Udder health in organic dairy herds in Northern Germany

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Abstract

The aim of this prevalence study was to describe the udder health situation at herd level of organic dairy herds in Northern Germany. Data from 21 voluntarily participating organic dairy herds (12-290 cows) were collected between 2011 and 2016, including somatic cell counts (SCC) from the dairy herd improvement test (DHI-test). Based on key figures from the DHI-test, the subclinical udder health status of each herd was described. Additionally, the incidence of clinical mastitis as well as the treatment of clinical mastitis cases and at drying off were obtained directly from farm records from questionnaires.

On average, 45% of the cows in a herd were classified to be udder healthy during the study period. The average monthly new intramammary infection rate was 34% in the dry period and 27% during lactation at herd level. Half of the cows which had shown an elevated SCC (>100,000 cells/mL milk) at the last record before drying off were cured by the first DHI-test day after calving. For drying off, farm managers most commonly used internal teat sealants (44%), followed by antibiotic (22%) and homeopathic (5%) dry cow therapy wherein a combined treatment was possible. The average subclinical heifer mastitis rate was 36% at first record after calving. Additionally, 1.6% of the lactating cows had an incurable udder infection. The incidence of total clinical mastitis was 37 cases in 100 cow years under risk.

The determined results were compared with those of conventional dairy herds published by other authors. Thus, this descriptive study demonstrated that the udder health in organic dairy herds is mainly comparable or tends to be worse than in conventional dairy herds, depending on individual parameters. In particular, the new infection rate during the dry period, the clinical mastitis rate as well as the heifer mastitis rate need to be improved.

Keywords: prevalence, monitoring, mastitis, mastitis treatment, drying off, herd health

Introduction

Organic dairy production is gaining popularity. This fact is confirmed by the following figures for Lower Saxony where 166 of 8,875 dairy farmers managed their farms in accordance with organic principles in 2016 [1,2]. This was an increase of 48% compared to the previous year [1]. A mandatory legal basis for all organic farmers in the European Union has existed since the organic farming EC regulation concerning animal housing (Council Regulation (EC) No. 834/2007). This regulation aims at maintaining and enhancing animal health and welfare by preventive measures on housing, feeding, breeding and (herd) management. Administering allopathic remedies such as antibiotics must be avoided in organic milk production if complementary veterinary medicine is preferable. Prophylactic treatment is prohibited and the withdrawal period following allopathic treatment is twice as long compared to conventional farms. Herbal or homeopathic remedies should be used instead (Council Regulation (EC) No. 834/2007). In a German study in organic dairy herds, 33.6% of clinical mastitis cases were treated with homeopathic remedies whereas 29.7% of clinical mastitis cases were treated with allopathic, mostly antibiotic remedies [3]. In a study examining the effectiveness of the homeopathic treatment of clinical mastitis on one organic and three conventional dairy farms, no significant difference regarding the therapeutic effect on the cure rate of pathogen-positive mild and moderate clinical mastitis cases was found in contrast to antibiotic treatment [4]. Furthermore, no differences between homeopathic or antibiotic treatment of clinical mastitis cases were detected in a randomized clinical-trial in 39 different herds in Norway. However, the number of clinical mastitis cases of the aforementioned study was small [5].

Moreover, grazing or access to an open-air cow area is mandatory for cows, at least in summer months (Council Regulation (EC) No. 834/2007 Articles 5 and 14). However, despite all efforts in organic agriculture to promote disease prevention and animal welfare, the adaptation of farm animals to organic farming seems to be overstrained [6]. This is not in accordance with the opinion of consumers who expect organic products to come predominantly from healthy animals [7]. For instance, udder health was described as being a great problem in the organic dairy sector amongst others [7,8]. Data from the DHI-test enables effective monitoring of the udder health situation [9] and identification of problems of either a single farm or a group of farms. Moreover, farms can be compared with one another, for example, organic versus conventional herds. Key figures, using selected indicator figures based on milk control results are the rate of cows with SCC ≤100,000/mL milk, the new intramammary infection rate during lactation (NIR LAC), the rate of cows with incurable udder infection (INCUR), the heifer mastitis rate (HMR) as well as the new intramammary infection rate during the dry period (NIR DP) and the cure rate between the last test day before and the first test day after drying off (CR DP) (Table 1). Müller and Sau-

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Table 1: Definitions and reference values for computing selected dependent variables at herd level

Selected dependent variable	Definition
Rate of cows with SCC ≤100,000/mL milk*	Percentage of animals with SCC ≤100,000/mL milk in the present DHI-test based on all lactating cows detected by the DHI-test.
New intramammary infection rate during lactation*	Percentage of lactating cows with SCC >100,000/mL milk in the present DHI-test that were SCC ≤100,000/mL milk in the previous DHI-test.
Clinical mastitis rate	Percentage of all cows in the herd with abnormal milk (presence of flakes or clots) with or without cardinal signs of mammary gland inflammation (redness, udder swelling, pain and heat upon udder palpation) detected by the milking personnel.
Rate of recurring clinical mastitis	Percentage of lactating cows in the herd with at least one recurring case of clinical mastitis during the same lactation detected by the milking personnel.
Cows with incurable udder infection*	Percentage of all lactating cows which were detected by the DHI-test as having an SCC >700,000/mL milk on three consecutive occasions.
Heifer mastitis rate*	Percentage of heifers in milk with SCC >100,000/mL milk at the first DHI-test after calving (p.p.) based on all heifers at their first DHI-test.
Cure rate during the dry period*	Percentage of cows with SCC ≤100,000/mL milk in the first DHI-test after calving which had SCC >100,000/mL milk in the last DHI-test before drying off.
New intramammary infection rate during the dry period*	Percentage of cows with SCC >100,000/mL milk at the first DHI-test after calving which had SCC ≤100,000/mL milk in the last DHI-test before drying off.

*variables describing the subclinical udder health situation [18]

erwein [10] mentioned a rate of 56.2% of cows with an SCC ≤100,000/mL milk for a total of 35 organic dairy herds in North Rhine-Westphalia in Germany. Another study, on the other hand, published that 29% of cows with SCC ≤100,000/mL milk in the previous DHI-test had an SCC above this threshold in the following DHI-test month in Lower Saxony, Germany without considering seasonal effects [11]. Additionally, Krömker and Volling [11] mentioned a significantly higher NIR LAC for organic dairy herds compared to conventional herds. The INCUR with SCC >700,000/mL milk in three consecutive DHI-tests amounted to 1.6% for organic dairy herds, also in Lower Saxony [11]. In the same German federal state, 37% of organic dairy heifers suffered from subclinical mastitis at the first DHI-test day after calving [11].

