfare in Danish herds. Whether many visits necessarily lead to a higher health and welfare status is debatable but the increased control and readily assessable advices may help to maintain focus on continuous maintenance of welfare. If the general health status in Denmark is considered to be acceptable this can be used as a 'reference value' for the US herds and no results in this study were indicative of a reduced welfare in US herds having a non-antibiotic strategy.

The combination of information from the treatment protocol, the questionnaire interview and the qualitative semi-structured interview may contribute to a more complete coverage of the applied mastitis treatment strategy.

# 5.7 Systematic clinical examinations

Two clinical examination training sessions were organized in September in order to test the applicability of the protocol, to adjust it for any errors or shortcomings and to practice the examination process and thereby increase the intra-observer agreement during the study period. Even though training was conducted prior to the study there is a risk, of which correct identification of the visual and palpatory variables might be reduced in the beginning of the study period and increase over time with increasing experience.

Some of the variation in the systematical clinical examination results between farms may be attributed to the difference in examination conditions for the author rather than an actual difference in the clinical variables. Several farms used mixed breeds and thus there were a large variation in the size of the cows within the farm. This made clinical examination complicated in most of the milking parlors since the small cows were able to step forward and thus make it difficult to reach the udders for a thorough palpation. In two of the milking parlors (herd 3 and 17) a big shield was placed behind each cow to protect the milker from manure and kicks, which made evaluation of soiling on udder and flank difficult. It was easier to palpate the udders of the cows housed in a tie stall but the visual inspection of the udder and teats were harder than in a parlor, as the cows were not in an equally accessible inspection height, thus making a correct clinical registration difficult.

Asymmetry in the udder, distinct nodes and knotty tissue can be used as indicators of chronic changes in the udder (Klaas 2006). Changes associated with chronic case of mastitis can be a hard fibrous quarter or atrophy of the tissue, which both lead to asymmetry of the quarter. Drying off a quarter will also result in an asymmetric udder. The herd prevalence of blind quarters varied from 0 to 33% and the mean was 10%. This was in accordance with findings by Bennedsgaard *et al.* (2010) who recorded a

prevalence between 0 and 30% and a mean of 8.4 to 10.1%, during a one-year period in Danish organic herds phasing out antimicrobial drugs. The prevalence was also comparable to findings in other Danish organic and conventional dairy herds during the same period, having a prevalence of blind quarters of 8.4% and 9.0%, respectively. The prevalence of blind quarters may either indicate that many cases of mastitis are not cured in the herd, or it may reflect a conscious strategy of drying off quarters of cows with chronic mastitis (Vaarst *et al.* 2002). In this study, it seemed as if some farmers made a great effort to cure mastitis using a lot of different treatments and supportive therapies while others pretty quickly gave up on a difficult case and chose to blind the quarter instead. This was in accordance with a previous study on organic dairy farming (Vaarst *et al.* 2006). Even though it is difficult to define the level of too many blind quarters because it as above-mentioned is very dependent on the management of mastitis, a prevalence of above 30%, which is seen in some herds, is considered to indicate udder health problems.

The mean prevalence of distinct nodes and knotty tissue in the eighteen US herds was 14% and 5%, respectively. A prevalence of 7% distinct nodes and 17% knotty tissue was found in a study of 23 Danish organic dairy herds phasing out antimicrobials (Klaas 2006). The definition of the variables used in the was different from the definition used in this study but the total number of distinct nodes and knotty tissue was 19% and 24% for this study and the study performed by Klaas (2006), respectively. Caution should be taken when compared these values between studies but there seems to be a comparable prevalence of chronic changes in US and Danish herds using no or low levels of antibiotics to treat mastitis. No association was found between the prevalence of distinct nodes, knotty tissue, blind quarters and the number of udder treatments in a study on organic herds having a strategy of phasing out antimicrobial drugs performed by Klaas (2006), which may indicate that a low treatment frequency is not necessarily associated with a high proportion of cows with chronic mastitis.

The variables indicating chronic changes can be useful in the udder health assessment when compared to treatment strategies. They can be used in the evaluation of the outcome of different types of mastitis and treatment strategies. Klaas et al. (2004) identified an association between chronic alterations of the udder and a higher SCC and a lower milk yield. This can be useful knowledge in individual herds having problems with elevated SCC. However, it has to be kept in mind that it can be very difficult to assess the general udder health status base on information from the chronic variables. The systematic clinical examination is a snapshot of the present situation in the herd. Even though chronic changes have developed over time it is not possible to determine whether e.g. a high prevalence reflects a pending high herd prevalence of mastitis, if there have been major problems in the herd at a given point in time, whether it is related to another treatment strategy used in the past etc. Furthermore, no data was available about the individual parity of the cow. Parity may be important for interpreting the results, since a higher prevalence of chronic changes would be accepted in an older cow than in a younger cow, which has had fewer days at risk of getting mastitis and therefore theoretically should not have an equally high prevalence of chronic changes induced by mastitis.

