Selective dry cow therapy and the influence of milk yield at drying-off under Dutch practical circumstances

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Abstract

Cows need a dry period prior to the next lactation to achieve a maximal milk production in the subsequent lactation. The dry period is also an important period in the udder health status of the cow. The introduction of the antibiotic dry cow therapy (**ADCT**) improved the udder health status since the sixties. Nowadays the use of antibiotics in the livestock industry is criticized due to human and veterinarian antibiotic resistance issues.

One way to reduce the use of antibiotics is to start a selective dry cow therapy (**SDCT**). In this study the use of a SDCT was tested on eight Dutch farms in the province Utrecht. Only 49,5% of the first selected cows passed all the selection criteria. During this study no significant differences between a blanket ADCT and a SDCT were observed. Moreover, no correlation between milk yield prior to drying-off and the first known somatic cell count (**SCC**) after parturition was observed during this study.

Every farmer should consider SDCT instead of blanket ADCT and evaluate this choice periodically. The choice of a SDCT instead of an ADCT should also be made farm-specific. Risk factors in udder health during the dry period should be optimized or be as favorable as possible to achieve the best result.

Introduction

The dry period

The dry period can be divided in three different periods: a period of involution, a steady-state period, in which a keratin plug is formed, and a period of transition. The mammary gland is most susceptible during the first and the last period of the dry period. [1] [2] [3] [4] [5] [6] [7]

Involution of the udder

Directly after cessation of milking a period of involution begins. [8] [9] Involution is a gradual process and one of the most susceptible periods for the mammary gland for obtaining an intramammary infection (**IMI**) [3] [9] [10], as the flushing of bacteria out of the gland by periodical milking and teat dipping stops abruptly. Because of an increased intramammary pressure the streak canal becomes relatively comprised and more susceptible for pathogens to enter the gland. Furthermore leucocyte function isn't optimal due to relative high fat and casein levels. [3] [10] The involution of the udder is completed approximately 30 days after drying-off. [3] [8] The lactation in an involuting udder can be reinitiated after four weeks or more after drying-off. [8]

As the involution period is a susceptible period, it would be preferable to hasten the involution of the udder. Reducing the milk yield before drying-off is usable to hasten involution. [10]

The development of a keratin plug

The keratin plug which is formed in the end of the streak canal acts on different ways to protect the mammary gland against IMI's during the steady-state period. In the first place the keratin plug is a direct physical barrier against pathogens. Next to it esterified and nonesterified fatty acids, like bacteriostatic myristic acid, palmitoleic acid and linoleic acid [11] are present in the keratin plug.

It takes several days for the plug to form and the plug disappears 7 to 10 days before parturition. [10]

Normally the plug is formed within 1 to 2 weeks of the dry period. [2] [12] If the plugs are formed within 6 weeks of the dry period, it is less likely that new IMI's occur. [12]
A quick development of the keratin plug minimizes the risk of a new IMI, because of the different defense-mechanisms of the keratin plug. Obviously a keratin plug isn't formed from one day to the next. Research proved that 10 days after drying-off still 50% of the teats hadn't formed a keratin plug. [7] [10] [12] Six weeks after drying-off this percentage is decreased to 5-20% according to Dingwell et al. [14] or 10% according to Woolford et al. [7] and sixty days after drying off this percentage decreased to 5%. [10] This percentage of 5% is also reported as the percentage of mammary glands that remains open during the dry period. [2] In the knowledge that 97% of the clinical mastitis in the early dry period occurred in glands that hadn't developed a keratin plug, the importance of this plug becomes very clear. [10] No significant differences between the closing of front and rear quarters are observed. [12]
In different studies reasons are indicated for the delayed teat closure or a complete failure of this closure. Slower rates of teat closure are reported in cows with a higher milk yield at drying-off, [2] [10] [13] [14] [15] because the milk accumulation influences the rate of teat closure. [1] [2] A decreased teat end condition is also related to a delayed development of the keratin plug. [2] Besides this, the rate of development is increased by the use of ADCT. This information suggests a role of bacteria in the delayed development of the keratin plug, which is supported by Berry et al.. [5] [10]

Transition of the udder

The transition of the udder starts about two weeks prior to parturition. [2] [3] [8] This period in the dry period of the cow remarks the transition of the involuted gland to a period of colostrogenesis and is initiated hormonally near the end of pregnancy. [3] The mammary gland becomes immunosuppressed and becomes more susceptible to IMI's through different factors. [9] [10] These factors include the breakdown of the keratin plug, the decrease of leucocyte's protection and antibiotic levels that drop below minimum inhibitory concentration (**MIC**) in antibiotic treated cows. [2] [10] IMI's acquired during the transition period are more likely to have a major influence on clinical mastitis during the subsequent lactation than those acquired in the involution period [10] and environmental bacteria are the most problematic pathogens during this period. [2]

