The impact of adopting non-antibiotic dry-cow therapy on cow performance and udder health

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Abstract

Background: On dairy farms, the prophylactic use of antibiotics at drying-off is being increasingly challenged. The objective of this study was to examine the effect of antibiotic dry-cow therapy (DCT) or non-antibiotic DCT, on dairy cow performance and udder health.

Methods: Holstein cows (n=285) with low risk of intra-mammary infection (<200,000 cells/ml) were assigned to one of two treatments, either antibiotic (A+TS; antibiotic treatment in combination with internal and external teat sealants) or non-antibiotic DCT (TS; internal and external teat sealant only).

Results: There was no statistically significant (P>0.05) difference between treatments for mean cow milk yield, composition or energy corrected milk yield. Mean SCC$\log_e$ (P = 0.047) was 0.16 $\log_e$ higher in the TS treatment (95% confidence interval (CI): -0.00 $\log_e$ to -0.33 $\log_e$) compared to A+TS. A 50% increase in the number of mastitis cases was observed in the A+TS treatment compared to TS (odds ratio (OR) = 1.5, 95% CI:

0.80 % to 3.01 %), although this was not significant. There was no statistical evidence (P>0.05) that treatment had any effect on colostrum quality and composition.

Conclusion: Results indicate that non-antibiotic DCT can be adopted in 'low risk' cows offered grass silage based diets in cubicle accommodation, with low risk of adverse effects on performance or udder health.

Introduction

Globally there is pressure to reduce the use of antimicrobials within livestock systems due to the increasing risk of antimicrobial resistance (AMR) and the subsequent threat to human and animal health [1, 2]. On dairy farms the prophylactic use of antibiotics at drying-off is being increasingly challenged. Correct management of the cow at drying-off is critical as the dry period is key for both the control of existing mammary infection and the prevention of new infections [3]. For this reason, blanket dry-cow therapy (BDCT), namely treating all four quarters of all cows in a herd at drying-off with intra-mammary antibiotics, has been common practice since the 1970's [4], with Biggs [5] reporting that the majority of United Kingdom (UK) dairy farmers continue to adopt BDCT. However, there have been marked improvements in udder health across the UK as evidenced by improvements in the hygienic quality of milk, specifically a reduction in somatic cell counts (SCC). For example, data from National Milk Records indicated a reduction in mean herd bulk tank SCC from 221,000 cells/ml in 2009 to 189,000 cells/ml in 2015 [6], with this likely due in part to initiatives such as the Dairy Mastitis Control Plan [7]. Because of these improvements, the possibility of moving away from BDCT to selective DCT (SDCT), which limits antibiotic treatment at the time

of drying-off to individual cows either with, or at risk, of a subclinical intra-mammary infection, is of increasing interest.

For SDCT to be successful it is important to accurately identify cows or infected quarters that require treatment [8]. Historical mastitis records and milk somatic cell count (SCC) at drying-off are commonly used to identify at risk cows, with an elevated milk SCC (>200,000 cells/ml) strongly suggesting intra-mammary infection [9, 10]. While cows with a milk SCC of <200,000 cells/ml are often considered low risk, there are concerns that these cows may have an increased incidence of new intra-mammary infections during the dry period and early lactation if not treated with antibiotics [11, 12]. However, there is evidence that internal teat sealants alone can be as effective as antibiotic DCT for mastitis control [8, 13, 14]. When used in cows with low SCC, the use of internal teat sealant alone was effective in reducing the incidence of intra-mammary infections and clinical mastitis in the first three months of lactation compared to cows receiving no treatment at drying-off [10, 15].

However, many farmers are hesitant to adopt SDCT due to concerns that any reduction in antimicrobial use at drying-off may result in an increase in mastitis incidence (and therefore increased antimicrobial use) in the subsequent lactation[16]. Within the UK, studies investigating non-antibiotic DCT have often been conducted on herds housed in straw bedding systems and offered diets containing alternative forages (e.g. Berry et al [9]). Straw bedded systems are not common within Northern Ireland (NI), with the majority of cows kept in cubicle housing systems, while grass silage is the predominant forage offered. Therefore, the aim of the current study was to examine the effect of antibiotic or non-antibiotic dry-off treatments, on post-calving milk yield, milk composition, udder health and colostrum quality in dairy cows accommodated in a cubicle house system, and offered grass silage based diets.