The udder tissue condition was as previously mentioned not considered to be an udder health indicator but rather a tool to assess how easy it was to perform a thorough deep palpation of each udder. Firm udders (score 3) were the most prevalent finding and this score was used in cases where 3-5 cm palpation into the udder tissue was possible. This will probably be enough to discover most of the distinct nodes present but some of the nodes present in the depth will be left unnoticed and an underestimation of the prevalence of nodes and to some extend also knotty tissue is possible, even though the knotty tissue is a more pronounced changes and thus are more likely to be identified.

The milkers were asked not to use post teat dipping before the clinical examination of the cow was performed but some of the milkers forgot it several times, some did not want to wait because of the delay in the total milking time and some did not speak English and thus it was not possible to ask them to wait. The post teat dipping made it difficult to examine the teats for warts, callus and teat soiling on these cows and misclassification bias is therefore considered to be present in this study, making over or underestimation of the variables very likely.

Teat and callosities is among other associated with improper milking machine settings leading to over-milking and the prevalance of clinical mastitis has been recorded to increase with increasing degree of teat end callosities (Neijenhuis *et al.* 2001). It was expected that the prevalence of teat end callosities varied widely since it is impossible to adjust the milking system to fit all cows in a herd perfectly, as some cows have a wide teat canal, and thus a short milking time while others have narrow teat canal and a longer milking time. A certain level of teat end callosities will therefore always be expected.

Warts on teats are in general not considered as a problem unless frond-like lesions that interfere with milking are present. No such problems were found during the clinical examination of the 802 cows in this study.

The prevalence of cows soiled with manure on the body and udder varied widely between herds. This was expected since the degree of soiling is related to weather conditions, lactation stage, housing and management systems. In, general the cows of this study were considered to be relatively clean since more than half of the cows had clean udders and no more than 88% of the cows had slight soiling around hooves, tail and thigh. These findings are probably related to the fact that most cows were still on pasture much of the day. No soiling of teats after milking was only recorded in four herds and a few herds seemed to have a problem with soiling of the teats after milking. Soiling of teats after milking should not be present at all and is a matter of improper milking preparation. An increased hygiene score has been reported to be associated with an increased SCC and an increased prevalence of intramammary contagious as well as environmental pathogens (Schreiner & Ruegg 2003). The soiling of legs has been associated with a higher BTSCC in another study (Klaas 2006). Barkema (1998) identified two types of farmers in a study of udder health management in conventional dairy herds. The groups were characterized as 'Clean and Accurate' and 'Quick and Dirty'. The first group consisted of farmers working precisely rather than fast and keeping a better hygiene, whereas the other group was fast rather than precise. The two groups were related to a low and high BTSCC, respectively. The above-mentioned factors are important to keep in mind when evaluating the udder health of the individual herd.

Very few studies existed on systematic clinical examinations and the ones available has, to the authors knowledge, not defined any threshold values indicating when a prevalence of the examined variables is considered to increase the probability of an elevated SCC, lower the milk yield and increase the prevalence of mastitis. This makes it difficult to assess the severity of the clinical findings but it was outside the scope of this study to assess the association between the individual herd results of the clinical examination with SCC, production level and incidence of mastitis.

### 5.8 Milk samples and test day results

Test day results were not available for more than twelve of the eighteen US dairy herds and results from the questionnaire interview and treatment protocols were used as estimates for comparison in the herds not having test day results. It is difficult to make conclusions on results that are not directly comparable due to different origin and this should be taken into consideration.

The milk production was significantly lower in the US herds compared to the other herds delivering milk to Thise Dairy and a sample of organic herds in other areas of Denmark. This may be due to the fact that many US farmers used mixed breed. Some of the US framers chose breeds who was also considered to be useful in the beef production and several of the farmers did as previously mentioned not breed for a high yield. Sato et al. (2005a) compared 30 organic and conventional geographically matched dairy herds in Wisconsin and found that the organic herds managed to produce milk without having an increased clinical mastitis rate, culling rate and BTSCC despite the strategy of non-use of antimicrobial drugs in these herds. The authors were of the belief that among other things the organic cows are not as highly bred for high production as conventional herds because of a strategy of less artificial insemination and a higher rate of mixed breeds. A higher milk yield is a risk factor for mastitis and an elevated SCC (Gröhn et al. 1995; Schukken et al. 1990). Five of the farmers in this study mentioned not pushing the cow for a high yield as an important aspect of preventing mastitis and this is in consistent with findings by Sato et al. (2005a) where the farmers claim that they maintain a high immune function by keeping the cows at a low production level.