The importance of the dry period in relation to udder health status

From an udder health perspective, the goal of the dry period is to have cows starting the new lactation with uninfected mammary glands. [1] [4] [5] [13] [14] The importance of the IMI's acquired during the dry period is underlined by the fact that over 50% of the clinical mastitis during the first 100 days in lactation resulted from infections acquired during the dry period [1] [5] [6] [10] [16] [17] and 52% of the clinical coliform mastitis in the first 100 days of lactation are related to IMI's acquired during the dry period. [18] During the dry period a new IMI is developed in 10-12% of the quarters. [2] [12] [14]
Following estimates of the National Mastitis Council one-third of every dairy cow suffers from mastitis and mastitis is the most devastating disease of adult dairy cows associated with great economic losses. [11] Economic losses through mastitis are the result of a reduced milk production, increased work, treatment costs, non-delivered milk, earlier culling, costs of the veterinarian and lost of milk quality for the dairy industry. [16] The consequent loss of production after an IMI is related to the duration and severity of this infection. [3] [11] Like clinical mastitis reduces the milk yield of a cow, an increased somatic cell count is also associated with a decreased milk production. Next to it the economic impact of IMI's is emphasized by the knowledge that inflammation and infection of the

mammary gland is the most common dairy cow disease worldwide. [17]
The dry period is also important to cure existing infections. Usually at least 80% of the cows with a high SCC at dry-off should be low at calving. [19] When a quarter is infected at drying-off, the risk of being infected at calving is 7,6 times greater. [1]
A relation between teat-end scores and new IMI's during the dry period is reported by different studies. [15] [16] During the dry period a general improvement of teat-end scores is observed [12] and through this way the dry period is indirectly also important in the prevention of mastitis.

The importance of the dry period in relation to milk production

The dry period is a crucial period for the udder health status of the cow. [1] [16] Furthermore cows need a dry period prior to lactation to achieve a maximal milk production in the following lactation. [3] [4] [8] [9] Without a dry period the milk production in the subsequent lactation is reduced by 20%. [8] A dry period of 10 to 40 days results in a significant lower milk production in the subsequent lactation in relation to a dry period of 40 to 60 days, because an adequate proliferation and differentiation of the secretory epithelium of the udder during the dry period is essential for an optimal synthetic and secretory function in the following lactation [3], because old cells do not secrete milk as efficiently or for as long as young cells do [8], and a close relationship between the duration of the dry period and the milk production in the subsequent lactation is described. [3] A dry period of 40 to 60 days is assumed optimal for production in the subsequent lactation. [4] [8] [9]

Dry cow therapy

For a lot of years ADCT was the most common method for drying-off, because ADCT reduces the rate of new IMI's by approximately 80%. [5] Two goals, which are in line with the goals of the dry period, need to be achieved through ADCT, namely elimination of existing infections and prevention of new infections. [2] [10] [17] [18]
The use of an ADCT is often discussed because of the statement that only infected cows must be treated and due to its high costs. [5] [6] [20] Besides this, the social concerns about antibiotic residues in milk and antibiotic resistance are growing. [5] [6] [14] [20] The public acceptance of the usage of antibiotics in the livestock industry is further decreased since a relation between this usage and the resistance of micro-organisms to antibiotics is proved. An association between increased levels of resistance in enteric flora of dairy cows and the use of ADCT is reported. This association is also reported between resistance levels and mastitis-causing organisms. [17] The society has greater acceptance to antibiotic use when it's only used for infected cows and when the antibiotics of use aren't used in human medicine. [6]
The reduction of antibiotic use is also issued by the World Health Organization and in some ways of farming, like organic and biological farming, the use of antibiotics is prohibited. [5] The increasing antibiotic resistance together with economic motivations led to the development of SDCT based on cow characteristics. [21]

Relevance of this study

The aim of this study is to check known risk factors for new IMI's during the dry period under Dutch practical circumstances. In herds with a low risk of acquiring new IMI's during the dry period, the use of SDCT is an alternative to ADCT. In this study the effect of a SDCT on the udder health status of the cow will be investigated. [6] The improvement of the farm's specific management around the dry period can be useful in farms that are used to ADCT as well as SDCT, but also for farmers that want to switch to SDCT to achieve a lower usage of antibiotics. Since a higher milk yield at drying-off is associated with a higher risk of new IMI's and mastitis [10] [15] and a delayed development of the keratin plug [2] [10] [13] [14] [15], the importance of this risk factor will be investigated in this study. On the other hand the study tries to establish cow specific conditions that can be implemented when a farmer uses SDCT. These conditions should be easy and cost-effective. Although it's already described in literature that the optimal decision whether to use SDCT is specific for each farm and should be based on farm-specific characteristics [17], the ultimate goal of this study is to develop a uniform advice for farmers in Utrecht about SDCT and the selection criteria that should be used in cow selection.