Materials and methods

This study was conducted at the Agri-Food and Bioscience Institute (AFBI), Hillsborough, Northern Ireland (NI), and involved the AFBI herd of Holstein-Friesian dairy cows.

Ethical approval

All procedures described in this paper were reviewed and approved by the Animal Welfare Ethical Review Body (AWERB) and conducted under an experimental license granted by the Department of Health, Social Services and Public Safety (DHSSPS) for NI, in accordance with the Animals (Scientific Procedures) Act 1986.

Experimental design

This study was conducted on one research farm between June 2018 and September 2019 (Year One) and between August 2019 and September 2020 (Year Two), and involved 154 cows in Year One and 131 cows in Year Two. A total of 85 cows completed two lactations within the study, while 115 cows completed one lactation within the study. No formal sample size calculation was conducted. All cows within the herd with low risk of intra-mammary infection were selected for enrolment on the study. Cows were considered ‘low risk’ if they had had a SCC of <200,000 cells/ml during each of the three monthly test-day milk recordings prior to drying-off, and had had no recorded cases of clinical mastitis during the three-month period prior to drying-off. These low risk cows were assigned to one of two dry-off treatments, either antibiotic (A+TS; n = 130) or non-antibiotic (TS; n = 155). Cows were dried off in groups weekly. Within each week, cows being dried off were listed in order of freeze

brand number (which reflected lactation number) and every other cow assigned to TS, with the remaining cows assigned to A+TS. In addition, a check was made to ensure that treatment groups remained balanced for mean lactation number, previous 305 day milk production and mean SCC during the three test-day milk recordings prior to drying off by a member of technical staff. Any imbalances were minimised by occasionally reversing the randomisation order. The single operator assigned to drying-off cows was not blinded to animal assignment to ensure correct treatment application.

Drying-off procedure

Cows were dried-off eight weeks before their expected calving date, following morning milking. These cows were milked in a separate batch using an external rotary milking parlour and dried-off while standing on the platform. All drying-off treatments were administered by a single operator wearing disposable gloves which were changed between each cow. On completion of milking, all four teats were dipped, with a pre-dip solution (*BlueMAX Premium, BouMatic, Madison, USA: active ingredient, Chlorine Dioxide)* and each teat-end was wiped with a clean paper towel until visibly clean. Each teat-end was then disinfected with cotton wool soaked in surgical spirit (70% isopropyl alcohol), working front teats to back teats. For cows on the A+TS treatment, each quarter was infused with one antibiotic tube (*Cepravin Dry Cow, MSD Animal Health, Milton Keynes, UK: active ingredient, Cefalonium*), working back teats to front teats. Teats were then disinfected again with surgical spirit as described above. Each quarter was then infused with internal teat sealant (*Orbeseal, Zoetis UK Limited, Surrey, UK: active ingredient, Bismuth Subnitrate)* with the syringe fully inserted into the teat canal for infusion, working back teats to front teats. All teats were then dipped

with an external teat sealant (*T-Hexx Dry-E, Progiene, Staffordshire, UK*). For cows on the TS treatment, preparation was as described above, with each teat then infused with internal teat sealant, and all teats then dipped with external teat sealant, as described above. Any antibiotic tubes or internal teat sealant tubes that were dropped or not correctly inserted into the teat canal on the first attempt were disposed of to minimise contamination. Following the drying-off procedure cows were prevented from lying for 30 mins and were housed away from the milking herd.

Cow management

Cows which were dried-off before September grazed as a single group without concentrate supplementation until three weeks prior to their expected calving date. Cows were then moved indoors to a free stall house, and offered grass silage, supplemented with 100 g/cow/day of a dry-cow mineral, and 75 g/cow/day calcined magnesite, until calving. Cows with drying-off dates during or after September were housed for the duration of the dry period. Cows were moved to a maternity pen bedded with straw 24 to 48 hours prior to their expected calving, as determined by physical observations. Post-calving (within 24 hours) cows were moved back to a free stall house with a solid concrete floor which was scraped every three hours using an automated system. The individual cubicles were fitted with rubber mats which were bedded with sawdust three times per week, and treated with lime twice weekly. The cubicle-to-cow ratio was >1.1 at all times, in line with recommendations of Farm Animal Welfare Council [17]. As this study was conducted at a research facility, cows were allocated to a number of nutritional studies during the subsequent lactation, with these nutritional treatment allocations taking account of the drying-off treatments imposed. None of these nutritional treatments were expected to impact udder health.