The dry period is of great importance for the udder health of a cow because it provides the opportunity to shorten the duration of udder infections. Nevertheless, it also poses a high risk for new intramammary infections (IMI) [12]. As mentioned in the Council Regulation (EC) No. 834/2007, homeopathic and herbal remedies should be used in organic livestock to optimize herd health if possible. Several studies were conducted to determine the effect of dry cow therapy with homeopathic nosodes on udder health [13,14]. Fidelak et al. [13], for example, tested the effectiveness of the DCT with herd-specific homeopathic nosodes in contrast to a DCT with placebo in organic dairy herds. No impact of the DCT with herd-specific homeopathic nosodes was found on the clinical mastitis rate, the NIR post partum (p.p.) or on the bacteriological cure rate [13]. Various studies confirm these results (e.g.[14]). Aside from these results relatively high costs and complex procedures for producing herd-specific homeopathic nosodes for DCT restrict their use in the field [13].

Hovi and Roderick [15] verified that the prevalence of subclinical mastitis during the dry period is much higher in organic than in conventional herds in the United Kingdom determined by individual SCC. In addition, Krömker and Volling [11] mentioned a significantly higher NIR DP in organic herds compared to conventional ones and proposed measures to minimize those new infections not only during the lactation period but also during the dry period. Furthermore, Kiesner et al. [16] examined the new intramammary infection rate during the dry period (NIR DP) as well as the cure rate during the dry period (CR DP) on five Northern German organic dairy farms and published an NIR DP of 44% and a CR DP of 68% cows determined on the basis of bacteriological examinations of milk samples. Thereby, the predominant bacteriological results of milk samples at drying off were Coryneforms (52%), Coagulase-negative staphylococci (47.2%) and *Staphylococcus* (*S.*) *aureus* (21.2%). After calving, the following pathogens were predominantly found in milk samples by bacteriological tests: Coagulase-negative staphylococci (33.2%), Coryneforms (24.4%) and *S. aureus* (6.8%) [16]. Finally, regarding clinical udder health, Hovi and Roderick [15] stated that the incidence of cows suffering from clinical mastitis (CMR) amounted to 39 cases in 100 cow years under risk on organic farms in the United Kingdom.

Relating to the udder health of organic dairy herds in general, many studies published udder health data similar or comparable to [7,10,17] or even worse [9] than data for conventional herds. The present study aims to describe the status quo of the udder health situation of organic dairy herds in Northern Germany.

Material and Methods

Farms:

Between July 2011 and December 2016 the authors conducted a prevalence study regarding the situation of udder health of organic dairy farms in Northern Germany. In total, 21 farms participated in the study until December 2016, whereas seven of them joined during the whole study period so that eventually, 102 farming years were evaluated. Sixteen of those farms were located in Lower Saxony, four in Schleswig-Holstein and one was located in Bremen. Each invited farm manager was familiar with the Competence Centre for Organic Farming called "Ökoring e. V.", Lower Saxony, Visselhövede, Germany due to prior consultation meetings.

The inclusion criteria were a herd size of at least 12 cows, a completed transformation process from conventional to organic farming by January 2011, voluntary participation as well as participation in the DHI-test. One third of all farms in the study region that met the inclusion criteria took part in the study. The participating farms are a convenience sample. The participating herd managers were willing to perform the corresponding documentation tasks. They mainly kept dairy cows of the Holstein Friesian breed but also breeds like the German Black Pied cattle, crosses of dairy and beef cattle, Angeln cattle, Simmental breed and Rotvieh. All farms ensured their dairy herds access to pasture, at least during the summer months. Information on bedding materials and special milking procedures of the participating farms were not gathered during the study period.

Data collection and evaluation:

The data of the DHI-test, which was carried out eleven times a year for each farm by the DHI-organization in the corresponding German states, were continuously recorded by the authors during the study period. The DHI-test uses SCC in milk, a meaningful indicator of udder health and milk quality, to provide information on the subclinical udder

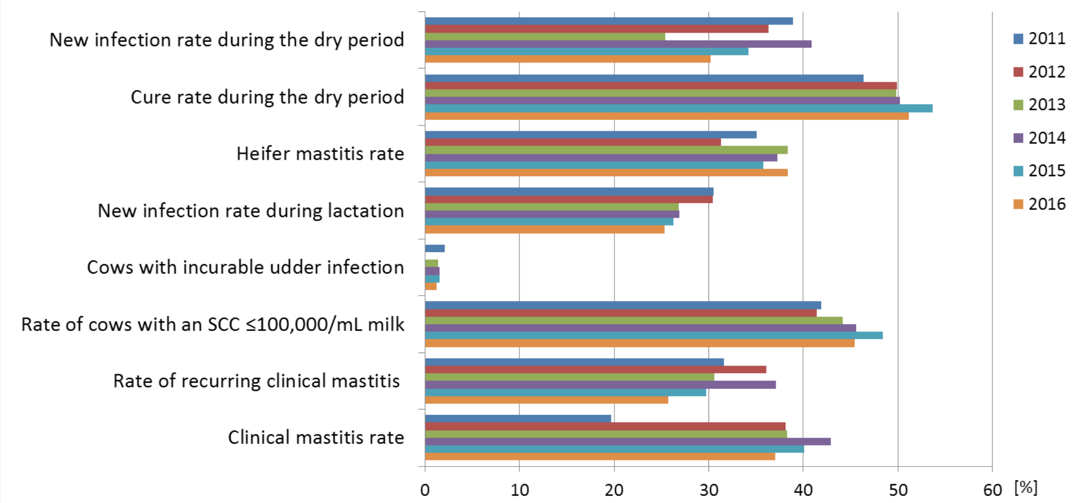

Figure 1: Yearly means of udder health specific variables at herd level of 21 organic dairy farms between 2011 and 2016. Each farm participated at least for one year. Definitions of the variables are given in Table 1.

health status at herd level. In doing so, the limit value for the distinction between a healthy or infected udder is 100,000 SCC/mL milk (12). The evaluated key figures describing the subclinical udder health as well as their definitions are marked with a "*" in Table 1. In addition to the definition of the cure rate during the dry period as given in Table 1 it should be pointed out that this rate included the self-cure processes as well as cure after treatment.

In parallel, animal health data questionnaires were sent in advance to the farm managers for the following six months twice a year. The farm managers were instructed to note the total monthly number of cows suffering from clinical mastitis, as well as the monthly number of cows with recurring clinical mastitis. A clear definition of clinical mastitis was stated to all participating farm managers at the beginning of the study, i.e., at the beginning of their participation in the project (Table 1). The farm managers were requested to instruct their milking personnel on it. Hence, these data reflect the clinical udder health status at herd level.

Moreover, the farm managers were asked to write down the number of cows which were treated because of clinical mastitis each month and to name the given treatment. Therefore, they could choose between a homeopathic, an antibiotic and a combined treatment which included a treatment with both, homeopathic as well as antibiotic remedies. Untreated clinical mastitis cases were not enumerated separately nor were other treatments like, for example, the permanent dry off of incurably infected quarters determined in the present study. In addition, the farm managers had to indicate how many cows were treated at drying off each month. For this, they could choose between several drying off methods: The use of internal teat sealants, antibiotic dry cow therapy (antibiotic DCT) or homeopathic dry cow therapy (homeopathic DCT), whereby double entries for a treatment were possible. Copies of these data questionnaires were returned to the Organic Competence Centre "Ökoring e. V." twice a year.

