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A survey of drying-off practices on commercial dairy farms in northern Germany and a comparison to science-based recommendations

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ABSTRACT

While dry cow management is important for health, milk production and fertility information on drying-off procedures implemented on commercial dairy farms is lacking. Current drying-off management procedures on commercial dairy farms were evaluated using a questionnaire and results compared with recommendations given in the current literature. Ninety-one participants from a farmer education event completed the survey. On average, cows were dried off seven weeks before calving. Only 9.9 per cent of the farms had a dry period length of five weeks or less. A continuous milking regime without dry period was not established on any farm participating in the survey. Most farmers performed an abrupt drying-off (73.0 per cent). Only 11.8 and 15.0 per cent attempted to lower milk yield prior to drying-off by reducing milking frequencies and adjusting feed rations, respectively. While a blanket antibiotic dry cow treatment was carried out on 79.6 per cent of the farms, selective dry cow treatment was not mentioned by any farmer. Although 77.4 per cent preponed the drying-off date in low-yielding cows, an altered drying-off procedure in high-yielding dairy cows was rare (9.7 per cent). This survey provides an insight into drying-off procedures currently applied on commercial dairy farms in northern Germany.

INTRODUCTION

It is well documented that dry cow management and the dry period are important for animal health (Kim and others 2003), milk production (Annen and others 2004, Andersen and others 2005) and fertility (Beever 2006) of dairy cows in the following and further lactations.

A recent study analysed the effect of different feeding strategies during drying-off on animal health measured by clinical findings (i.e. heart rate, rectal temperature, rumen contraction), intramammary infections, somatic cell count (SCC) and blood parameters (Odensten and others 2007a, b). Green and others (2007) investigated the influence of herd management practices during the dry period on the incidence rate of clinical mastitis after calving. Animal welfare parameters such as behavioural changes and concentrations of stress hormones during drying-off were evaluated recently by Tucker and others (2009) and Bertulat and others (2013). Drying-off procedures described in these studies, however, differed considerably. Procedures such as an abrupt drying-off (Annen and others 2004, Bertulat and others 2013), prolonged milking intervals in preparation of the drying-off (Odensten and others 2007a, b) and changes of the feed ration or feed restriction before last milking (Valizaheh and others 2008, Tucker and others 2009) were described. While these drying-off strategies are well known and have been applied for decades (Wayne and others 1933, Steyn, 1940), more recently the question has been addressed whether drying-off dairy cows is necessary (Rémond and others 1992, Madsen and others 2008). Advantages and disadvantages of continuous milking with omitting a dry period (Fitzgerald and others 2007, Schlamberger and others 2010) and varying dry period lengths were investigated (Watters and others 2008, Santschi and others 2011). In addition, studies have focused on the benefits of antibiotic dry cow treatment in combination with (Berry and Hillerton 2007, Bradley and others 2011) or without (Bradley and Green 2001, Dingwell and others 2002) an internal teat sealant. Despite considerable research efforts to improve current drying-off strategies (Ollier and others 2013, Zobel and others 2013), there is a dearth of information what drying-off procedures are actually implemented on commercial dairy farms.

Therefore, the objective of this study was to evaluate current drying-off management procedures on dairy farms in northern

Germany using a questionnaire, focusing on preparation strategies before drying-off, dry period length, antibiotic dry cow treatment and the effect of milk yield on decisions related to the drying-off procedure. Furthermore, these management strategies will be compared with recommendations given in the current literature on drying-off procedures.

MATERIALS AND METHODS

A comprehensive questionnaire was developed focusing on farm characteristics, dry cow management and the perception of drying-off-related behaviour. The questionnaire is provided as a online supplementary file to this paper.

Five open-ended questions covered general farm information such as farm size, milk production and bulk milk SCC. Furthermore, 23 closed-ended questions with the option to add comments were asked in order to obtain information regarding the management of late lactating cows (5 questions), the general drying-off management and preparation before drying-off (10 questions) and the management of cows in the early dry period (8 questions). The last set of questions (eight questions) covered the perception of the drying-off procedure concerning animal health and animal welfare aspects. A five-point Likert scale was used for these questions.