Selective dry cow therapy

An alternative method for ADCT is SDCT [6] [17]. The accent of SDCT isn't the prevention of new IMI's, but it focuses on the therapeutic effect (the elimination of existing IMI's). [17] The use of antibiotics in high SCC cows at drying-off or when the risk of new IMI's is high, remains essential to eliminate IMI's. [6] [10] In an ideal situation only infected cows are treated based on the SDCT. [20]
A lot of research about SDCT is finished during the last decennia and these studies proved that a similar amount of new IMI's developed in treated and untreated groups of uninfected cows. Nevertheless the quantity of clinical mastitis was higher in the untreated group in early lactation. In addition it should be mentioned that when infected and uninfected cows are randomly divided in a treated and an untreated group, the untreated group has a higher incidence of new IMI's, although the SCC during the following lactation is significantly lower in the untreated group of low SCC-cows then in the group of treated high SCC-cows. [17] The incidence of IMI's with SDCT (when the cows are selected through the farmer's selection criteria) was higher than with ADCT. Selection at quarter level is more risky than selection at cow level [6] and uninfected quarters in an infected cow are more susceptible than uninfected quarters in an uninfected cow. [6] [20] The explanation for this last finding could be due to an individual cow susceptibility or due to a cross-contamination within the cow. [6]
Out of these studies follows that it's an illusion that the incidence of new IMI's is lower in a group of untreated cows. The prevention of new IMI's could be improved if all infected cows were detected and treated before drying-off. In the study of Robert et al. 57% of the untreated cows became infected during the dry period, which indicated that the selection criteria used by farmers were not accurately enough to detect all infected cows. If all untreated cows were also uninfected, 17% of the new IMI's could have been prevented. [20] The efficiency of a SDCT is determined by good selection criteria. It's quite easy to select cows that should be cured, but it's very difficult to select cows that are at risk of obtaining an IMI so they can be preventively treated. [22]
Halasa et al. investigated the differences between ADCT, SDCT and no antibiotics. A distinction is made in this study between selection and treatment at cow level and selection and treatment at quarter level. In this study they proved that ADCT provided more protection against new IMI's in relation to SDCT [20] [21], but this is only reported with selection and treatment at quarter level. When the selection and treatment isn't made at quarter level but at cow level, this difference isn't significant. [21] Both ADCT and SDCT provide more protection against new IMI's than no antibiotics. [5] [21]
Since there's no appropriate, cheap, sensitive and specific cow-side test that can accurately show which cows are infected, ADCT is still the best method to guarantee the udder health as best as possible. This reason makes clear that a SDCT isn't used widespread [4] [14], despite the growing public concerns.

Risk factors for intramammary infections during the dry period

The literature consulted on IMI's during the dry period mentions different risk factors during the dry period. These risk factors are based on the susceptible periods of the dry period (involution and transition) and consider different points of view, namely quarter level, cow level and farm level. [16] The total susceptibility of a cow to receive new IMI's is the result of a complex interaction between the host, the environment and the pathogens. [10] [12]

At the quarter level the most important risk factor is the condition of the tip of the teat. Lesions or keratinisation of this tip are associated with an increased prevalence of IMI's. [15] [16] In a study of Dingwell et al. 25% of the cows had at least one cracked teat-end during the study. Quarters that had a teat-end crack had a 1.7-time greater risk in relation to the development of new IMI's. [12] The teat-end condition isn't associated with the milk yield of the cow before drying off. [15] The anatomy of the teat canal also plays a role in the susceptibility of the mammary gland to new IMI's during the non-lactating period. [3]

Also, if there's no generation of a keratin plug, the specific quarter is more susceptible for IMI's according to different studies. [10] [12] [13] [16] Other studies however, contradict this observation. [15]

Although the administration of an ADCT intends to improve the udder health, it's a potential risk for the mammary gland as potential IMI-causing pathogens could enter the teat canal when the infusion isn't hygienic. [10] The incidence of new IMI's during the dry period is higher in cows treated with a placebo compared to untreated or treated cows. [6] Using a partial insertion technique could minimize the risks of intramammary infusion of potential IMI-causing pathogens. [10]

An IMI or case of clinical mastitis is more likely to occur when a quarter is already infected at drying-off. [1] [20]

Factors of risk at the cow level contain increased length of the dry period [5] [14] [16] [20], increased length of the preceding lactation [20], age of the cows [2] [11] [14] [16], production of the cows [10] [14] [16], inefficient defense-mechanisms of the mammary gland, present bacteria at the teat end, Friesian breed, udder edema [2] and a previous infection [20] or an subclinical mastitis prior to drying-off [2]. The increased risk by increased length of the dry period could be explained by the biological hypothesis that these cows are exposed to the risk of new IMI's during a prolonged period. [20] The incidence of IMI's is lower just after calving in cows that produced less milk before drying-off than in cows that produced relatively more milk. [1] [4] [15] The increasing incidence of new IMI's during the dry period because of an increasing milk production is caused by environmental pathogens. Infections of staphylococci for example aren't associated with milk yield at dry off. [13]

An association between parity and the development of new IMI's during the dry period exists. When the parity of a cow increases, the incidence of new IMI's also increases. This increase could be related to a decrease in the integrity of the streak canal. [12] [14] An association between parity and increased SCC after calving is also reported. An SCC of more than 199.000 cells/ml in the 60 days before drying-off, increasing milk yield between 0 and 30 days before drying-off and a reduced time interval between calving and measuring SCC are also associated with an increased SCC after calving. [23]