Due to data collection in approximately one third of organic dairy farms in this region over several years, both, seasonal as well as annual effects could be reduced.

Statistical Analyses:

Data were collected and analyzed using the programs Excel (Microsoft Corporation) and SPSS (IBM SPSS 24.0, Chicago USA). The statistical unit was a herd year mean. The Kolmogorov-Smirnov-Test was used to test if normality can be obtained for udder health variables. Apart from the treatment rate of cows suffering from clinical mastitis with homeopathic remedies (p=0.003) and the INCUR (p=0.00005), normality can be assumed for all udder health variables. Mixed model linear regression analysis was used to check result variables for the effects of the study year. The farm was included as a random effect. Significant effects of the study year on the target variables could not be determined. The effect of the repeated measurements of the study farms was determined for the target variables, but was never significant. As the variation between farms was considerably greater than the variation between years within a farm, the herd year was chosen as the statistical unit. This resulted in a slight reduction in the variation, but allowed a more accurate estimation of the mean values which were the primary values in this study.

Therefore, it can be assumed that the data represented the unbiased perennial mean of the udder health variables. Hence the corresponding variables were presented only descriptively.

Results and Discussion

The objective of this study was to estimate the udder health situation on organic dairy farms in Northern Germany at herd level. For this purpose, a comprehensive survey completed by the participating farm managers and monitoring of farm data took place during the study period.

In general, based on data from the DHI-test, monitoring of the udder health at herd level can be undertaken. It is advantageous that the analysis of the widely automated survey of DHI-test data is standardized [11].

For analyzing the questionnaires, the authors relied on the information given by the farm managers or their milking personnel. Therefore, an additional control of veterinary protocols and farm data documents did not take place within the scope of this study. Thus, estimated figures were also possible in this context.

A total of 102 farm years were enrolled in this study, representing 9,874 cows in the period from July 2011 to December 2016. The mean herd size was 94 +/- 44.6 dairy cows (mean +/- standard deviation (SD)). Significant changes of the yearly means of udder health specific variables could not be determined during the study period (Figure 1), p>0.05.

Regarding the udder health situation of the participating organic dairy farms in the present study as listed in detail in Table 2, results of udder health variables are not uniform but partly show a very high variability (Table 2). This variability shows that in principle a good udder health situation is also possible on organic dairy farms.

Rate of cows with SCC ≤100,000/mL milk:

In Germany a threshold of SCC 100,000/mL milk was stipulated to dis-

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Table 2: Udder health parameters at herd level calculated on the basis of the data from DHI-test results and questionnaires of 21 organic dairy herds

	Mean (%)	Median (%)	Standard Deviation (SD) (%)	Percentile 5%	Percentile 95%	Minimum (%)	Maximum (%)
Rate of cows with SCC ≤100,000/ mL milk¹	45.4	44.5	13.5	25.0	67.0	19.0	79.0
New infection rate during lactation²	27.4	25.0	9.2	16.0	44.9	11.0	50.0
Total clinical mastitis rate³	36.6	29.0	25.1	6.3	79.7	3.0	167.0
Rate of recurrent clinical mastitis⁴	31.5	30.5	22.1	0.0	68.9	0.0	86.0
Homeopathic treatment rate of clinical mastitis⁴	34.9	29.0	33.0	0.0	99.1	0.0	100.0
Antibiotic treatment rate of clinical mastitis⁴	36.4	32.0	28.6	30.8	93.4	0.0	100.0
Combined treatment rate of clinical mastitis⁴	8.3	0.0	16.1	0.0	43.4	0.0	87.0
Cows with SCC >700,000/mL milk in three sequent DHI-tests¹	1.5	1.0	1.3	0.0	4.0	0.0	6.0
Heifer mastitis rate⁵	36.3	36.0	18.1	6.2	69.7	0.0	82.0
Antibiotic DCT³,ᵃ	22.8	23.5	17.9	0.0	54.0	0.0	70.0
Homeopathic DCT³,ᵃ	4.6	0.0	14.2	0.0	40.6	0.0	75.0
Dry off with internal teat sealer³	44.2	47.5	28.3	0.0	85.0	0.0	100.0
Cure rate during dry period⁶	50.4	51.0	16.2	22.0	78.0	16.0	87.0
New intramammary infection rate during dry period⁷	34.1	32.5	21.6	0.0	75.0	0.0	100.0

Reference value: [1] all lactating cows in herd, [2] all lactating cows with SCC ≤100,000/mL milk in the previous DHI- test, [3] all cows in herd, [4] clinical mastitis rate, [5] all heifers in herd in milk at their first DHI-test day, [6] cows with SCC >100,000/mL milk in the last DHI-test before drying off, [7] cows with SCC ≤100,000/mL milk in the last DHI-test before drying off, [a] dry cow therapy (DCT)

tinguish a healthy udder from one suffering from subclinical mastitis [11,18]. In the present study the rate of cows with SCC ≤100,000/mL milk was 45.4% +/- 13.5% at herd level, calculated as annual means of monthly herd data (Table 2). Krömker and Volling [11] published a result for the rate of cows in 73 German organic dairy herds with an SCC ≤100,000/mL milk as being 42% +/- 16%, which is similar to the result of the present survey. Volling [19] stated a rate of 54% +/- 13% with an SCC >100,000/mL milk in conventional dairy herds with an average bulk milk-SCC in Lower Saxony, Germany compared to conventional dairy herds with a low bulk milk-SCC of the same German federal state. Conversely, this means that 46% of cows in those herds had SCC ≤100,000/mL milk which classified them as udder healthy. Compared to those conventional farms with an average udder health situation in Lower Saxony, Germany, the rate of cows with SCC ≤100,000/mL milk is similar to that of organic dairy herds participating in the present study. This thesis is confirmed by several authors who did not find significant differences for the rate of udder healthy cows between organic and conventional farms in Germany either, neither with a threshold of SCC 100,000 cells/mL (42% +/- 16% vs. 50% +/- 14%, respectively) [11] nor with 150,000 cells/mL milk (56.2% cows vs. 64% cows, respectively) [10]. On the other hand, Hovi and Roderick [15] stated a higher rate of cows with SCC >200,000/mL milk in organic (34%) than in conventional dairy herds (20%) in the United Kingdom. Nevertheless, the rate of udder healthy cows at herd level in the present study is unsatisfactory concerning both, animal health and welfare as well as the consumers´ opinion of organic livestock. Organic dairy farmers in the United Kingdom were concerned about maintaining low SCCs without using antibiotic DCT [15]. Furthermore, possible reasons for increasing SCC at cow level might be a lower milk yield or an advanced herd age, which was detected by Müller and Sauerwein [10] in a study with 35 organic and 33 conventional farms in North Rhine-Westphalia, Germany. Indeed, both aforementioned aspects apply to organic dairy farms compared to conventional farms in Germany [20]. Apparently, as the deviations between participating organic dairy farms show, some of the participating organic farm managers were not able to reduce the NIR during lactation and/or during the dry period and/or to shorten the duration of IMI, with both aspects being responsible for the udder health status of a herd [11].