147

148 *Cow measures*

149 In addition to the test-day milk sampling described above, on the evening prior to and
150 morning of dry-off, milk samples were taken from each cow, treated with a preservative
151 tablet (lactab Mark III, Thompson and Cooper Ltd., Runcorn, UK), and stored at 4°C
152 until analysed (normally within 48 h). Milk samples were analysed for SCC (cells/ml)
153 using an infrared milk analyser (Milkoscan CombifossTM7; Foss Electric, Hillerød,
154 Denmark), and a weighted concentration determined for the 24 h prior to dry off.
155 Following calving, cows were milked twice daily between 06:00 and 08:00 hours and
156 between 15:00 and 17:00 hours) using a 50-point rotary milking parlour (*Boumatic,*
157 *Madison, USA*). Milk yields were recorded at each milking and a mean daily milk yield
158 calculated for each cow over the first 150 days of lactation. As part of normal test-day
159 milk recording, samples were taken from each cow on a monthly basis during the first
160 five months post-calving. A 'bulked' milk sample (in proportion to yield) was collected
161 during two consecutive milkings. Milk samples were then stored at 4°C until analysed
162 for fat, protein and lactose content, and for SCC using a CombiScop FTIR 600 HP
163 *(Perkin Elmer, Massachusetts, USA*). All cases of clinical mastitis were recorded
164 during the first 150 days-in-milk (DIM) by trained staff, based on observed changes in
165 the cow, udder and milk. In Year Two, a colostrum sample was collected from each
166 cow within two hours of calving, with 2 x 30 ml colostrum samples stored at -20°C until
167 analysis. One sample was analysed for fat protein and lactose content using a FOSS
168 NIR Systems Model 6500-M *(FOSS analytics, Hillerød, Denmark*), while the second
169 sample was analysed for Immunoglobulin G (IgG) concentration using an ELISA kit
170 for bovine IgG (*Bio-X Diagnostics*, *Rochefort, Belgium*) as per the manufacturer
171 instructions.

Statistical analysis

Previous lactation variables (305 day milk yields and milk compositions) and dry period length and calving interval were analysed using linear mixed model methodology using REML estimation with cow as the random effect and treatment as the fixed effect. In the experimental study mean daily milk yield, milk composition (fat, protein and SCC), and energy corrected milk (ECM) were analysed using linear mixed model methodology using REML estimation. Previous lactation 305 day milk yield, 305 day fat % and 305 day protein % were included as covariates for the corresponding variables. Monthly milk $SCC\log_e$ over the first five months post-calving were analysed using REML analysis, with month included as the repeated measure and fixed effect in the model. Mastitis incidence for each cow was converted to a binary variable (0/1) where any incidence greater than zero was coded as one, and analysed using generalised linear mixed model methodology using binomial distribution and logit function. In each of these analysis cow was included as random effect, and year and treatment included as fixed effects. After fitting the models the predicted difference between treatments, or odds ratio (OR) in the case of mastitis, were calculated together with 95% confidence intervals (CI). Colostrum composition and IgG concentration were analysed using linear mixed model methodology using REML estimation, with cow included as a random effect and treatment included as a fixed effect in the model. Where possible model validation was carried out using graphical inspection of the appropriate residual plots. All data were analysed using GenStat 20th Edition (*VSN International Limited, Oxford UK*).

Results

The cows within this study were selected from within a research herd comprising of approximately 300 milking animals (mean parity 3.4 and mean calving interval 373 days) over the two year experimental period. Mean 305 day yield within the herd over the experimental period was 8,958 kg with mean bulk tank SCC of 112,000 cells/ml.