According to Rajala-Schultz et al. even in cows receiving an ADCT an increasing milk yield at dry-off results in an increasing incidence of environmental IMI's at calving. For every 5 kg increase in milk yield at drying-off above the value of 12.5 kg, the incidence of having an IMI caused by environmental organisms increases by 77%. [13] The increase in IMI incidence is 80% according to Newman et al.. [1] An increased milk yield is associated with a greater susceptibility of the mammary

gland in development of IMI's. [1] [12] This association could be related to a delayed development of the keratin plug. [12] Although an increased milk yield before drying-off is associated with an increasing incidence of new IMI's during the dry period, Green et al. doesn't describe the increased milk yield as a risk factor in obtaining clinical mastitis, but this article confirms the association of a reduced SCC after parturition with a milk yield underneath ten kilograms a day. [23]
Leaking of milk may also be a risk factor for mastitis. [1] [2] [4] [10] [12] [13] [14] [15] Leaking of milk can be caused by overfeeding cows before calving, if dry cows are in sight or sound of the milking parlor, if dry cows are in the presence of calves or cows that have recently calved or if cows are giving high milk yields at the moment of dry off. [10] Intermittent milking can also cause milk leakage and, although a protective effect by decreasing the milk yield at drying-off is described, it increases the risk of IMI at calving for uninfected quarters. [1] Increasing intramammary pressure increases the susceptibility of cows for new IMI's. [2] [4] [12] The increasing volume in the udder also leads to lower concentrations of natural protective factors like lactoferrin and immune cells and immune factors. [4] [12]
A study of Robert et al. with cows dried-off with SDCT reported short teats as a risk factor for new IMI's. This risk factor is only described for uninfected cows at dry off. [20] Low teat height above the ground is also associated with a potential risk for clinical or subclinical mastitis after calving. [2]
At the farm level it's important to accommodate the dry cows in a clean, cool and dry environment, [1] [2] [11] [14] [16] reduce stocking density and reduce bacterial contamination of the environment. [23] In contrary to some of these recommendations dry cows are often housed in old and poor maintained buildings or kept on pasture with little attention. [10] When dry cows are housed in a tie-stall barn, the probability for quarters to develop a new IMI during the dry period is significantly increased. [14] Factors which are beneficial for a decreasing risk of mastitis are a good drainage of the dry cow accommodation, use of mattresses on the cubicles and disinfection of the cubicles. An increasing thickness of the litter of the calving box also decreases the risk of mastitis. [2] Good hygienic measures are important during the parturition of the calf. [10]
Although management measures sometimes promote the combined housing of pregnant heifers and dry cows, this would increase the risk of E. Coli mastitis. From the point of view of udder health, it would be better to separate both groups. [2] [10] Concerning the heifers it's also important to avoid intensive concentrate feeding to the heifers and moving the heifers from one place to another at the day of calving. [2]
Some practices related to milking procedures are associated with a lower SCC during lactation. These practices are important in preventing a high SCC and lowering the risk of infection during the dry period. These are the preventive factors mentioned by Dufour et al.: wearing gloves during milking, using automatic take-offs, using post milking teat dipping [4], milking problem cows last, yearly inspection of the milking system and use of a technique to keep cows standing following milking. Other management preventive factors are: use of a freestall system, sand bedding, cleaning the calving pen after each calving, surveillance of dry cow udders for mastitis, use of ADCT, parenteral selenium supplementation (deficiency of selenium could have serious consequences on udder health, because it results in compromised neutrophil function [11]), udder hair management and frequent use of the California Mastitis Test. The same study proved that a significantly higher BMSCC was found in the period after installation of an automatic milking system in Denmark and the Netherlands. This could be a risk factor, although this significant difference isn't found in Germany and France. The BMSCC was significantly lower in farms with an automatic milking system where teats were cleaned more than once, where the floor of the waiting area was cleaned with an

automatic scraper and where additional ventilation was used. [22]
The calving interval is a management factor which could be useful in the prevention of new IMI's during the dry period. A prolonged calving interval reduces milk yield at drying-off, because when a cow is more days in milk, the milk yield will decrease normally. Because of this prolonged calving interval, problems with udder health through a high milk yield at dry off could be prevented. [15] This risk factor contradicts with the risk factors introduced by Robert et al.. They describe a prolonged preceding lactation as a risk factor for new IMI's during the dry period. [20]
Attention should also be given to prevent vitamin [2] [11] [16] and mineral deficiencies and a negative energy balance. [2] [16] Negative energy balance and number of feed spaces per cow have been related to the severity or incidence rate of E. Coli mastitis. [10] These circumstances make the udder more susceptible to this opportunistic environmental bacterium. [18] To prevent a negative energy balance the dry matter intake during the dry period and the transition period should not be restricted, although overfeeding should also be avoided. Monitoring of the feeding efficiency is possible by scoring the body condition periodically. [2]
A lot of risk factors at the farm level could be strongly confounded by the attitude of the manager of the herd. Associations which are observed with lower SCC could be improved thanks to a knowledgeable and motivated herd manager. [22]
The risk factors for obtaining an IMI are listed in table 1.