NIR LAC:

Besides the duration of mastitis, the NIR also determines the udder health status at herd level, as mentioned above [11]. Due to restrictions in the Council Regulation (EC) No. 834/2007 which demand a reduced use of allopathic remedies, only few therapeutic options for improving the udder health status exist as a result of a reduction in the duration of intramammary infections in organic dairy herds. That is why reducing NIR is very important in order to optimize the udder health status of organic dairy herds [11].

The NIR LAC of the organic dairy farms participating in the present study was 27.4% +/- 9.2% (Table 2). Data similar to the results in the present study were published by Vaarst [17] with a subclinical mastitis rate of 28% (10-90% quartiles = 11-44%) for organic and 43% (10-90% quartiles = 20-65%) for conventional herds. Busato et al. [21] detected a higher prevalence of subclinical mastitis of 47.8% between day 7 and 100 of lactation and 61.5% between day 100 and 305 of lactation at cow level based on the outcome of Californian mastitis test results. Other authors determined significantly higher NIR LAC in organic than in conventional dairy herds due to the DHI-test (29% +/- 19% vs. 19% +/- 11%, respectively) [11]. Amongst others Vaarst [17] mentioned

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deep bedded freestalls, a poor environment, the prohibited preventive use of antibiotic DCT without a positive pathogen detection in the milk sample, and the potential negative energy balance during the high yielding period because of organic feeding as risk factors for (subclinical) mastitis for organic dairy herds in Denmark. Likewise, the demanded bedding of the lying areas with organic material might represent an important risk factor for a higher NIC LAC in organic than in conventional dairy herds because bedding materials constitute primary sources of environmental pathogens causing mastitis [22]. Compared to inorganic bedding material, significantly higher amounts of coliforms, *Klebsiella* spp. and *Streptococcus* spp. were found in organic bedding material of lactating cows [23]. Thus, the risk of intramammary infections occurring is higher in herds kept in housing systems with bedded lying areas with organic materials [24]. Additionally, the high herd age of organic dairy herds represents another risk factor for a higher NIR LAC than in conventional dairy herds [21]. Indeed cows in organic dairy herds have a significantly longer useful lifetime than cows on conventionally managed farms in Germany (39 vs. 27 months, $p<0.05$) [25]. Therefore, the advanced herd age in organic dairy herds is a possible reason for a higher NIR LAC of organic herds than of conventional herds. In order to improve the NIR LAC, managers of organic dairy herds should be more concerned about hygiene during milking and in the barn [11,19].

CMR and REC CM:

In the present study the average incidence rate of clinical mastitis was 36.6% +/- 25.1% (Table 2) which was similar to results of a study by Hovi and Roderick [15] who reported an average farm incidence rate of clinical mastitis of 41.5% +/- 22.8% for conventional herds and 39% +/- 28.7% for organic herds. In terms of the incidence of clinical mastitis, no essential differences were found between organic and conventional farms either [3]. The correlation between the CMR and the rate of cows with SCC ≤100,000/mL milk was not significant in the present study ($r=0.141$, $p=0.157$).

As mastitis often recurs and may occur multiple times within lactation [26], in the present study, nearly one third (31.5% +/- 22%, Table 2) of cows suffering from clinical mastitis were detected as having experienced a clinical relapse. Lower rates were published by Pinzón-Sánchez and Ruegg [27]. Whilst new clinically mild and moderate mastitis cases in the latter study were mostly caused by environmental pathogens like environmental Streptococci, *Escherichia coli* and *Klebsiella* spp., environmental Streptococci and *Serratia* spp. were detected in milk-samples without bacteriological cure after intramammary antibiotic treatment in the United States. The bacteriological cure seemed to be less effective for environmental Streptococci than for coliforms like *Escherichia coli*, *Klebsiella* spp. and *Enterobacter* spp. [27]. Both results for CMR and REC CM in organic dairy herds participating in the present study are unsatisfactory regarding the animal health and welfare on the one hand and the consumers´ perception of organic dairy farming on the other hand. One possible reason for a high CMR in organic herds as described in the present study is the restricted use of antibiotic remedies which leads to a higher incidence of mastitis on organic farms [15]. Furthermore, clinical mastitis is mostly caused by environmental pathogens [27] which are often contained in bedding materials [22] which are stipulated for lying areas in organic dairy herds (Council Regulation (EC) No. 834/2007) as mentioned above. The colonization of the bedding material with mastitis causing pathogens is related to the incidence of clinical mastitis [23]. Organic dairy farm managers should prevent (recurring) clinical mastitis: By being aware of and minimizing supporting risk factors such as a short duration of first case clinical mastitis treatment, missing bacteriological cures for first clinical mastitis, parity >2, days in milk, the udder placed below the hock and difficult to milk [27,28] for recurring mastitis and increasing parity, missing DCT, wrong management during the DP and poor hygiene in the barn as well as during the milking process for elevated SCC or clinical mastitis [19,29].

The high value for the maximum of CMR in the present study is explainable because it shows the CMR in total, including first cases as well as clinical relapses. In any case the variability between farms is very high (3.0%-167.0%, Table 2). Data collection of clinical mastitis cases depends heavily on the willingness of farmers and their milking personnel so that different levels of motivation of the participating farmers/milking personnel may have played a role in the wide range of CMR between farms. A high variability for the CMR between farms is also described in other surveys [3,7] and shows that the occurrence of clinical mastitis cases in dairy herds is considerably affected by the overall farm management [3]. Therefore, amongst others, the aforementioned individual cow- and management factors were probably responsible for the high variation in the CMR among farms.

Treatment rate of clinical mastitis:

As mentioned above, the annual total average of cows suffering from clinical mastitis was 36.6% +/- 25.1% in the present study (Table 2). In this study farmers treated 34.9% +/- 33.0% of cows in a herd suffering from clinical mastitis with homeopathic remedies and 36,4% +/- 28.6% with antibiotic remedies. Furthermore, 8.3% +/- 16.1% of cows in a herd suffering from clinical mastitis were treated with both, homeopathic as well as antibiotic remedies (Table 2). Some other studies reported that up to 85% of clinical mastitis cases at herd level in German organic dairy herds were treated allopathically [30,31]. The most used remedies among Danish organic farmers were antibiotics to treat clinical mastitis because in their opinion the antibiotic treatment method has the best prognosis to cure the cows, mostly eliminating the bacteria [8]. Those allopathic treatment rates were much higher than the results of comparable studies [7,15,32]. In accordance with the Council Regulation (EC) No. 834/2007, allopathic treatment of mastitis in organic dairy farming is only acceptable to avoid suffering and pain if all other promising treatment methods have been considered prior to this. It is interesting that Danish organic farm managers exclusively chose antibiotic remedies to treat infected cows showing clinical signs of the disease like, for example, fever or a swollen, hard, red udder quarter [8]. Surveys on the effectiveness of homeopathic treatment in contrast to an antibiotic treatment strategy were made in the past: Whilst Hektoen et al. [5] found out that the effectiveness of the treatment of clinical mastitis cases did not differ significantly between homeopathic or antibiotic treatment, Keller and Sundrum [33] determined that the treatment of clinical mastitis cases with individualized homeopathic remedies was significantly less successful compared to antibiotic treatment. The effect of different treatment remedies on both, the bacteriological as well as cytological cure rates depended heavily on the mastitis causing pathogen, though [33]. As homeopathic treatment of clinical mastitis cases is not a universal treatment method, it should be based on the bacteriological analysis of milk samples [33] if homeopathic treatment is an option.