The calculated BTSCC was significant higher in the organic herds from rest of Denmark compared to the result obtained from the US herds. As mentioned previously organic farmers in the US tend to have a smaller herd size and that may have an effect on the bulk tank somatic cell count and the incidence of mastitis. Few cows in a herd makes it easier for the farmers to know the cows from each other and thus respond faster to small changes in the cows' milk or behavior, which may result in fewer cases of actual clinical mastitis. In contrast to this, it is hard to keep a close eye on all cows in larger herds and hence there is a risk of mastitis first being detected at a later stage and thus it is more likely to be a severe case. Moreover, farmers having larger herds may be more prone to discard milk from cows with high somatic cell counts because it does not have the same impact on the total amount of milk delivered to the dairy as it has in small herds. The variability between farms is also influenced by the difference in herd

management since some farmers sell or cull cows with blind quarters, chronic elevated SCC, long/asymmetric udders etc. and other farmers keep these cows in the herd.

A non-significant lower milk yield and calculated BTSCC was found in the US herds compared to the values found in the Thise herds having a strategy of low-antimicrobial consumption. This was not surprising since many of the same management strategies are probably used in these herds.

The odds of having a PCR-negative result for *S. aureus* were significantly greater in the low-antibiotic Thise herds and other Thise herds compared to the US herds. This was not a surprising result since many farmers seemed to have problems with *S. aureus* even though several of them did a lot of testing, culling, separation etc. in order to minimize the spread of the bacteria. The odds of having a PCR-negative result for *S.agalactiae*, *S. uberis* and *S. dysgalactiae* were significantly lower in the low-antibiotic Thise herds and other Thise herds compared to the US herds, thus indicating that these bacteria might not be that big a problem in US herds having a non-antibiotic strategy. The US herds, the low-antibiotic Thise herds and other Thise herds were all *S. agalactiae*-negative. This was not a surprising result for the US herds since no farmers mentioned is as a problem they have ever dealt with.

The milk samples for Mastitis PCR Assay were not collected in exactly the same way from all herds in the US. Some were taken from the top of the tank with sampling equipment and others from the pipe at the bottom of the tank in a cup. In Denmark, a representative sample was collected by pumping out the milk and thus the sampling may have influence the prevalence of some bacterial findings but this is not considered to affect the evaluation of the major pathogens.

### 5.9 Antimicrobial resistance in livestock production

One of the major public concerns regarding livestock production is the potential adverse effects associated with antimicrobial use. However, there is no consensus on how big a problem it really is, how a possible phasing out of antimicrobials in food production will affect animal welfare and food safety and if it actually will decrease the occurrence of antimicrobial resistance. This is an important aspect in the discussion of organic principles since reduction of antimicrobial resistance among others is suggested to be one of the advantages in organic farming.

Negative consequences of antimicrobial drug usage is the risk of selection for antimicrobial resistant bacteria that cause human infections. Resistance in food borne zoonotic bacteria as *Salmonella, Camphylobacter, Yersinia, Listeria* and *E. coli* may be transferred to and cause infection in humans. Transfer of antimicrobial resistance genes between food animal bacteria and human bacteria has also been reported. The selection for and spread of resistance in bacteria limits the treatment options for human and animal infections and therefore it has been recommended to limit the use of antimicrobial drugs, carefully consider which cases to treat and select the appropriate antimicrobial drugs for treatment (Aarestrup 2000). Few studies have evaluated the effect of the antimicrobial drug restrictions on the occurrence of resistant bacteria but a decrease in the incidence of resistance to antimicrobials used as growth promoters has been observed in Denmark since their use was banned in the 1990'ties (Aarestrup

2000). Bennedsgaard (2003) showed that organic herds having a low consumption of antimicrobial drugs did not have a significantly different incidence of antimicrobial resistance in the two indicator bacteria *E. coli* and *S. aureus* compared to conventional herds where antimicrobial use is common practice. This is in contrast to findings of Sato et al. (2005b) who showed a significantly lower prevalence of resistance to 7 antimicrobials in *E. coli* isolates from organic dairy herds compared with isolates from neighboring conventional dairy farms. A literature review has been conducted by the National Mastitis Council Research Committee to determine if scientific data exist to demonstrate an association between the use of antimicrobial drugs to treat bovine mastitis and enhanced resistance in mastitis pathogens. Relatively few studies have been published that compared resistance patterns over time using consistent technology and procedures but available studies demonstrated similar patterns of resistance today as those recorded over the last nearly four decades. Therefore, evidence has not been presented to suggest that resistance among mastitis pathogens to antimicrobial drugs is either an emerging or progressing phenomenon (Erskine et al. 2004). The Danish Integrated Antimicrobial Resistance Monitoring and Research Program reported a relatively stable consumption of antimicrobial agents in Danish cattle since 2005, no changes in occurrence of resistance among Camphylobacter jejuni, E. coli and Methicillin-resistant S. aureus from cattle has been found and the general occurrence of resistance among Danish cattle is low compared to many other European countries (DANMAP 2009).