The questionnaires were distributed using a convenience sample of 370 farmers attending a continuing education event organised by a German cattle breeding organisation (Rinderzuchtverband Schleswig-Holstein, e.g. Neumünster, Germany). Attendants were dairy farmers from northern Germany, a region dominated by farms holding an average of 97.5 cows per farm with an average milk production of 8471 kg (German Cattle Breeders' Federation 2013). The participation in the survey was voluntary and anonymous. A total of 200 questionnaires were distributed and the farmers were asked to fill out the survey during the event.

Data were entered into Excel spread sheets (V.2010, Microsoft, Redmond, Washington, USA) and statistical analyses were performed using IBM SPSS Statistics for Windows (V. 20.0, IBM Deutschland GmbH, Ehningen, Germany). Means and corresponding sd were calculated for continuous and ordinal variables and are reported as mean±sd. Frequencies were computed for binary and categorical variables. The interrelation between two categorical variables was summarised using cross-tabulations. Binary and multinomial logistic regression models were calculated to verify the association between different responses (i.e. categorical variables). OR and (95% CI were estimated to determine the association between different management procedures and opinions of the farmers. Percentages were rounded to the nearest first decimal place. The significance level was set at $P \leq 0.05$.

RESULTS

A total of 98 questionnaires were returned (i.e. response rate 49.0 per cent). Also, 3 out of 98 survey forms (3.1 per cent) had more than half of the questions unanswered and thus were excluded from further analysis. Additionally, four duplicates (i.e. survey forms with identical answers) were excluded as well, leaving 93 survey forms for the final analysis.

In the first and second block of questions (covering farm data and management at drying-off), 95.7 per cent of all questions were answered. The response rate for the last block focusing on animal welfare aspects of the drying-off procedure was 87.0 per cent.

General farm data and management of late lactating cows

The number of cows dried off annually on participating farms ranged from 35 to 1000 dairy cows. A median of three full-time equivalents (minimum 1; maximum 19) were employed in the milk production. One employee cared for an average of 52±27 cows. The farms had a mean 305 days production of 8949±1154 kg milk with 4.2±0.28 per cent fat and 3.5±0.18 per cent protein. The average annual bulk milk SCC was estimated at 172,000 ±63,500 cells/ml.

The information considering housing and management of late lactating cows is shown in Fig 1 and Table 1, respectively. Before drying-off, cows were mostly housed in freestalls with cubicle housing systems (89.2 per cent) and milked twice daily (96.7 per cent) in a milking parlour (89.2 per cent). While cows on two farms were exclusively held on pasture (2.2 per cent), 31.2 per cent of the farms offered access to pasture for late lactating cows at least part of the day.

Time of drying-off

Cows were dried off approximately seven weeks (minimum four weeks; maximum 10 weeks) before the calculated calving date. While 3.7 per cent of the farms favoured a short dry period length of 35 days or less, only 18.3 per cent had a defined dry period length of 56–63 days. The majority (64.5 per cent) dried off their dairy cows 40–55 days before the calculated calving date. Not a single farm participating in this study omitted the dry period and favoured a continuous lactation. Only one farm (1.1 per cent) had a regular dry period of more than 70 days. The farms participating in this survey, however, did not differentiate between primiparous and multiparous cows but implemented a general dry period length for all cows regardless of age.

Interestingly, the majority (76.3 per cent) of the farms did not implement a preplanned schedule for drying-off and replied that cows were dried off as needed. Only 14.0 and 9.7 per cent of the farms had a weekly or bi-weekly drying-off routine.

Preparation before drying-off

The majority of the farmers (73.0 per cent) performed an abrupt drying-off without any previous preparation of the cows. Only 11.8 and 15.0 per cent of the farms attempted to lower milk yield prior to drying-off by reducing the milking frequency and adjusting the ration,