In the present study, organic farm managers used homeopathic remedies on the one hand, because they have no withdrawal period for milk and, on the other hand, because their application is explicitly mentioned as being a favored remedy for treating diseases in the aforementioned Council Regulation ((EC) No. 834/2007). In another German study homeopathic remedies were used for 17.5% of acute clinical mastitis cases at herd level on organic dairy farms [31]. Another study stated a prevalence of clinical mastitis treatment with homeopathic remedies of 11% at herd level [30]. In the United Kingdom, the majority of organic dairy farmers used homeopathic remedies as alternative treatment methods in 49.8% of clinical mastitis cases [15] and therefore significantly fewer antibiotic remedies than farmers of conventional dairy farms. However, organic dairy farms applying about 50% homeopathic and 50% antibiotic remedies to treat clinical mastitis were also detected [7,15,32]. Furthermore, the use of a combined treatment of clinical mastitis with homeopathic as well as antibiotic remedies was possible in the present study. This was also mentioned by Krömker and Pfannenschmidt [3] who stated a combined treatment rate of clinical mastitis of 1.7%, which was lower than that in the present study (Table 2).

Especially noticeable are the large ranges percentage-wise regarding the chosen form of treatment for clinical mastitis by the participating farms (homeopathic treatment: 0.0%-100.0%, antibiotic treatment: 0.0%-100.0%, combined treatment: 0.0%-87.0%, Table 2) which was also reflected in previous studies [15,31]. A high SD, especially for the only antibiotic (28.6%) and solely homeopathic treatment (33.0%) is also remarkable in the present study (Table 2).

There were farms which did not treat clinical mastitis cases with antibiotic remedies in the present study (Table 2), as also mentioned in the survey by Winckler and Brinkmann [31]. The doubled latency on milk and meat in accordance with the Council Regulation (EC) No. 834/2007 might be one reason for that. Likewise, it seems to be possible that some farmers had the desire to reduce antibiotic treatments to follow the philosophy of organic farming and preferred homeopathic and herbal remedies to cure clinical mastitis, like Vaarst et al. [34] reported from Danish organic dairy farmers.

INCUR:

The present study found similar results for organic farms (1.5% +/- 1.3%, Table 2) as described in Lower Saxony, Germany [11], where INCUR was comparable for organic (1.6% +/- 2.4%) and conventional herds (1.7% +/- 1.8%). Nonetheless, also higher results for INCUR of up to 5% with a wider range of 1-19% compared to the results of the present study (0.0-6.0%, Table 2) were published for organic dairy herds [35].

The herd age, especially advanced number of lactations, is said to play a role as a risk factor for chronic subclinical mastitis [36]. However, this does not apply to the participating herds in the present study. Although cows of organic dairy herds in Germany have a significantly longer usefully lifetime than cows of conventional herds [25], the INCUR of organic dairy herds in Lower Saxony is comparable to conventional dairy herds from the same German federal state as mentioned above [11].

Furthermore, herds with a high INCUR probably have a problem with mastitis caused by *S. aureus*, which often causes subclinical chronic mastitis with high SCC [37]. Baars and Barkema [38] suggested that the prohibited routine antibiotic DCT may be a reason for an unsuccessful control of *S. aureus* infections and difficulties in keeping SCC down on organic dairy farms. Preventing a pathogen spread and protecting the udders of healthy cows should be the aim of farm managers. In the case of chronic mastitis caused by *S. aureus,* for example, the culling of cows suffering from chronic mastitis which is only necessary in rare cases, the separation of udder healthy cows from cows intramammarily infected by *S. aureus* and/or optimizing the milking process and the milking hygiene are possible measures to reduce the rate of subclinical mastitis at herd level [37].

HMR:

The HMR was 36.3% +/- 18.1% in the present study. Results similar to our data without a significant difference were published for the HMR in German organic and conventional herds [11]. Another study in Lower Saxony reported an HMR for conventional herds of 31% at approximately 41 days p.p. [39]. Results worse than those of the present study were published by Volling [19] with an HMR of 42% +/- 15% for conventional herds with an average bulk milk-SCC in Lower Saxony, Germany. Additionally, an HMR of 21.3% in the United States [40] at first milking was reported for conventional herds, using a threshold of SCC >200,000/mL milk. Although other authors used higher thresholds, the HMR on organic dairy farms in North Germany seems to be a serious problem. A high heifer mastitis rate does not match with the consumer`s opinion of healthy animals originating from organic production methods, on the one hand, and animal health and welfare aspects as mentioned in the Council Regulation (EC) No. 834/2007, on the other hand. Possible risk factors might be a high calving age, short front teats, udder edema and juvenile intersucking in the breeding group as mentioned by Krömker et al. [39] for conventional herds. Especially the first calving age, which is significantly higher on organic (31 months) than on conventional dairy farms (28 months) ($p < 0.01$) in Germany [25], represents an important risk factor for organic herds. A large range percentage-wise between participating farms which was noticed in the present study (0.0%-82.00%, Table 2) was also mentioned by Cook et al. (0%-58%) [40] and shows that the improvement in HMR is also dependent on individual on-farm factors. Some exemplary reasons for those farm factors causing a high HMR in some herds are calving areas with poor hygienic conditions resulting in dirty udders, a housing system with an ineffective fly control as well as a lactating herd with high bulk milk-SCC and a higher incidence of mastitis in general [41–43].

Drying off management:

The dry period offers the opportunity on the one hand to shorten the duration of udder infections but, on the other hand, also poses the risk of new udder infections. That is why it is important for udder health [12]. Whilst participating organic farmers in the present study used homeopathic DCT for about 4.6% +/- 14.2% (Table 2) of cows in a herd, Winckler and Brinkmann [31] reported a use of homeopathic DCT of only 0.4% (0%-12%). Homeopathic DCT is rather recommended for dairy herds with low SCC (SCC <200,000/mL milk) at drying off than for dairy herds with high SCC to prevent intramammary infections during that period [44]. Further farmers using homeopathic DCT spare themselves the long latency after treatments with antibiotic remedies corresponding to the Council Regulation (EC) No. 834/2007. Probably some farmers are so convinced of the effectiveness of homeopathic DCT, and use it even with positive detection of mastitis-causing pathogens although no effect of a treatment with homeopathic remedies on the bacteriological cure rate was shown [13,14]. On the other hand, high costs of producing a herd-specific homeopathic nosode might deter some farmers from using homeopathic DCT [13]. These reasons might explain the variability in the application of homeopathic remedies at drying off on participating farms in the present study (Table 2).