The fact that several studies (Bennedsgaard *et al.* 2010; Vaarst *et al.* 2006) show no apparent negative effect on production and animal health in herds having a strategy of non-use or low consumption of antimicrobial drugs could indicate that the performance and health of the cows does not depend on the use of antimicrobial drugs to treat disease, but of how the animals are cared for before, during and after disease. Moreover, it is can be argued that the animals' immune systems should be able to fight most cases of disease when chemical substances do not disturb the natural balance, which may be one of the reasons that organic farmers do not seem to need antibiotic treatment to keep their cows healthy

Many of the farmers in this study were of the opinion that converting to organic farming had improved the health situation in their herd significantly. In general, the farmers expressed that their spending on veterinary bills had dropped considerably after they had converted to organic farming, and a couple of them had their veterinary bill reduced by approximately 90% per month, which in one case was equal to a saving of about 2000 US\$. Many of the farmers expressed that they only used their local veterinarian to a limited extent after they converted to organic farming in particular because they consider their veterinarian to have limited knowledge about organic farming and principles and because they are not open-minded towards alternative farming strategies. This attitude is in accordance with earlier findings by Vaarst *et al.* (2006). It is difficult to reveal if the reduced veterinary bill after conversion is due to the fact that organic farmers to a lesser degree use veterinarians for advice or if it is due to organic farming making the animals healthier. As previously mentioned, there is no consensus in earlier studies about the health status of the organic herds having a strategy of non-use or low consumption of antimicrobial drugs compared to conventional herds.

### 6. Conclusions

The main herd characteristics found in this study were: A period as certified organic dairy herd ranging between one month and 23 years (mean 8.1 year), a herd size from 17 to 413 (mean 116 cows). Eleven different breeds were used in the organic herds and a preference for mixed breeds was found, 44% used a tie stall barn, 28% had loose housing system with cubicles and concrete floor and 17% used loose housing with a deep litter system, a culling rate from 0-36% (mean 16%) and a mortality rate from 0-7% dead cows per year (mean 2%).

Many different approaches to the management of mastitis were identified in this study. In general, the US organic farmers focused on prevention of disease rather than treatment and examples of common preventive approaches were: Good milking routine and hygiene, identification of problem cows, not pushing the cows for high milk production and offer feeding supplements to the cows. Promptness with reference to identification and intervention was considered as one of the main success criteria for mastitis treatment and the most commonly used treatment types were udder liniment or ointment, herbal products, stripping, homeopathic remedies, immune stimulants and drying off quarters.

Three different types of mastitis treatment strategies related to the type of mastitis and the farmers performing the treatments were identified in the US dairy herds: 'The quick and simple strategy', 'The time consuming and advanced strategy' and 'The mixed strategy'.

It is difficult to evaluate the overall udder health situation of the eighteen US dairy herds based on udder health indicators mainly obtained during one visit but none of the results from the PCR analysis, the systematic clinical examination, the test day results and the treatment protocols indicated a low udder health status in these non-antibiotic herds. This was supported by the comparison to Danish organic low-antibiotic herds and other organic herds from Denmark, which also did not indicates the presence of a low udder health status.

When the above-mentioned results are held up against each other it can be suggested that organic farmers manage to successfully control udder health indicators despite having a strategy of non-use of antimicrobial drugs.

### 7. Future research

One concern related to a non-antibiotic treatment strategy is the risk of reduced short-term animal health and welfare. It is very difficult to assess if a non-antimicrobial strategy affects the welfare of the animals based on the information gathered in this study an thus further analyses are needed within this focus area. It could be interesting to do a more thorough analysis over a longer period of time dealing with criteria for treatment, treatment type, treatment duration and efficacy of treatment in the individual cow.

The economy is an important aspect in the consideration of conversion to antibiotic-free farming. It might be interesting to do cost-benefit analysis of the lower performance associated with the antibiotic-free organic production in relation to costs associated with mastitis therapy based on alternative therapies.

If antibiotic-free farming is going to be the goal of more organic farmers in the future it is important that more research on alternative products used for mastitis treatment and the effect of route of administration are conducted. This makes it easier to guide farmers to select the optimal treatment routines and ensure appropriate treatment.

Hopefully this study may help veterinarians, farmers and other relevant professions reflect on their approach to the treatment of mastitis and promotion of udder health.