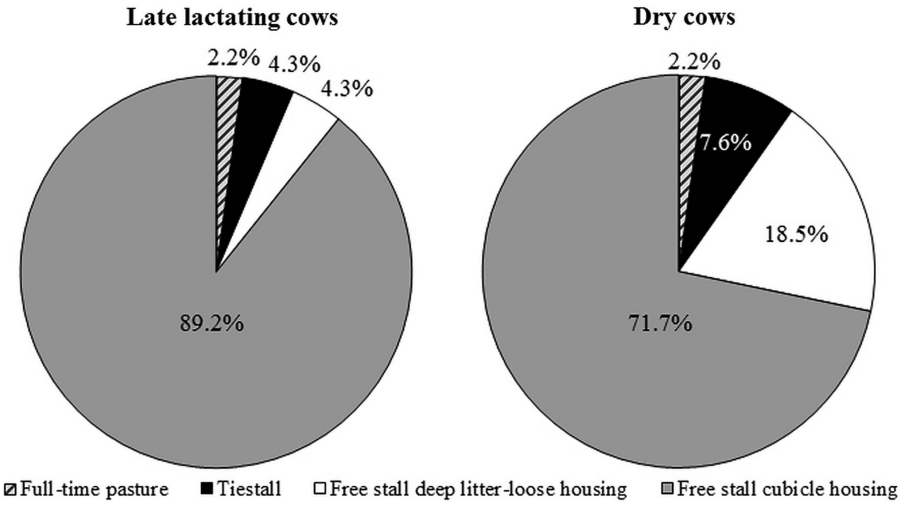

FIG 1: Percentages of responding farm managers to questions related to housing of late lactating and dry cows (n=93)

respectively. While milking intervals were prolonged 2–14 days before drying-off (mean±sd; 6.7 ±4.3 days), changes in the feeding routine were established up to 60 days before drying-off (mean±sd; 22.0 ±18.7 days). Also, 7 out of 89 farmers (7.9 per cent) each reduced the feed quantity and changed the feed composition mostly by reducing concentrate in the mixed ration, respectively. A combination of reduced milking frequency and adjusted ration was described by only 3.3 per cent of the farmers. Furthermore, 4.5 per cent had a separate drying-off preparation group to which the cows were transferred to 14–70 days before drying-off.

Antibiotic dry cow treatment and teat sealant

A blanket antibiotic dry cow treatment was conducted on 79.6 per cent of the farms participating in this survey, whereas a bacteriological examination of milk before drying-off was less common (i.e. 31.0 per cent). Bacteriological examinations of milk samples of all cows before drying-off were conducted on 6.6 per cent of the farms, while 24.4 per cent of the farmers mentioned them for selected cases such as high-yielding cows. A relationship between the use of antibiotics and bacteriological examinations was not found (P=0.31). A total of 64.9 per cent of all antibiotic dry cow treatments were conducted without preceding bacteriological examination. A selective dry cow treatment was not mentioned by any farmer.

An internal teat sealant was used at drying-off by just 33.3 per cent of farmers participating in this survey. While a relationship between performing a bacteriological examination and the decision to use an internal teat sealant could not be shown in this study (P=0.24), farms that used antibiotics were 2.8 times more likely to use an internal teat sealant as well (95% CI 0.998 to 7.876; P=0.05). A total of 22.6 per cent of the farms used a combination of internal teat sealant and antibiotic dry cow treatment, 9.7 per cent did not implement any dry cow treatment at all. Two farmers mentioned the application of homeopathic drugs at the time of drying-off to influence the drying-off procedure.

TABLE 1: Percentages of responding farm managers to questions related to the management of late lactating cows (n=93)

Survey question and answer category	Percentages
What kind of milking system are you using?	
Milking parlour	89.2
Rotary parlour	5.4
Milking robot	3.2
Pipeline milking system	2.2
How often are cows milked per day?	
Once daily	1.1
Twice daily	96.7
Three times daily or more	2.2
What do you feed cows in late lactation?	
Total mixed ration	49.5
Roughage mix+concentrate	50.5
Concentrate per hand	41.1
Concentrate per automat	8.8
Do you feed cows individually according to milk yield?	
Yes	31.2
No	68.8

Management and housing after drying-off

Several changes concerning the housing and management of dairy cows after drying-off were mentioned by the farmers in our survey. After the last milking, most famers transferred cows to a separate dry cow pen (94.1 per cent) and this was often located in a different barn. More dry cows were housed in freestalls with deep bedding compared with late lactating cows. The number of farms keeping dry cows in tie stalls doubled (Fig 1). After drying-off, more cows (45.7 per cent) were provided part-time access to pastures in comparison to late lactating cows (P=0.01). In addition, two farms offered grazing for dry cows during the summer month.