Antibiotic DCT was used for on average 22.8% +/- 17.9% of cows at herd level in the present study (Table 2). The use of antibiotic DCT for 24.6% of cows in a herd, similar to results in the present study, was also published for organic dairy herds in Lower Saxony, whereas conventional farms in the same German federal state used these agents in about 90% of treated cows [9]. This difference between organic and conventional herds seems to be in compliance with the Council Regulation (EC) No. 834/2007 which permits the antibiotic treatment at drying off on organic dairy farms only on rare occasions. Organic farms are regularly visited by German organic farming organizations concerning implementing the aforementioned European Council Regulation.

As a prophylactic treatment with allopathic remedies without positive bacteriological analyses of milk samples is not permitted by almost all German organic farming associations where organic farmers are members, some participating farms seemed to have a high pathogen pressure resulting in positive bacteriological analyses of milk samples and, thus, an antibiotic DCT of up to 70% of the cows at herd level (Table 2). Farmers who did not use antibiotic DCT either had no positive detection of mastitis causing pathogens in the analysis of milk samples or largely refrained from using antibiotic remedies to enforce the principles of organic farming (Council Regulation (EC) No. 834/2007).
In contrast to the results in the present study, which detected the usage of internal teat sealants at drying off for 44.2% +/- 28.3% cows at herd level (Table 2), a very low rate for the use of internal teat sealers at drying off (8.4% - 11.3%) was published for German organic dairy herds between 2008 and 2010 (detected within an interdisciplinary intervention study) [35]. As the application of internal teat sealants significantly protects from NIR DP [16], those herds probably had fewer problems with NIR DP so that the farm managers decided not to use internal teat sealers at drying off [35]. On the contrary, some participating farm managers in the present study treated almost every cow in a herd with internal teat sealants (0.0%-100.0%, Table 2). In general, teat sealants are less restricted (Council Regulation (EC) No. 834/2007) and are probably an alternative for organic dairy herds as they are antibiotic-free and a prophylactic method for improving herd health without causing a latency on milk or meat. Besides the problem with NIR DP, the aforementioned factors probably provide reasons for a high rate of using internal teat sealants at drying off in several herds participating in the present study. Farm managers who did not use internal teat sealants seemed to have no problem with NIR DP.

CR DP:

The average CR DP of participating herds was 50.4% +/- 16.2% in the present study, including spontaneous cures as well as cures after DCT (Table 2). Similar results for CR DP were obtained with 48.6% in 2007 and 2008 and 51.7% in 2009 at herd level for organic herds by Brinkmann et al. [35]. However, also a better CR DP of 67.8% was described, detected on the basis of bacteriological examination of milk samples [16]. The result of a survey on conventional herds with an average bulk milk-SCC in Lower Saxony, which had a CR DP of 48% +/- 14%, comes close to the CR DP of the present study [19]. Also Krömker and Volling [11] discovered that organic herds performed comparably to conventional herds with a CR DP of 54% +/- 22% at herd level in Germany. Another study, in contrast, published a higher CR DP for conventionally managed dairy cows from 3 months before drying off to 3 months after the dry period than for organically managed dairy cows (p=0.001) including self-cure as well as cure after treatment (at least in 30 of 33 conventional herds antibiotic DCT was used) detected by using DHI-test results [10], pointing out that the antibiotic DCT supports the cure rate in conventional dairy herds [10]. In a survey by Hovi and Roderick [15] farmers shared this thesis while believing that the restricted use of antibiotic DCT might lead to high SCC because it makes it difficult to keep the level of SCCs low [38].
Regarding the CR DP Brinkmann et al. [35] referred to a large variance between participating dairy herds which is similar to the variance detected in the present study (16.0%-87.0%, Table 2). Between farm-differences of factors affecting the cure rate in general like age, the stage of lactation, SCC prior to treatment and the number of clinical mastitis cases in the previous lactation, the species and strain of mastitis causing pathogens at cow level [45–47] as well as housing conditions and stocking density at herd level [29] may explain the variability in CR DP of participating farms in the present study.

NIR DP:

In the present study the NIR DP was 34.1% +/- 21.6% (Table 2). Other studies also agreed with the fact that in organic herds about one third of animals susceptible to mastitis developed IMI between the last DHI-test before drying off and the first DHI-test after calving [9,11,35]. Additionally, Kiesner et al. [16] also stated an NIR DP of 44% for a small convenience sample of organic herds in Germany based on results of bacteriological examinations of milk samples. Volling [19] determined a much lower NIR DP, namely that of only 23% +/- 13% for conventional herds, although these data came from conventional herds with an average bulk milk-SCC in Lower Saxony. Nonetheless, also worse results with 48% were found by studies on conventional farms at cow level [48]. However, the latter mentioned study used bacteriological analyses of milk samples to detect new IMI. Whilst Müller and Sauerwein [10] did not determine significant differences between German organic and conventional herds regarding the NIR DP, Krömker and Volling [11] referred to significant differences between the NIR DP between those two management systems in Lower Saxony (32% +/- 39% (organic) vs. 19% +/- 16% (conventional), respectively). The latter might be a result of the Council Regulation (EC) No. 834/2007 which permits the use of allopathic remedies only on rare occasions. Therefore, the improvement in housing conditions is very important for optimizing udder health during the dry period, especially on organic dairy farms [16]. However, the latter study did not provide information about bedding material but all dried off cows had continuous access to pasture or were kept on pasture during the entire dry period [16].
Krömker and Volling [11] also determined that the NIR DP seems to be one of the main problems of organic dairy herds with regard to the udder health situation in Germany. In order to improve the udder health, especially the NIR DP, it is very important to optimize the hygienic conditions of the environment and to choose the optimal and essential therapeutic treatment at drying off [16,29]. The potentially increased use of internal teat sealants probably led to a lower NIR DP than in herds not administered internal teat sealants in the present study. Kiesner et al. [16] also found a significant difference of NIR DP between organic dairy cows receiving internal teat sealants and unsealed ones ($p \leq 0.001$). The high variability between farms of NIR DP in the present study (0.0%-100.0%, Table 2) as well as in some other surveys [35,40] demonstrates that a low NIR DP is possible on (organic) dairy farms when considering measures to reduce intramammary infections in addition to the dry off treatment with internal teat sealants as mentioned above. These are namely good hygienic conditions in housing like the configuration of lying areas and their maintenance, the use of potential bedding-additions and high cleaning frequency of the floors which all have a high impact on the NIR DP [19].

Conclusion

This descriptive study found that udder health is a major problem on organic dairy farms despite all efforts in organic farming to prevent the disease by implementing effective regulations. Furthermore, contrary to the consumers´ opinion, the findings indicate an udder health situation largely comparable to that on conventional dairy farms with a tendency towards a worse udder health situation in some aspects although animal health is a fundamental aim in organic production (Council Regulation (EC) No. 834/2007). Due to these poor production results of the present study, organic dairy farmers have to enhance the udder health of dairy cows to fulfill their own self-formulated high claims on organic farming as well as the high demands concerning

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animal health and welfare clearly stipulated in the Council Regulation (EC) No. 834/2007, on the one hand, and to meet public expectations of organic livestock, on the other hand.