Reduction of milk yield prior to drying-off

Considering the fact that increased milk yield prior to the dry period is associated with increased risk of obtaining new IMI's during the dry period, attention should be given to management strategies that decrease milk production before drying-off. [14] By reducing the milk yield prior to drying-off the involution of the udder would be hastened. [10] Different methods of drying-off exist in the current management systems and the general advice is to dry off abruptly and avoid intermittent milking. [4]
By intermittent milking, milking once daily is meant for example. Some research has demonstrated that in some cases intermittent milking could decrease the incidence of new IMI's. [1] [10]
Intermittent milking reduces the milk yield to the end of the lactation, results in a more rapid involution and an increase in natural protective factors like Lactoferrin. [1] Oliver et al. described a decline of the milk yield of 23% after the intermittent milking during the last week of lactation and a decline in milk yield of 69,2% in cows milked intermittently and fed only hay in the last week of lactation. [3] Dingwell et al. described a decline of the milk yield of 22% to 47% of total milk yield during the last week of lactation following intermittent milking. Although evidence for the use of intermittent milking at the end of lactation is described, no single recommendation can be made since no univocal protocol about intermittent milking is documented. [4]
Another possibility to reduce the milk yield at drying-off is the suppression of concentrate supplementation. This intervention reduces the milk yield prior to drying-off and the intramammary pressure is reduced similar to intermittent milking. The suppression of concentrate supplementation could be one of the recommendations of a mastitis control plan. [4] [20]
When a quarter is already infected, the protective effect of the reduced milk yield at drying-off is lost. The reduction of milk yield is only relevant for uninfected quarters. [1]

Table 1: Factors influencing the susceptibility obtaining an intramammary infection

Level	Risk factor	Effect	Reference
Quarter level	Teat end lesions	-	15, 16
	Teat end keratinisation	-	15, 16
	Decreased integrity of the teat canal	-	3, 12, 14
	Keratin plug	+	10, 12, 13, 16
	Unhygienic ADCT administration	-	10
	An infection at drying-off	-	1, 20
Cow level	Increased length of the dry period	-	5, 14, 16, 20
	Increased length of the preceding lactation	-	20
	Increasing age of the cow	-	2, 10, 14, 16
	Increased production of the cow	-	10, 14, 16
	Inefficient defense-mechanisms of the mammary gland	-	2
	Present bacteria at the teat end	-	2
	Friesian breed	-	2
	Udder edema	-	2
	Previous infection	-	20
	Subclinical mastitis prior to drying-off	-	2
	Increasing parity	-	12, 14
	Increasing milk yield at dry-off	-	1, 12, 13, 23
	Leaking of milk	-	1, 2, 4, 10, 12, 13, 14, 15
	Overfeed prior to calving	-	10
	Dry cows in sight or sound of the milking parlor	-	10
	Dry cows in the presence of calves	-	10
	Dry cows in the presence of cows that have recently calved	-	10
	Cows dried-off with a high milk yield	-	10
	Short teats	-	20
	Low teat height above the ground	-	2
Farm level	A clean, cool and dry environment for the dry cows	+	1, 2, 10, 14, 16
	Increased stocking density of the dry cows	-	23
	Bacterial contamination of the dry cow environment	-	23
	Dry cows housed in a tie-stall barn	-	14
	Good drainage of the dry cow environment	+	2
	Matresses on the cubicles	+	2
	Disinfection of the cubicles	+	2
	Thick litter in the calving box	+	2
	Good hygienic measurements during parturition	+	10
	Combined housing of pregnant heifers and dry cows	-	2, 10
	Intensive concentrate feeding to the heifers	-	2
	Moving the heifers at the day of calving	-	2
	Milking procedures		
	Wearing gloves	+	4
	Using automatic take-offs	+	4

Post milking teat dipping	+	4
Milking problem cows last	+	22
Yearly inspection of the milking system	+	22
Using a technique to keep cows standing following milking	+	22
Freestall system	+	22
Sand bedding	+	22
Cleaning the calving pen after each calving	+	22
Surveillance of dry cow udders for mastitis	+	22
Antibiotic dry cow therapy	+	22
Parenteral selenium supplementation	+	11, 22
Udder hair management	+	22
Frequent use of the California Mastitis Test	+	22
Automatic milking system		
Clean teats more than once	+	22
Automatic floor scraper in the waiting area	+	22
Additional ventilation	+	22
Decreased calving interval	-	15
Prevent vitamin and mineral deficiencies	+	2, 11, 16
Negative energy balance	-	2, 16
Restricted feed intake in the dry period and transition period	-	2
Overfeeding	-	2
Monitoring the feeding efficiency	+	2
Restricted number of feed spaces	-	10
Knowledgeable and motivated herd manager	+	22

Materials and methods

Inclusion criteria

Herd participation

Eight farmers located in the province Utrecht in the Netherlands participated in this study. These farmers were suggested by their veterinarians as these farmers liked to participate in this study and the BMSCC of the farm was underneath 250.000 cells/ml.
Because of the variation in between the farms there is a realistic section of the farms in Utrecht. Most farmers use a conventional milking system on their farm; only one farmer uses an automatic milking system. The most cows present on the farms were Holstein Friesian cows. One farm shelters also Fleckvieh cows and Holstein Friesian cows inbreeded with Fleckvieh cows.