Feed rations were changed at the time of drying-off by the majority of farmers (85.9 per cent). While 76.5 per cent changed their ration to a low-energy-density roughage mix, 9.4 per cent fed a hay or hay-straw-mix after drying-off. Only 7.1 per cent did not change the ration, but reduced the feed quantity. While 7.1 per cent mentioned that cows before and after drying-off received the same ration, only one of them had a ration change before drying-off in order to prepare cows. Eight (8.6 per cent) farmers did not answer this question.

Limited water access for one and three days and a reduction of the daily lighting period for one and four days after drying-off were mentioned by two farmers, respectively.

Deviations from the standard drying-off protocol

In the fourth part of the questionnaire, the farmers were asked under which conditions they alter their drying-off protocols, change the drying-off schedule or even omit the dry period.

One reason for abandoning a drying-off protocol mentioned by participating farmers was low milk yield. Most farmers (77.4 per cent) preponed the drying-off date if milk yield dropped below an individual threshold. This level, however, varied considerably between farms (9.8±3.3 kg). About one-third (35.3 per cent) used 10 kg as a cut-off value. But thresholds below 10 kg milk yield per day (38.2 per cent) and between 10 and 15 kg (26.5 per cent) were mentioned, as well. While an earlier drying-off of low-yielding cows was frequently mentioned, an altered drying-off procedure in high-yielding dairy cows was rare (9.7 per cent). Thresholds for high milk yield were set between 18 and 35 kg per day and changes to the drying-off protocol varied. Strategies mentioned were a reduction of milk yield by feed change or restriction, shortening of the dry period to four weeks or the application of a higher dosage of the intramammary antibiotic dry cow treatment. While on two farms quarters of high-yielding cows were treated with two syringes of antibiotic dry cow treatment, we assume that farmers implementing such practices are not aware of pharmacological (i.e. extended withdrawal time) and legal (i.e. extra label drug use) ramifications.

The second most important factor to adjust the drying-off procedure was udder health. The majority (78.5 per cent) of farmers participating in this survey forewent the drying-off in cows with clinical mastitis. Also, 16.7 per cent even delayed drying-off cows with a case of subclinical mastitis. Interestingly, farmers that conducted a bacteriological examination before drying-off were 5.1 times more likely to consider a subclinical mastitis a reason to adapt the drying-off procedure ($P \leq 0.001$) compared with farmers that did not use bacteriological examinations. Interestingly, farmers that forwent antibiotic dry cow therapy were not more likely to treat subclinical mastitis before drying-off (P=0.31).

The third reason to postpone the drying-off mentioned by farmers participating in this survey was high SCC (20.4 per cent), although thresholds varied considerably between 100,000 and 600,000 cells per ml (296,000±134,000 cells per ml). An association between postponed drying-off due to high SCC and bacteriological examinations before drying-off (P=0.54) or antibiotic dry cow treatment (P=0.27) did not exist.

Dry cow monitoring

All participating farmers monitored their dry cows but the monitoring schedules varied considerably. Most farms (67.7 per cent) implemented a daily dry cow monitoring, 9.7 and 2.2 per cent of the farmers checked their cows once or twice weekly. Only 20.5 per cent of the farms did not regularly implement a dry cow monitoring.

A total of 95.6 per cent of the farmers examined the cows in the dry cow pen. Of these, 68.9 per cent checked their cows while they were free in the pen, on 26.7 per cent of the farms cows were fixed in headlocks or kept in tie stalls, respectively. The milking parlour was mentioned four times (4.4 per cent). The intensity of monitoring, however, differed considerably. A total of 38.2 per cent of the farmers specified that one of their parameters for the dry cow examinations was the general behaviour of the dry cow group (i.e. disproportionate restlessness). Furthermore, 92.1 per cent evaluated the general health status of the cow, for example, body condition score, lameness score and general behaviour. An inspection of the udder (i.e. for swelling and redness) was done by 87.1 per cent of the farmers, while 40.4 per cent especially looked for milk leakage. Only 29.2 per cent of the participating farmers regularly touched the udder and checked for udder pain.

Perception of drying-off related behaviour

Several studies demonstrated that cows suffer stress after drying-off and might show behavioural changes (Leitner and others 2007, Valizaheh and others 2008, Tucker and others 2009, Bertulat and others 2013). Therefore, the last section of our survey aimed at studying farmers' awareness of behaviours indicative of stress and asked to estimate the frequency of those observations. While agitation, reduced feed intake and increased vocalisation were mentioned by nearly all farmers, an increase of aggressive behaviour, increased licking of the udder and waiting in front of the gates to the milking parlour were less frequently seen (Fig 2). Overall, each farmer reported at least one stress-related behaviour.