Especially the NIR DP, the CMR and the HMR represent critical issues regarding the udder health situation on organic dairy farms participating in the present study. Thus, improvements in udder health are necessary and mandatory. In particular, the requested bedding material in lying areas, the advanced herd age and high first calving age as well as the restricted use of antibiotic remedies in organic dairy herds represent special challenges concerning the udder health in organic dairy herds. That is why development is required especially regarding the improvement of housing conditions, milking hygiene, and the use of successful alternative therapy options to improve the udder health of organic dairy herds in general. At the same time, the high variability between the participating farms in the present study shows scope for advancing organic dairy farming.

Disclosure of conflicts of interest

The authors declare no potential conflicts of interest.

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References

1. Kompetenzzentrum Ökolandbau Niedersachsen GmbH. Biomarkt Niedersachsen: Marktdaten 2016 Bio-Milch bringt den Öko-Markt in Schwung. Schröder Druck und Design GmbH, Walsrode; 2016.
2. Licher C, Gräflich F. Strukturwandel: Weniger Milchkühe und weniger Milchviehhaltungen ermittelt; 2017 [cited 2018 December 04]. Availiable from: https://milchwirtschaft.de/aktuelles-und-veranstaltungen/aktuelles/2017/01-Strukturwandel-Milchkuehe-Milchviehhaltungen.php.
3. Krömker V, Pfannenschmidt F. Zur Inzidenz klinischer Mastitiden und ihrer Therapie in Milchviehbetrieben des ökologischen Landbaus [Mastitis Incidence and Therapy in Organic Dairy Farms]. In: Heß J, Rahmann G, editors. Ende der Nische, Proc. 8. Wissenschaftstagung ökologischer Landbau, Kassel: kassel university press GmbH; 2005.
4. Werner C, Sobiraj A, Sundrum A. Efficacy of homeopathic and antibiotic treatment strategies in cases of mild and moderate bovine clinical mastitis. J Dairy R 2018;77:460–7.
5. Hektoen L, Larsen S, Ødegaard SA, Løken T. Comparison of Homeopathy, Placebo and Antibiotic Treatment of Clinical Mastitis in Dairy Cows-Methodological Issues and Results from a Randomized-clinical Trial. J Vet Med 2004;A 51:439–46.
6. Sundrum A. Organic livestock farming. Livest Prod Sci 2001;67:207–15.
7. Weller RF, Bowling PJ. Health status of dairy herds in organic farming. Vet Rec 2000;146:80–1.
8. Vaarst M, Thamsborg SM, Bennedsgaard TW, Houe H, Enevoldsen C, Aarestrup FM, de Snoo A. Organic dairy farmers' decision making in the first 2 years after conversion in relation to mastitis treatments. Livest Prod Sci 2003;80:109–20.
9. Krömker V, Volling O. Therapeutisches Eutergesundheitsmanagement in Milchviehbetrieben des ökologischen Landbaus. In: Zikeli S, Claupein W, Dabbert S, Kaufmann B, Müller T and Valle Zárate A, editor. Zwischen Traditition und Globalisierung. Proc. 9. Wissenschaftstagung ökologischer Landbau, Stuttgart: Dr. Köster, Berlin; 2007.
10. Müller U, Sauerwein H. A comparison of somatic cell count between organic and conventional dairy cow herds in West Germany stressing dry period related changes. Livest Sci 2010;127:30–7.
11. Krömker V, Volling O. Status der Eutergesundheit in Milchviehherden auf der Basis von Daten der Milchleistungsprüfung in Niedersachsen. In: Neuhoff S, Stumm C, Ziegler S, Rahmann G, Hamm U, Köpke U, editor. Ideal und Wirklichkeit - Perspektiven ökologischer Landbewirtschaftung. Proc. 12. Wissenschaftstagung, Bonn: Dr. Köster, Berlin; 2013, p. 496–9.
12. Krömker V. Trockenstellen unter antibiotischem Schutz. In: Deutsche Veterinärmedizinische Gesellschaft, editor. Tagung der Fachgruppe "Milchhygiene", Arbeitskreis "Eutergesundheit" der Deutschen Veterinärmedizinischen Gesellschaft e. V., Hannover: DVG, Gießen; 1999.
13. Fidelak C, Berke M, Klocke P, Spranger J, Hamann J, Heuwieser W. Nosoden zum Trockenstellen – eine placebokontrollierte Blindstudie [Dry Cow Therapy with homeopathic nosodes- a randomized double blind study]. In: Zikeli S, Claupein W, Dabbert S, Kaufmann B, Müller T, Valle Zaraté A, editors. Zwischen Tradition und Globalisierung. Proc. 9. Wissenschaftstagung ökologischer Landbau, Stuttgart: Verlag Dr. Köster, Berlin; 2007.
14. Meaney W. Treatment of mastitis with homeopathic remedies. IDF-Mastitis Newsl 1995;20:5–6.
15. Hovi M, Roderick S. Mastitis and mastitis control strategies in organic milk. Cattle Pract 2000;8:259–64.
16. Kiesner K, Wente N, Volling O, Krömker V. Selection of cows for treatment at dry-off on organic dairy farms. J Dairy Res 2016;83:468–75.
17. Vaarst M. Mastitis in Danish organic dairying. Proc. Br. Mastit. Conf., Garstand: 2001, p. 1–12.
18. Landeskontrollverband Schleswig-Holstein e. V.. Erlaeuterungen zum Eutergesundheitsbericht; 2018 [cited 2019 March 02]. Availiable from: https://www.lkv-sh.de/mlp/mlp-Ergebnisse-mlp/erlaeuterungen-zum-eutergesundheitsbericht.
19. Volling O. Eutergesundheitsmanagement in Milchviehherden mit sehr niedrigem Herdensammelmilchzellgehalt in Niedersachsen. Georg-August-Universität Göttingen, 2011.
20. Blank B, Schaub D, Paulsen HM, Rahmann G. Vergleich von Leistungs- und Fütterungsparametern in ökologischen und konventionellen Milchviehbetrieben in Deutschland. Landbauforsch · Appl Agric For Res · 2013;1:21–8.
21. Busato A, Trachsel P, Schällibaum M, Blum JW. Udder health and risk factors for subclinical mastitis in organic dairy farms in Switzerland. Prev Vet Med 2000;44:205–20.
22. Hogan J, Smith KL. Managing Environmental Mastitis. Vet Clin Food Anim 2012;28:217–24.
23. Hogan J, Smith K, Hoblet K, Todhunter D, Schoenberger P, Hueston W, Pritchard DE, Bowman GL, Heider LE, Brockett BL, Conrad HR. Bacterial counts in bedding materials used on nine commerial dairies. J Dairy Sci 1989;72:250–8.
24. Barth K, Frank K, Häußermann A, Aulrich K, Krömker V. Mastitiserreger in der Einstreu, auf der Zitzenhaut und im Zitzenkanal, sowie in der Milch ökologisch gehaltener Kühe Einleitung und Zielsetzung. In: Neuhoff D, Stumm C, Ziegler S, Hamm U, Köpke U, editors. Ideal und Wirklichkeit - Perspektiven ökologischer Landbewirtschaftung. Proc. 12. Wissenschaftstagung ökologischer