Cow selection

To participate in this study, the cows were selected on two different ways. The first selection criterion was based on the periodical results of the milk production registration (**MPR**). In these results the SCC of each cow was registered. The SCC is a measure of udder health performance [22] [23] and marketability of the milk. [22] As a condition to participate in the study the last three SCC-results in the MPR of a cow at the moment of drying-off should be 150.000 cells/ml or less.
The second selection criterion was based on the SCC of each quarter at the moment of drying-off. When the selected cow was milked, first the udder was cleaned and then the foremilk was milked out of the quarter and a milk sample of each quarter was taken. During the testing of the samples, the cow is milked normally. When the test results in all quarters had a SCC of 150.000 cells/ml or less, the tested cow can participate in this study.
For testing the SCC of each quarter the Delaval Cell Counter (**DCC**) was used. The DCC is a portable device for counting the SCC in bovine raw milk. Advantages of the DCC are the small amount (60 µL) of milk required and the quick results (about 40 seconds per sample). Because of a good repeatability (0,99, SD = 0,052), recovery rate and potential matrix effects the DCC is a useful tool for identifying the SCC of milk samples and thus grading udder health status as the SCC is an indicator of the cellular (mainly leucocytes) activity of the immune defense of the udder. [24] [25]

Experimental design

Two ways of drying-off were handled in this study. The cows in one group all got ADCT intramammary administered (antibiotic positive) and the cows in the other group didn't got any antibiotics at all (antibiotic negative). The selected cows were randomly selected to one of the two different groups.
After the cow was milked entirely, the teats of the cow were cleaned with an antiseptic alcohol tissue and then the ADCT was applied according to the instructions in the antibiotic positive group. After administration of the antibiotic, the teat was massaged from the tip to the base. At last an external teat spray or dip was administered. The antibiotic negative group was milked entirely and after that the teats were cleaned with an antiseptic alcohol tissue and an external teat spray or dip was administered. In all cases the teat spray or dip, which was used on the specific farm, was used in the study.
Both the antibiotic positive and the antibiotic negative cows were separated from the milk producing cows. The dry cows were housed like the farmer used to house the dry cows. Thanks to this normal housing the normal situation is best approached and the influences of the housing system on the udder health are minimized.

Statistical analysis

The obtained data where stored in a Microsoft Excel database during the study and imported into SPSS Statistics Version 20. The mean SCC before drying-off was compared with the mean of the first SCC directly after the dry period with a paired T-test. An independent samples T-test was used to compare the SCC before drying-off and the SCC after the dry period in order to reveal a difference. At last the Pearson's correlation test was used to observe a correlation between the milk yield prior to drying-off and the first known SCC after the dry period.

Results

Descriptive results

The number of participating cows from each farm ranged from one to nine cows (mean = 5,75; SD = 2,87). To achieve this number of cows an average number of 11,63 (SD = 5,20) cows per farm was tested following the first selection criterion. The percentage of tested cows that could participate in this study ranged from 27,8% to 83,3% with a mean percentage of 49,5% (SD = 20,9). 47 Out of 93 cows (50,5%) didn't pass the second criterion (selection on the quarter SCC with the DCC) and couldn't participate in this study, because one or more of the cow's quarters tested above 150.000 cells/ml. The milk yield at drying-off didn't differ a lot between the participating farms. The milk yield ranged from 6 kg to 21 kg and the mean milk yield of all cows was 14,13 kg (SD = 3,40). The precise distribution of the cows and the milk yield between the participating farms is described in table 2.

Table 2: Descriptive results of the different farms.

Farm:	1	2	3	4	5	6	7	8	Total:	Mean:	SD:
Selected cows:	12	16	3	18	10	13	15	6	93	11,63	5,1
Participating cows:	8	9	1	5	3	9	6	5	46	5,75	2,87
Percentage participating:	66,7	56,3	33,3	27,8	30,0	69,2	40,0	83,3		49,5	20,9
Mean milk yield (kg):	12,23	13,99	12,00	12,80	15,33	15,83	14,33	15,20		14,13	
SD milk yield (kg):	3,89	3,77		3,11	1,53	3,72	2,07	3,42		3,40	