## 8. References

Aagaard-Hansen, J. and Yoder, P.S. (2007): *Buying Research. A Customer's Guide.* DBL – Centre for Health Research and Development, Department of Veterinary Pathobiology, Faculty of Life Sciences, University of Copenhagen.

Aarestrup, F. (2000): Occurrence, selection and spread of resistance to antimicrobial agents used for growth promotion for food animals in Denmark. *APMIS.* Suppl. 101, pp. 3-48.

Barkema, H. W. (1998): Udder health on dairy farms. A longitudinal study (summary of a recent PhD thesis). *Mastitis Newsletter.* Vol. 23, p. 12.

Bennedsgaard, T.W. (2003): Reduced use of veterinary drugs in organic dairy herds – Potentials and consequences. Ph. D. thesis, The Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Bennedsgaard, T.W., Enevoldsen, C., Thamsborg, S.M. and Vaarst, M. (2003a): Effect of mastitis treatment and somatic cell counts on milk yield in Danish organic dairy cows. *Journal of Dairy Science.* Vol. 86, pp. 3174-3183.

Bennedsgaard, T.W., Klaas, I.C. and Vaarst, M. (2010): Reducing of antimicrobials – Experiences from an intervention study in organic dairy herds in Denmark. *Livestock Science*. Vol. 131, pp. 183-192.

Bennedsgaard, T.W., Thamsborg, S.M., Vaarst, M. and Enevoldsen, C. (2003b): Eleven years of organic dairy production in Denmark: herd health and production related to time of conversion and compared to conventional production. *Livestock Production Science*. Vol. 80, pp. 121-131.

Blowery, R. and Edmondson, P. (2010): *Mastitis Control in Dairy Herds.*  $2^{nd}$  Edition, CAB International, Wallingford, pp. 1-4.

Danish Cattle Federation (2007): *Figures on Danish Cattle 2007,* [online]. Danish Cattle Federation, Skejby, DK. [cited; February 14<sup>th</sup> 2011]. Available on the internet: <URL:http://www.lr.dk/kvaeg/diverse/kvbrug ital2007-uk-web.pdf>.

DANMAP (2009): *Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, foods and humans in Denmark,* [online]. Statens Serum Institut, Danish Veterinary and Food Administration, Danish Medicines Agency, National Veterinary Institute, Technical University of Denmark, National Food Institute, Technical University of Denmark, DK. [cited; January 29<sup>th</sup> 2011]. Available on the internet: <URL:http://www.danmap.org/pdfFiles/Danmap 2009.pdf>.

EC (2007): Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91, [online]. Official Journal of the European Union [cited; December 27<sup>th</sup> 2010]. Available on the internet: <URL: <a href="http://eur-">http://eur-</a>

lex.europa.eu/LexUriServ/LexUriServ.do?uri=0J:L:2007:189:0001:0023:EN:PDF>.

Ellis, K.A., Innocent, G.T, Mihm, M., Cripps, P., Mclean, W.G., Howards, C.V. and Grove-White, D. (2007): Dairy cow cleanliness and milk quality on organic and conventional farms in the U.K. *Journal of Dairy Research*. Vol. 74, pp. 302-310.

Erskine, R., Cullor, J., Schaellibaum, M., Yancey, B. and Zecconi, A. (2004): Bovine mastitis pathogens and trends in resistance to antibacterial drugs. *National Mastitis Council Research Committee Report.* Pp. 400-414.

Eurofins Steins Laboratory (2011): *Mastitis; PCR test – Tolkning af resultater,* [online]. Eurofins Steins Laboratorium, Holstebro, DK. [cited; February 9<sup>th</sup> 2011]. Available on the internet: <URL: <a href="http://www.eurofins.dk/dk/f0devarer--agro/landbrug/kvaeg/mastitis.aspx">http://www.eurofins.dk/dk/f0devarer--agro/landbrug/kvaeg/mastitis.aspx</a>>.

Fitzpatrick, J.L., Young, F.J., Eckersall, D., Logue, D.N., Knight, C.J. and Nolan, A. (1998): Recognising and controlling pain and inflammation in mastitis. *Proceedings of the British Mastitis Conference*. Pp. 36-44.

Fossing, C., Vaarst, M., Houe, H. and Enevoldsen, C. (2006): Contributions to variability of clinical measures for use as indicators of udder health status in a clinical protocol. *Acta Veterinaria Scandinavica*. Vol. 48, pp. 1-9.

Gillespie, B.E. and Oliver, S.P. (2005): Simultaneous detection of mastitis pathogens, *Staphylococcus aureus, Sterptococcus uberis,* and *Sterptococcus agalactiae* by multiplex real-time polymerase chain reaction. *Journal of Dairy Science.* Vol. 88, pp. 3510-3518.