DISCUSSION

The response rate of the presented survey was relatively high at 49.0 per cent compared with similar questionnaires (Caraviello and others 2006, Heuwieser and others 2010, Gottardo and others 2011) and most probably caused by the presence of one of the authors at the time participating farmers completed the questionnaire (Caraviello and others 2006).

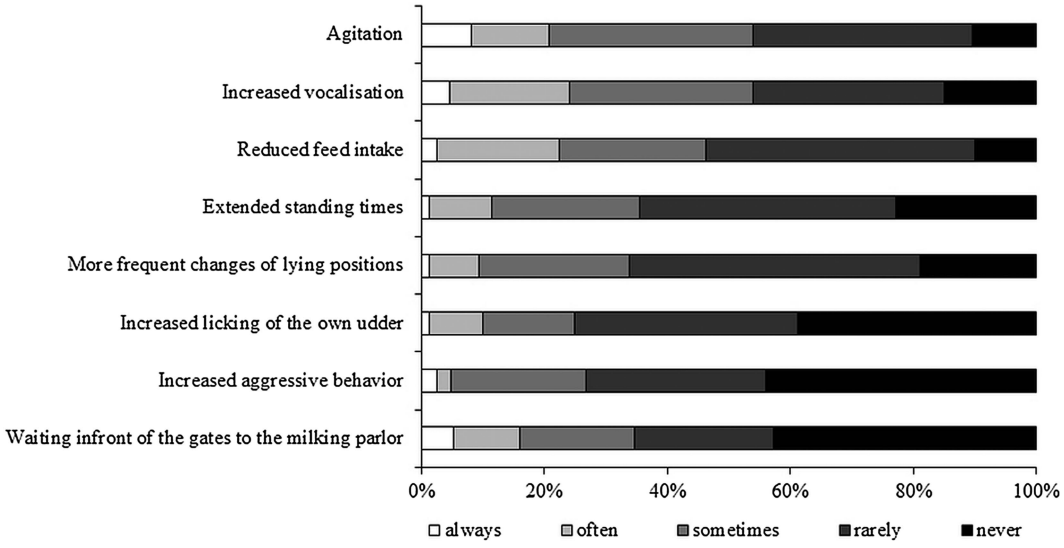

FIG 2: Percentages of responding farm managers to questions related to the perception of the dry-off procedure (n=93)

The response rate for the different blocks of questions (i.e. 87.0–95.7 per cent) was similar to that of a survey on fresh cow management (Heuwieser and others 2010), mentioning that 70–91 per cent of questions were answered depending on the type of questions.

Time of drying-off

The optimal dry period length is a subject of controversial and ongoing discussions. While an optimal lifetime production has been described for a dry period length between 40 and 60 days (Bachman and Schairer 2003, Kuhn and others 2006), most recently Pinedo and others (2011) suggested a dry period length between 53 and 76 days considering udder health and milk yield in the following lactation. Several studies have demonstrated that a shortened dry period of 35–40 days was associated with reduced milk yield in the subsequent lactation (Pezeshki and others 2007, Watters and others 2008), but higher milk persistency (Atashi and others 2013). Prevalence of intramammary infections (Church and others 2008) and postpartum disease (Watters and others 2008) were not affected by a shortened dry period. Completely omitting the dry period also reduced the milk production in the next lactation (Annen and others 2004, Andersen and others 2005, Madsen and others 2008, Schlamberger and others 2010, Steeneveld and others 2013) and affected the colostrum quality (Rastani and others 2005, Caja and others 2006). However, risks for metabolic diseases were reduced (Schlamberger and others 2010) and milk protein increased (Madsen and others 2008, Schlamberger and others 2010). An extended dry period of more than 70 days was shown to have a negative effect on lifetime yield (Kuhn and others 2006), on the calving to conception interval (Pinedo and others 2011) and on the culling rate caused by subclinical mastitis and infertility (Pinedo and others 2011).