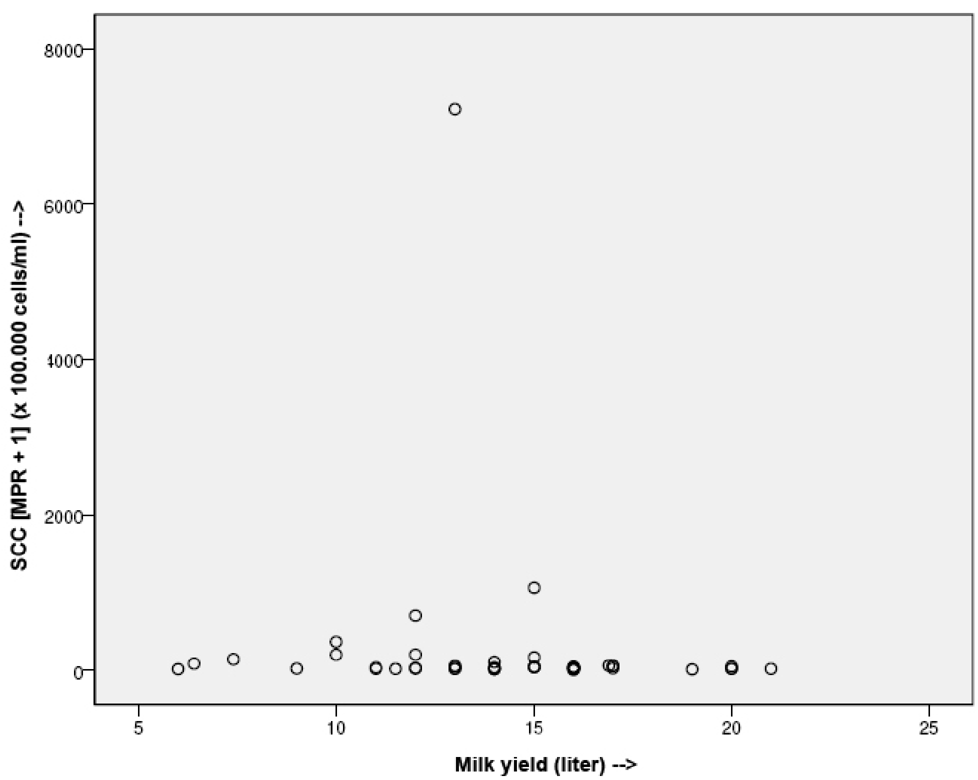
The SCC in the last MPR (**MPR**) before drying-off was compared with the first SCC in the MPR (**MPR+1**) directly after the dry period. Because of this study design, four groups were created. These groups are compared by a paired T-test. The paired T-test revealed a mean SCC of 59,37 (SD = 31,247) and 98,53 (SD = 237,136) of the MPR and MPR +1 respectively in the group with the ADCT. In the group that wasn't treated with antibiotics, the mean SCC was 53,46 (SD = 36,655) and 362,00 (SD = 1407,596) respectively at the moment of MPR and MPR + 1. Both groups show a much greater deviation in the MPR+1-group.

Following the results of an independent samples T-test, no significant difference (P = 0,564) between the SCC of the ADCT-cows and the SDCT-cows was observed before drying-off. Because of the random selection, a difference between these data would be undesirable. The same test was carried out with the data of MPR + 1 and also revealed no significant difference (P = 0,349) between the two groups of cows.

The mean milk yield at drying-off in this study was 14,13 kg (SD = 3,44). The distribution of the first SCC in lactation and the milk yield at drying-off are presented in figure 1. Since there's one erratic result (13; 7.225), this result is withhold in figure 2 to give a better image of the distribution of the

results.
All data of milk yield at drying-off and the SCC of MPR+1 were tested in a Pearson's correlation test, but no correlation (P = 0,628) between these data was observed. Since one observation of the SCC-data of MPR+1 differs a lot from all other data (13; 7.225), this observation was filtered out of the available data. After this filter the correlation between milk yield at drying-off and the first SCC in lactation still wasn't significant (P = 0,371).
The same approach is used to search for a correlation between the milk yield at drying-off and the SCC of MPR + 1 of cows with an ADCT and the group of cows with SDCT. Both groups didn't show a correlation between the mentioned data (P = 0,857 and P = 0,747 respectively) in the Pearson's correlation test.

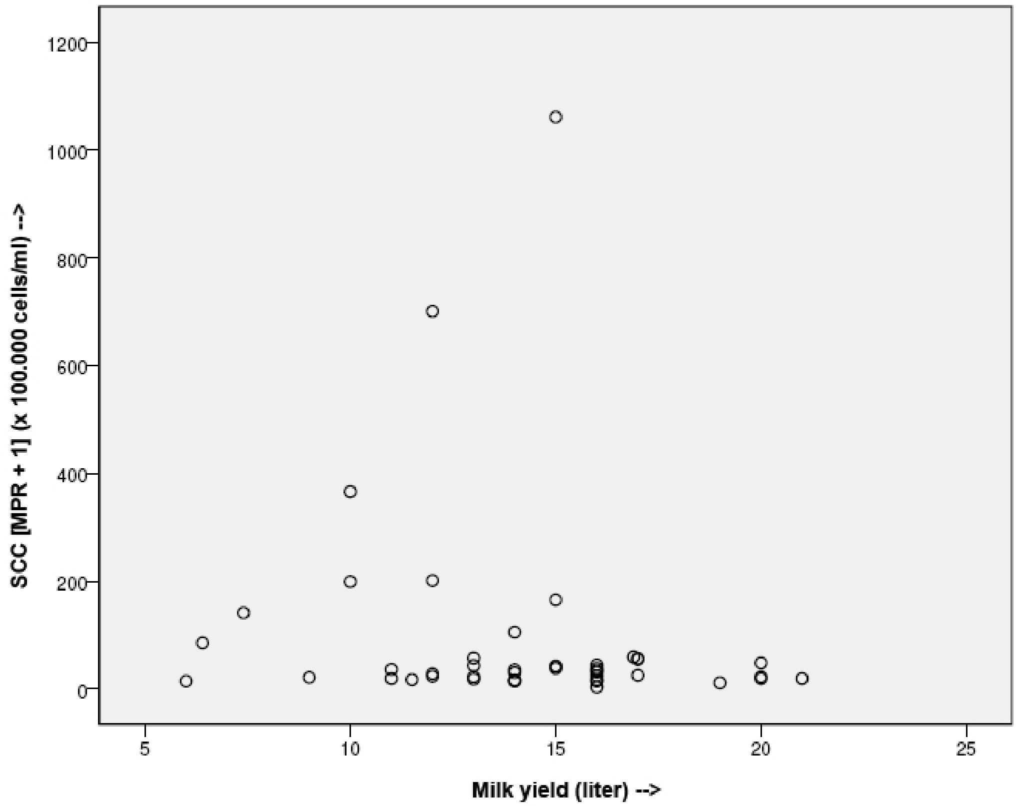
Figure 1: The distribution of the first known SCC in lactation in relation to the milk yield prior to drying-off.