Gröhn, Y.T., Eicker, S.W. and Hertl, J.A. (1995): The association between previous 305-day milk yield and disease in New York State dairy cows. *Journal of Dairy Science*. Vol. 78, pp. 1693-1702.

Hardeng, F. and Edge, V.L. (2001): Mastitis, ketosis, and milk fever in 31 organic and 93 conventional Norwegian dairy herds. *Journal of Dairy Science*. Vol. 84, pp. 2673-2679.

Harmon, R.J. (1994): Symposium: Mastitis and genetic evaluation for somatic cell count. *Journal of Dairy Science*. Vol. 77, pp. 2103-2112.

Hovi, M. (2001): Alternative therapy use on UK organic farms – Constraints and pitfalls. In: *Proceedings of the fifth NAHWOA Workshop. Rodding, Denmark, November 11-13, 2001.* Pp. 6-12.

Katholm, J. (2009): *Optimal brug af antibiotika - Antibiotika er nødvendige for at bekæmpe infektioner hos både husdyr og mennesker*, [online]. Dansk Landbrugsrådgivning, Landbrugsinfo. [cited; February 8<sup>th</sup> 2011]. Available on the internet:

<URL:<a href="http://www.landbrugsinfo.dk/Kvaeg/Maelkekvalitet/Sider/Optimal-brug af anti-biotika.aspx">http://www.landbrugsinfo.dk/Kvaeg/Maelkekvalitet/Sider/Optimal-brug af anti-biotika.aspx</a>.

Kirk, J.H., DeGraves, F. and Tyler, J. (1994): Recent progress in treatment and control of mastitis in cattle. *JAVMA*. Vol. 204, pp. 1152-1158.

Klaas, I.C. (2006): Development and application of systematic clinical udder examinations as supplementary tool in udder health assessment. Ph. D. thesis, The Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Klaas, I.C., Enevoldsen, C. and Houe, H. (2004): Systematic clinical examinations for identification of latent udder health types in Danish dairy herds. *Journal of Dairy Science*. Vol. 87, pp. 1217-1228.

Koskinen, M.T., Holopainen, J., Pyörälä, S., Bredbacka, P., Pitkälä, A., Barkema, H.W., Bexiga, R., Roberson, J., Sølverød, L., Piccinini, R., Kelton, D., Lehmusto, H., Niskala, S. and Salmikvi, L. (2009): Analytical specificity and sensitivity of real-time polymerase chain reaction assay for identification of bovine mastitis pathogens. *Journal of Dairy Science*. Vol. 92, pp. 952-959.

Malterud, K. (2003): Kvalitative metoder i medisinsk forskning. En Innføring.  $2^{nd}$  Edition. Universitetsforlaget, Oslo, pp. 57-67.

Milne, M.H., Nolan, A.M., Cripps, P.J. and Fitzpatrick, J.L. (2003): Preliminary results of a study on pain assessment in clinical mastitis in dairy cows. In: *British Mastitis Conference* 2003, *Lancashire*, *UK*, 8th October 2003. P. 117.

National Mastitis Council, NMC, (2006): *NMC Recommended mastitis control program*, [online]. National Mastitis Council, Verona, USA. [cited; February 1st 2011]. Available on the internet: <URL:<a href="http://www.nmconline.org/docs/NMCchecklistInt.pdf">http://www.nmconline.org/docs/NMCchecklistInt.pdf</a>.

Neijenhuis, F., Mein, G.A., Britt, J.S., Reinemann, D.J., Hillerton, J.E., Farnsworth, R., Baines, J.R., Hemling, T., Ohnstad, I., Cook, N., Morgan, W.F. and Timms, L. (2001): Evaluation of bovine teat condition in commercial dairy herds: 4. Relationship between teat-end callosity or hyperkeratosis and mastitis. In: *Proceedings of the 2<sup>nd</sup> International Symposium on Mastitis and Milk Quality. 2001.* Pp. 362-366.

Nielsen, C., Østergaard, S., Emanuelson, U., Andersson, H., Berglund, B. and Strandberg, E. (2010): Economic consequences of mastitis and withdrawal of milk with high somatic cell count in Swedish dairy herds. *Animal.* Vol. 4, pp. 1758-1770.

Pol, M. and Ruegg, P.L. (2007): Treatment practices and quantification of antimicrobial drug usage in conventional and organic dairy farms in Wisconsin. *Journal of Dairy Science*. Vol. 90, pp. 249-261.

Rasmussen, M.D., Blom, J.Y., Nielsen, L.A.H. and Justesen, P. (2001): Udder health of cows milked automatically. *Livestock Production Science*. Vol. 72, pp. 147-156.