Several authors (Kuhn and others 2006, Pezeshki and others 2007) suggested adapted dry period lengths for individual cows. Dry period lengths of 60 days were recommended for cows in first lactation and 35 days for overconditioned cows in second and higher lactation (Pezeshki and others 2007).

All farms participating in this survey, however, implemented a general dry period length for all cows regardless of age averaging 42–49 days before calculated calving date. While that is slightly later than the optimum of 60 days, a negative effect of a shorter dry period is not substantiated by recent publications.

Science-based recommendations for an optimal drying-off schedule, that is, if cows should be dried off in groups weekly, bi-weekly or individual according to their date of insemination, are not available Therefore, the schedules implemented on the farms participating in this survey cannot be interpreted.

Preparation before drying-off

All drying-off management procedures implemented by farmers participating in this survey were shown to have certain advantages but also negative effects on animal welfare or udder health. Besides an abrupt drying-off, various drying-off preparation strategies (i.e. reducing milking frequencies, adjusting feed rations, limiting water supply) have been known for decades (Wayne and others 1933); however, the advantages and disadvantages of reduced milk yield before drying-off and appropriate methods to reduce milk yield are still being debated.

Recent studies have demonstrated that high milk yield at drying-off caused elevated stress levels (Bertulat and others 2013) and increased the odds of environmental intramammary infection after calving (Rajala-Schultz and others 2005) when an abrupt cessation of milking was implemented. Therefore, it is recommended that this procedure should include a consistent monitoring of cows after drying-off, especially of those cows with high milk yield.

Green and others (2007, 2008) published two extensive retrospective record analyses evaluating the effect of milk yield at dry-off on different udder health parameters. Although increased milk yield before drying-off was not identified as a significant risk factor when clinical mastitis was investigated (Green and others 2007), decreasing milk yield by reducing the plane of nutrition before drying-off was associated with lower SCC in the subsequent lactation (Green and others 2008). Tucker and others (2009) compared the effect of feed restriction and reduced milking frequencies on udder health and behaviour aspects in dairy cows before and after drying-off. While milk yield was reduced with both strategies, only the reduction of feed intake was able to reduce milk leakage and the prevalence of intramammary infections after drying-off. Cows treated with a reduced feed allowance, however, vocalised significantly more than control cows without feed restriction. The authors speculated that these cows might suffer from hunger and thus feed restriction may pose an animal welfare concern. A gradual cessation of milking had no effect on milk leakage or behaviour in this study (Tucker and others 2008) while in another trial cows with a gradual drying-off had less milk leakage and spent less time anticipating the milking (Zobel and others 2013). Odensten and others (2005, 2007a, b) compared different feeding strategies in cows prepared for drying-off by a reduction of milking frequencies five days before drying-off. A more drastic feed restriction in the form of a straw diet caused increased cortisol levels, indicating stress, effected non-esterified fatty acid, β-hydroxybutyrate and urea concentrations, but did not improve udder health (Odensten and others 2005, 2007a, b).

According to recent literature, it is important to consider the risks and benefits and customise the drying-off procedure to the farm conditions. The ability to implement various drying-off procedures in a given herd varies depending on the facilities, available labour and management structure of the farm (Dingwell and others 2001).

Antibiotic dry cow treatment and teat sealant

A recent meta-analysis compared the effects of antibiotic and non-antibiotic dry cow treatment (Halasa and others 2009a, b). The authors showed that cows treated with antibiotics had a lower risk (relative risk (RR)=0.61) for new intramammary infections and a higher risk for curing existing intramammary infections (RR=1.78) compared with cows without antibiotic dry cow treatment.

Principles of the prudent and rational use of antimicrobials in animals and guidelines for the antimicrobial use in cattle are well researched (Guardabassi and others 2009). According to the guidelines for the prudent use of antibiotics in veterinary medicine, antibiotic usage should be limited and the susceptibility of pathogens ensured before treatment (Federation of Veterinarians of Europe 1999). In 2012, Teale and Moulin published a review on the existing guidelines where they emphasised that the selection of an antimicrobial should be based especially on previous antimicrobial resistance profiles. Therefore, a blanket dry cow therapy and antibiotic usage without previous bacteriological examination cannot be recommended.