Discussion

The attempt of this study was to find some practical criteria to select cows for a safe SDCT instead of a blanket ADCT. During the duration of this study 93 cows on eight farms were selected through the last three SCC's on the MPR before drying-off. Unfortunately 47 cows didn't pass the second criterion (selection on the quarter SCC with the DCC) and couldn't participate in this study. Knowing this and if we presume that a quarter with a SCC above 150.000 cells/ml is too much at risk obtaining an IMI during the dry period, it's unsafe to select cows for a SDCT when you're taking only the SCC of the last three MPR-results in account. The results would be of great practical interest if it was possible to

Figure 2: The distribution of the first known SCC in lactation in relation to the milk yield prior to drying-off after filtering of one result (13; 7.225).



predict a low SCC of each quarter based on the SCC of the last three MPR-results without the intervention of the DCC. The selection procedure based on the last three MPR-results could then be extrapolated to relatively safe criteria in practice.

Since there's no significant difference between the first known SCC after the dry period of the antibiotic positive and the antibiotic negative group in this study, there's no significant risk in using SDCT instead of ADCT based on our selection criteria. These results suggest a safe usage of SDCT when our selection criteria are used. This outcome should be extrapolated with care since a small sample size is used in this study.

The selection criteria of this study could also be discussed. A lot of different criteria are used in different studies and in the field. These criteria were selected, because they were expected to be safe and prevent significant risks for the farmers that were participating in this study. One of the farmers didn't treat most of the deselected animals with antibiotics and the experiences of this approach were very good. This observation suggests that not only selection criteria are important, but other factors play a role in the udder health during the dry period. Potential risk factors are listed in this article. The importance of these potential risk factors could explain the great distribution in percentages of participating cows between the different farms.

However breed isn't found as an important factor in udder health management, the farmer mentioned above keeps Fleckvieh cows and the breeding organization claims that this breed is characterized by a low SCC, healthy cows and durability. The impact of different breeds on udder

health during the dry period should be further investigated, since the differences in breeds and the available data in this study are insignificant for such investigation.
Because of the growing public concerns about antibiotic usage in the livestock industry and antibiotic resistance, each farmer should make a well-considered decision about SDCT in my opinion. The decision for SDCT should be made farm-specific, because it's described in literature that the optimal decision whether to use SDCT is specific for each farm and should be based on farm-specific characteristics [17] and this observation is confirmed in this study. The decision whether to use SDCT should also be evaluated periodically.
The risk factors should be minimized or be as favorable as possible to obtain the best result. Starting a SDCT with a lot of risk factors could have devastating consequences to the udder health status of the farm without the advantages of the SDCT. On the other hand the potential risk factors for SDCT are dynamically and the farm-specific advice could change from favorable to unfavorable or vice versa all times, which underlines the importance of a periodic evaluation.
Further investigation is necessary to reveal ultimate practical selection criteria and discover the importance of different risk factors in udder health during the dry period. The data in this study were insignificant to give practical advice about uniform practical selection criteria or the absolute importance of milk yield prior to drying-off as a risk factor.
With the available data no significant correlation between milk yield prior to drying-off and udder health is revealed. Maybe there's no correlation between milk yield prior to drying-off and the first known SCC in the subsequent lactation or the data in this study were inadequate to find a significant correlation. In order to describe the importance of this potential risk factor better this study should be repeated with a greater sample size.

Conclusions

On behalf of this study a couple of conclusions can be made. At first, no significant difference between cows dried-off with antibiotics and without antibiotics is found in the first SCC after parturition in this study. Based on this outcome, there would be theoretically no risk in drying-off cows with the same inclusion criteria as those used in this study.
In addition to this outcome, no significant correlation is found between the milk yield at drying-off and the first SCC after parturition. This correlation isn't proved in all data, as well as in the ADCT group as the SDCT group. This outcome suggests that no association between the first SCC after the dry period and the milk yield at drying-off is observed.
Further some risk factors in udder health management are listed in this study. The factors which are important in the prevention of IMI's could be related to management factors during lactation and to a couple of factors on quarter, cow and farm level. The factors which are encountered in different studies are listed in table 1.

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