Landbau, Bonn: Dr. Köster, Berlin; 2013, p. 472–3.
25. Blank B, Schaub D, Paulsen HM, Rahmann G. Herd parameters in organic and conventional dairy farms and their role in greenhouse gas emissions from milk production. In: Rahmann G, Godinho D, editors. Tackling Futurure Challenges Org. Anim. Husbandry. Proc. 2nd OAHC, Hamburg/Trenthorst; 2012, p. 269–72.
26. Hertl JA, Schukken YH, Welcome FL, Tauer LW, Gröhn YT. Pathogen-specific effects on milk yield in repeated clinical mastitis episodes in Holstein dairy cows. J Dairy Sci 2014;97:1465–80.
27. Pinzón-Sánchez C, Ruegg PL. Risk factors associated with short-term post-treatment outcomes of clinical mastitis. J Dairy Sci 2011;94:3397–410.
28. Pantoja JCF, Almeida AP, dos Santos B, Rossi RS. An investigation of risk factors for two successive cases of clinical mastitis in the same lactation. Livest Sci 2016;194:10–6.
29. Green MJ, Bradley AJ, Medley GF, Browne WJ. Cow, Farm, and Management Factors During the Dry Period that Determine the Rate of Clinical Mastitis After Calving. J Dairy Sci 2007;90:3764–76.
30. Brinkmann J, March S, Höller B, Winckler C. Eutergesundheit in der ökologischen Milchviehhaltung – Einfluss von Laktatonsstadium und Laktationszahl auf die Behandlungsinzidenz klinischer Mastitiden. In: Zikeli S, Claupein W, Dabbert S, Kaufmann B, Müller T and Valle Zárate A, editor. Zwischen Traditition und Globalisierung. Proc. 9. Wissenschaftstagung ökologischer Landbau, Stuttgart: Dr. Köster, Berlin; 2007.
31. Winckler C, Brinkmann J. Präventive Tiergesundheitskonzepte in der ökologischen Milchviehhaltung. 2004.
32. Krutzinna C, Boehncke E, Herrmann HJ. Die Milchviehhaltung im ökologischen Landbau. Berichte über Landwirtschaft Zeitschrift für Agrar und Landwirtschaft 1996;74:461–80.
33. Keller D, Sundrum A. Comparative effectiveness of individualised homeopathy and antibiotics in the treatment of bovine clinical mastitis: randomised controlled trial. Vet Rec 2018;10.1136/vr:1–11.
34. Vaarst M, Bennedsgaard TW, Klaas I, Nissen TB, Thamsborg SM, Østergaard S. Development and Daily Management of an Explicit Strategy of Nonuse of Antimicrobial Drugs in Twelve Danish Organic Dairy Herds. J Dairy Sci 2006;89:1842–53.
35. Brinkmann J, March S, Barth K, Becker M, Drerup C, Isselstein J, Klocke D, Krömker V, Mersch F, Müller J, Rauch P, Schumacher U, Spiekers H, Tichter A, Volling O, Weiler M, Weiß M, Winckler C. Status quo der Tiergesundheitssituation in der ökologischen Milchviehhaltung in Deutschland - Ergebnisse einer repräsentativen bundesweiten Felderhebung. In: Leithold G, Becker K, Brock C, Fischinger S, Spiegel AK, Spory K, Wilbois KP and Williges U, editor. Es geht ums Ganze - Forschen im Dialog von Wissenschaft und Praxis. Proc. 11. Wissenschaftstagung ökologischer Landbau, Gießen: Dr. Köster, Berlin; 2011, p. 162–9.
36. Cardozo L, Thaler Neto A, Souza G, Picinin L, Felipus N, Reche N, Schmidt FA, Werncke D, Simon EE. Risk factors for the occurrence of new and chronic cases of subclinical mastitis in dairy herds in southern Brazil. J Dairy Sci 2015;98:7675–85.
37. Krömker V. Strategien zur Bekämpfung von Mastitiden durch kuhassoziierte Mikroorganismen als Herdenproblem. Arch Für Leb 63 2012;1:2–5.
38. Baars T, Barkema HW. Bulk milk somatic cell count and the use of resources in organic dairy farming. A case study on subclinical mastitis caused by Staphylococcus aureus. Proc. 3rd ENOF Work., Ancona: 1997, p. 175–87.
39. Krömker V, Pfannenschmidt F, Helmke K, Andersson R, Grabowski NT. Risk factors for intramammary infections and subclinical mastitis in post-partum dairy heifers. J Dairy Res 2012;79:304–9.
40. Cook NB, Bennett TB, Emery KM, Nordlund KV. Monitoring Nonlactating Cow Intramammary Infection Dynamics Using DHI Somatic Cell Count Data. J Dairy Sci 2002;85:1119–26.
41. Piepers S, Peeters K, Opsomer G, Barkema HW, Frankena K, De Vliegher S. Pathogen group specific risk factors at herd, heifer and quarter levels for intramammary infections in early lactating dairy heifers. Prev Vet Med 2011;99:91–101.
42. De Vliegher S, Laevens H, Barkema HW, Dohoo IR, Stryhn H, Opsomer G, De Kruif A. Management Practices and Heifer Characteristics Associated with Early Lactation Somatic Cell Count of Belgian Dairy Heifers. J Dairy Sci 2004;87:937–47.
43. Waage S, Sviland S, Ødegaard SA. Identification of Risk Factors for Clinical Mastitis in Dairy Heifers. J Dairy Sci 1998;81:1275–84.
44. Maeschli A, Ivemeyer S, Notz C, Walkenhorst M, Heil F, Klocke P. Eine randomisierte Vergleichsstudie zur Verwendung von Homöopathie und internen Zitzenversieglern zum Trockenstellen von Milchkühen. In: Leithold G, Becker K, Brock C, Fischinger S, Spiegel AK, Spory K, Wilbois KP and Williges U, editor. Es geht ums Ganze - Forschen im Dialog von Wissenschaft und Praxis. Proc. 11. Wissenschaftstagung ökologischer Landbau, Gießen: Dr. Köster, Berlin; 2011, p. 70–3.
45. Sol J, Sampimon OC, Snoep JJ, Schukken YH. Factors Associated with Bacteriological Cure During Lactation After Therapy for Subclinical Mastitis Caused by Staphylococcus aureus. J Dairy Sci 1997;80:2803–8.
46. Østerås O, Edge VL, Martin SW. Determinants of Success or Failure in the Elimination of Major Mastitis Pathogens in Selective Dry Cow Therapy. J Dairy Sci 1999;82:1221–31.
47. Deluyker HA, Van Oye SN, Boucher JF. Factors Affecting Cure and Somatic Cell Count After Pirlimycin Treatment of Subclinical Mastitis in Lactating Cows. J Dairy Sci 2005;88:604–14.
48. Neave FK, Dodd FH, Henriques E. Udder infections in the ‘dry period’. I. J Dairy Res 1950;17:37.