The positive effect of internal teat sealants on the risk of new intramammary infections in the dry period and early lactation has been demonstrated in several studies (Berry and Hillerton 2002, Halasa and others 2009b, Bhutto and others 2011). Huxley and others (2002) demonstrated that an internal teat sealant can significantly reduce the number of new intramammary infections with major pathogens acquired during the dry period compared with an antibiotic dry cow therapy with 250 mg cephalonium (Cepravin Dry Cow) under UK field conditions. Nevertheless, several publications advise exclusive use of internal teat sealants only in cows with low SCC and without subclinical mastitis (Crispie and others 2004, Rabiee and Lean 2013). While only a bacteriological examination of the milk can guarantee that a quarter is not subclinically infected (Crispie and others 2004), a thorough assessment of individual cow SCC data can be used to identify cows likely to be infected at drying-off (Deluyker and others 2005, Bradley and others 2010).

Most studies (Rabiee and Lean 2013) used either a teat sealant or an antibiotic drug at the time of drying-off. But a combination of internal teat sealant and antibiotic dry cow treatment has been demonstrated to lower the prevalence of new intramammary infections and clinical mastitis (Godden and others 2003, Halasa and others 2009b, Runciman and others 2010) and to increase the odds of cure in quarters with subclinical mastitis at drying-off (Newton and others 2008, Bradley and others 2010) in contrast to a single antibiotic dry cow therapy. While a combined treatment with antibiotics and internal teat sealant in all cows is often recommended for an optimal prevention of new intramammary infections during the dry period, Bradley and others (2010) demonstrated that a combined therapy is only suitable for quarters with increased SCC. In the study mentioned above, odds of coliform mastitis in the next lactation increased for uninfected quarters that received antibiotic and internal teat sealant compared with sealant alone (Bradley and others 2010).

An internal teat sealant was only used by 33.3 per cent of the farmers participating in this survey. This is in agreement with previous results describing the usage of milking gloves and teat sealant in Germany (Fischer-Tenhagen and others 2012). The authors demonstrated that 18.7 per cent of German dairy farmers always and 11.0 per cent sometimes used a teat sealant for drying-off, respectively.

Management and housing after drying-off

Similar to ration changes in preparation to the drying-off procedure, feed changes at the time of drying-off are intended to reduce milk yield and milk leakage, prevent

intramammary infections and hasten the mammary involution (Dingwell and others 2004, Odensten and others 2007a, b, Tucker and others 2009). Besides ration changes, the number of farms offering access to pastures for dry cows was considerably higher than those with pasture access for late lactating cows. This management practice has the potential to reduce the prevalence of lameness (Haskell and others 2006) and thus prevent milk production loss (Huxley, 2013). While these management practices have been proven to be beneficial, limited water access and a reduction of the daily lighting period cannot be recommended. The negative effects of those drying-off strategies on health and animal welfare parameters are well documented (Battaglia 1998, Rushen and others 2007, Valizaheh and others 2008).

Deviations from the standard drying-off protocol

While standard operating procedures are useful tools to implement dairy management practices efficiently and consistently, it might be necessary in some instances to deviate from such guidelines and implement adjustments.

One reason to alter the standard drying-off regime is very high or low milk yield. Natzke and others (1975) demonstrated that cows with an average milk yield of less than 4 kg at the time of drying-off were more likely to have new intramammary infections during the dry period. An earlier drying-off might be beneficial in these cows. Negative effects of high milk yield at the time of drying-off are well documented (Huxley and others 2002, Rajala-Schultz and others 2005, Bertulat and others 2013). Management practices to reduce milk yield, however, have negative side effects as well, for example, elevated stress levels (Odensten and others 2007a, b), increased risk for mastitis (Tucker and others 2008, Zobel and others 2013) or pronounced metabolic responses (Odensten and others 2007a, b). A shortening of the dry period could be advantageous but might interfere with the required dry period length for milk withdrawal after antibiotic dry cow treatment. While at least some farmers are aware of the challenge to dry off high-yielding dairy cows, specific science-based recommendations for this subpopulation of cows are not available.