Riffon, R., Sayasith, K., Khalil, H., Dubreuil, P., Drolet, M. and Lagacé, J. (2001): Development of a rapid and sensitive test for identification of a major pathogens in bovine mastitis by PCR. *Journal of Clinical Microbiology*. Vol. 39, pp. 2584-2589.

Ruegg, P.L. (2009): Management of mastitis on organic and conventional dairy farms. *Journal of Animal Science.* Vol. 87, pp. 43-55.

Ruegg, P.L. and Reinemann, D.J. (2002): Milk quality and mastitis tests. *Bovine Practitioner*. Vol. 36, pp. 41-54.

Sato, K., Bartlett, P.C., Erskine, R.J. and Kaneene, J.B. (2005a): A comparison of production and management between Wisconsin organic and conventional dairy herds. *Livestock Production Science.* Vol. 93, pp. 105-115.

Sato, K., Bartlett, P.C., Saeed, M.A. (2005b): Antimicrobial susceptibility of *Escherichia coli* isolates from dairy farms using organic versus conventional production methods. *Journal of the American Veterinary Medical Association.* Vol. 226, pp. 589-594.

Schmidt, K.L., Hillerton, J.E. and Harmon, K.J. (2001): NMC guidelines on normal and abnormal milk based on SCC and signs of clinical mastitis. National Mastitis Council, Madison, WI, USA.

Schreiner, D.A. and Ruegg, P.L. (2003): Relationship between udder and leg hygiene scores and subclinical mastitis. *Journal of Dairy Science*. Vol. 86, pp. 3460-3465.

Schukken, Y.H., Grommers, F.J., Van De Geer, D., Erb, H.N. and Brand, A. (1990): Risk factors for clinical mastitis in herds with a low bulk milk somatic cell count. 1. Data and risk factors for all cases. *Journal of Dairy Science*. Vol. 73, pp. 3463-3471.

Schukken, Y.H., Wilson, D.J., Welcome, F., Garrison-Tikofsky, L. and Gonzalez, R.N. (2003): Monitoring udder health and milk quality using somatic cell count. *Veterinary Research.* Vol. 34, pp. 579-596.

Seegers, H., Fourichon, C. and Beaudeau, F. (2003): Production effects related to mastitis and mastitis economics in dairy cattle herds. *Veterinary Research*. Vol. 34, pp. 475-491.

Sørensen, L.P., Mark, T., Sørensen, M.K. and Østergaard, S. (2010): Economic values and expected effect of selection index for pathogen-specific mastitis under Danish conditions. *Journal of Dairy Science*. Vol. 93, pp. 358-369.

Tikofsky, L.L. (2005): The organic farming philosophy and its effect on udder health. In: *NMC Regional Meeting Proceedings. 2005.* Pp. 14-23.

USDA (2011): *Organic Production and Handling Requirements,* [online]. National Organic program, 7 CFR Part 205. USDA, ed. [cited; February 14<sup>th</sup> 2011]. Available on the internet: <URL: <a href="http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=397b2da08fe4620bd22d21b907100c94&rgn=div6&view=text&node=7">http://ecfr.gpoaccess.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/text-idx.gov/cgi/t/text/t

Vaarst, M. (2001): Mastitis in Danish organic dairying. In: *Proceedings of the British Mastitis Conference.* 2001. Pp. 1-11.

Vaarst, M., Bennedsgaard, T.W., Klaas, I., Nissen, T.B., Thamsborg, S.M. and Østergaard, S. (2006): Development and daily management of an explicit strategy of nonuse of antimicrobial drugs in twelve Danish organic dairy herds. *Journal of Dairy Science*. Vol. 89, pp. 1842-1853.

Vaarst, M., Paarup-Laursen, B., Houe, H. and Fossing, C. (2002): farmers' choice of medical treatment of mastitis in Danish dairy herds based on qualitative research interviews. *Journal of Dairy Science*. Vol. 85, pp. 992-1001.

Weller, R.F. and Bowling, P.J. (2000): Health status of dairy herds in organic farming. *Veterinary Records.* Vol. 146, pp. 80-81.

Wilson, D.J., Gonzalez, R.N., Case, K.L., Garrison, L.L. and Grohn, Y.T. (1999): Comparison of seven antibiotic treatments with no treatment for bacteriological efficacy against bovine mastitis pathogens. *Journal of Dairy Science*. Vol. 82, pp. 1664-1670.

Zwald, A.G., Ruegg, P.L., Kaneene, J.B., Warnick, L.D., Wells, S.J., Fossler, C. and Halbert, L.W. (2004): Management practices and reported antimicrobials usage on conventional and organic dairy farms. *Journal of Dairy Science*. Vol. 87, pp. 191-201.