Another factor to adjust for in the drying-off procedure is udder health. Whereas it is obvious that cows with clinical mastitis should not be dried off, several studies proved that the application of an antibiotic dry cow therapy is efficacious to cure subclinical mastitis during the dry period (Hallberg and others 2006, Arruda and others 2013). To achieve adequate cure rates, however, the selection of an effective antibiotic drug considering the guidelines for the prudent use of antibiotics is mandatory (Ungemach and others 2006). Farmers that do not implement a blanket antibiotic dry cow treatment should test cows before drying-off for subclinical mastitis and select cows with a positive bacteriological finding for an antibiotic dry cow therapy (Halasa and others 2009a, Cameron and others 2014). A subclinical mastitis left untreated is likely to become clinical during the dry period and early lactation (Green and others 2002, Arruda and others 2013). Furthermore, cows with subclinical mastitis are at risk to infect other cows during the next lactation and increase the bulk milk SCC (Deluyker and others 2005, Salat and others 2008, Bhutto and others 2012).

An increased SCC is a valid indicator for subclinical mastitis (Bhutto and others 2012, Rajala-Schultz and others 2012) and used in many protocols for selective dry cow therapy instead of bacteriological examinations (Torres and others 2008). While the national mastitis council set a threshold of 200,000 cells per ml as indicative of infections (National Mastitis Council 2001), thresholds between 100,000 and 300,000 cells per ml have been used in previous studies to differentiate infected mammary quarters from uninfected (Deluyker and others 2005, Berry and Meany 2006, Schwarz and others 2010, Malek dos Reis and others 2011).

Dry cow monitoring

During the early dry period, cows are most susceptible to clinical mastitis (Cousins and others 1980, Oliver and Mitchell 1983). Therefore, sufficient monitoring of the cows is important in this period. To the best of our knowledge, there is no study available addressing monitoring of dairy cows after drying-off.

Strengths and limitations of the study

We are well aware that the present study has several limitations that should be considered when interpreting the results. Like most surveys, our study is based on a convenience sample and therefore results are not representative. Similar to Caraviello and others (2006), who questioned farmers participating in a progeny testing programme of Holstein sires, we questioned farmers attending an education event organised by a cattle breeding organisation. The number of participating farms in the current study was limited, but similar to that of Caraviello and others (2006), who evaluated 103 surveys from large US commercial farms. Participating farms were located only in the northern part of Germany. Previous studies, which similar to our survey questioned farmers in a circumcised area, however, had mostly fewer responses. In Pennsylvania, Kehoe and others (2007) and Heinrichs and others (2013) analysed 55 and 44 surveys on colostrum management and on dairy heifer production, respectively. Adams and others (2014) only had a sample size of 20 farms that answered a questionnaire on dairy beef quality assurance in Colorado.

Nevertheless, this is the first survey addressing current drying-off management practices implemented on commercial dairy farms. Except for one publication from the proceedings of a meeting (Dingwell and others 2001), no data are available considering the use of different drying-off strategies. Our study provides a good overview of the most important and most common drying-off procedures used in commercial dairy farms and also considers the rationale of antibiotic dry cow treatment. It was

not the scope of the study, however, to explore the reasoning why farmers use one strategy or another. Information about the nature of the intramammary infection, the specific antibiotic treatment, reinfection and cure rates was not part of this survey because of the complexity of these subjects.

CONCLUSION

This questionnaire was developed in order to gain information on what drying-off procedures are actually implemented on commercial dairy farms. Despite a limited number of participants, the results of this survey provide insight into the drying-off procedures currently applied on commercial dairy farms in northern Germany. We did not include questions about the kind of antibiotics that were used at dry-off or which tests were performed to evaluate udder health at drying-off in order to limit the number of questions to a reasonable level. Information about a preceding bacteriological examination, however, was included because control and restriction of antibiotic usage in dairy cows has been recently discussed. The guidelines for the prudent use of antibiotics in veterinary medicine clearly state that antibiotic usage should be limited and the susceptibility of pathogens ensured before treatment. We wanted to evaluate whether and how often this recommendation was implemented. It was furthermore shown that recommendations made by scientists are recognised by farmers and implemented in the daily routine, including consideration of milk yield before the drying-off procedure and the use of a combination of teat sealant and antibiotic dry cow treatment. However, selective dry cow therapy does not appear to have become a common management tool. Obsolete practices such as the limitation of water access were applied only sporadically. As critical management practices have the potential to influence the perception of the dairy industry by the general public, implementation of research results into daily routines must be improved. Furthermore, future studies should consider relevant issues such as increasing milk yield and antibiotic drug use and provide clear recommendations.

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