# APPENDIX 1 - Management and production information

#### Herd:

Number of years as organic dairy herd:

Herd veterinarian:

Breed(s): Holstein, Jersey, Brown Swiss, Guernsey, Other:

- Mixed:

Number of milking cows per year: ~

Annual ECM/cow: ~

Other productions at the farm:

#### Number of employees:

#### **Housing:**

- Free stall with cubicles
  - Mattresses
  - Mats
  - Straw (cut/whole)
  - Shavings
  - Sand
  - Paper
- Loose housing:
  - Beds: straw/ "deep litter"-straw/sand/paper
  - Deep litter system
- Tie stall:
  - Tied all the time/loose when not milking

## Grazing (~ months of the year):

Farm area: Acres Grazing area: acres

#### **Reproduction:**

- Herd bull:
- AI:
- Breeding goals:

## Tail docking:

**Horn**: ( ~ % cows with horn)

#### Milking:

- System: Carousel, herringbone, parallel, side-by-side, stanchion (tiestall)
- \_ cows (today)
- \_ times/day
- hours/milking
- \_ persons/milking

#### **Milking routines:**

- Premilking teat dipping:
- Postmilking teat dipping:
- Gloves:
- **Teat cleaning**: Cloths/papers (Individual/shared)
- Prestripping (massage):

#### Main feedstuffs:

## Feed supplements:

- Lactating:
- Dry cows:
- Young stock:

## Cows ... /last 12 months:

- Purchased:
- Sold:
- Dead:
- Culled:

## Calves/Young stock ... /last 12 months:

- Purchased:
- Sold:
- Dead:
- Culled:

Number of calves treated for diarrhea last 12 months: Number of calves treated for pneumonia last 12 months:

/dead following the disease /dead following the disease

## **Calving**

- Calving:
- Calving pen also used for sick cows:
- Time for removing the calf:
- Colostrum routine:

## Use of laboratory diagnostics:

Number of cows with blind quarters:

Number of cows with quarters not milked in the bulk tank at the moment:

Nursing cows used in case of mastitis:

## Interval between calvings:

• Planned: Realized:

## Age at first calving:

• Planned: Realized:

Normal dry period length:

# **APPENDIX 2 – Treatment protocol**

Please fill out one row per cow, but if the same cow is being treated more than once, fill out a new row every time you treat the cow

**Initials:** Initials of the employee observing/treating the mastitis

Cow no.: Cow ID - number of the earmark or the collar of the cow or the name of the cow

- **Mastitis case:** Mild: Clots/flakes in the milk, no systemic signs, Udder: +/- swelling, warmth, pain, redness
  - Moderate: +/- changes in milk (flakes, blood, creamy pus). Udder: swelling, warmth, pain, redness, +/- loss of appetite
  - Severe: Systemic signs: Fever, depression, loss of appetite. Changes in the milk. Udder: Swelling, warmth, pain
  - E. coli (severe/fatal): Peracute onset, high fever, lack of appetite, depression. Milk: Watery/creamy pus

**Treatment:** What is the cow treated with? E.g. blinding quarter, nurse cows, stripping, ointments, herbs, sick pen, pain-killer, no treatment

- If one or more routine treatments are used on your farm, please describe the routine(s) in a few words in the following row(s). The number of the routine treatment can be recorded in the column "treatment" instead of a description.

Routine 1:		_	
<b>Routine 2:</b>			
Routine 3:			

**Effect of/status after treatment:** This should be recorded when the status of the cow changes after the treatment is initiated/after the following treatment(s). Follow-up: Is the cow recovering, healthy, dead, culled, treated with antibiotics, sold to non-organic production etc.

## **Example:**

Date	Initials	Cow no.	D = dry cow L = lactating	Milking time	Mastitis case		Treatment	Effect of/status after treatment
1/9	CS	xxxxx-xxxx	L	☐ Morning x☐ Afternoon	☐ Mild x☐ Moderate	□ Severe □ E. coli	Stripping 4 times/day, ointment X OR 1 (= routine 1, described above)	
2/9	CS	xxxxx-xxxx	L	x□ Morning □ Afternoon	x□ Mild □ Moderate	□ Severe □ E. coli	1 (e.g. Stripping 4 times/day, ointment X)	Healthy
6/9	CS	Үуууу-уууу	L	☐ Morning x☐ Afternoon	☐ Mild ☐ Moderate	x□ Severe □ E. coli	Stripping 6 times/day, herbs, Pain-killer	
9/9	CS	Үуууу-уууу	L	☐ Morning x☐ Afternoon	☐ Mild ☐ Moderate	x□ Severe □ E. coli	Blinding quarter	Recovering