There was no significant difference identified between treatments in 305 day cumulative milk yield, milk fat and protein content, or SCC during the previous lactation (Table 1). Dry period length and calving interval were not significantly different between treatments (Table 1). During the experimental period, there was no statistically significant difference between A+TS and TS for average monthly milk fat content (mean difference: -0.01 %; 95% CI: -0.11 to 0.09 %), and average monthly milk protein content (mean difference: 0.01 %; 95% CI: -0.03 to 0.05 %) during the five month period post calving ($P > 0.05$: Table 2). Mean difference in daily milk yield between the treatments was 0.78 kg (95% CI: -0.14 to 1.70 kg), with TS cows having a lower milk yield. When converted to an ECM yield basis the difference in yield between treatments was 0.60 kg of milk (95% CI: -0.33 to 2.13 kg). Cows dried off with antibiotics had a lower mean milk SCC (81,000 vs. 84,000 cells/ml) during the first five monthly milk recordings post-calving compared to those dried off without antibiotics (Table 2). When mean SCC was expressed as $SCC\log_e$, TS cows had a greater SCC (0.16 $\log_e$) than A+TS cows ($P = 0.047$; 95% CI: -0.00 $\log_e$ to -0.33 $\log_e$, Table 2). When monthly $SCC\log_e$ was examined (Figure 1), during the first month following calving the milk $SCC\log_e$ of TS cows was greater by 0.40 $\log_e$ ($P = 0.001$; 95% CI: -0.16 to -0.63) than A+TS cows. However, there was no difference between treatment groups during any of months two to five. The odds of A+TS cows developing mastitis at least once during the first 150 days of the subsequent lactation was not significantly

222 different, although the risk was 1.5 times the odds of TS cows (95% CI: 0.80 to 3.01;
223 P = 0.198).
224
225 There was a high proportion of dry period protection for both TS and A+TS cows (93%
226 and 97%, respectively; Table 3). Despite having a SCC of <200, 000 cells/ml during
227 the three test-day milk recordings prior to dry-off, a small proportion of cows (7% and
228 3% for TS and A+TS, respectively) had a SCC of >200,000 cells/ml in the dry-off milk
229 sample. Of these cows with infection, the cure rate was 30% and 25% for TS and
230 A+TS, respectively; Table 3). In Year Two, there was no statistical evidence in this
231 study that drying-off treatment influenced colostrum composition (fat, protein, lactose
232 content) or immunoglobulin G concentration (P>0.05: Table 4).
233
234 **Discussion**
235 The purpose of the current research was to allay the concerns of local farmers by
236 examining if SDCT could be adopted with minimum adverse effects on cow health and
237 performance. Similar concerns to those reported by Orpin[16] have been raised by local
238 producers, namely the concerns of higher cell counts and subsequent financial
239 penalties, greater risk of mastitis in the next lactation, and even cow mortality. A recent
240 farmer survey undertaken within NI, indicated that over 30% of farmers who had
241 already adopted SDCT were concerned that SDCT may have increased mastitis
242 incidents and SCC within the herd; however less than 10% of farmers where likely to
243 discontinue SDCT (Lavery et al., unpublished data). This may indicate that farmers
244 will tolerate a certain level of increased mastitis and SCC when implementing SDCT.
245 While SDCT has been adopted on many farms in Europe, housing systems in Northern
246 Ireland (cubicle houses with either slatted passageways or slurry scraping systems)

and diets offered (predominantly based on wet grass silage) are perceived by local dairy farmers to pose a particular challenge to udder health. This study was undertaken on a single research farm to ensure that best practice in terms of dry-off protocols and dry cow management was followed.

While actual SCC values were similar (84,000 and 81,000 cells/ml for TS and A+TS, respectively), mean data over the first five months of lactation indicated a higher SCC $\log_e$ in milk of cows treated with TS compared to A+TS. Similarly, over three research farms, McParland et al.[18] reported low SCC cows treated with antibiotic and internal teat sealant maintained significantly lower test day somatic cell scores throughout lactation compared to low SCC cows treated with internal teat sealant only (60,483 and 80,990 cells/ml, respectively). In an on-farm study Rajala-Schultz et al.[19] also found that low SCC cows that received antibiotic DCT had a significantly lower SCC than untreated low SCC cows (approximately 35,000 cells/ml lower), although the authors highlighted this effect varied from herd to herd. In both these studies the difference in SCC between the antibiotic treated and non-antibiotic treated groups was considerably greater than in the current study, which may reflect the use of a single herd with a single trained operator administering the treatments in the current study. Within this study the difference in mean milk SCC$\log_e$ was driven by higher SCC within the TS treatment during the first month post-calving. This might be due to cows treated with antibiotics benefiting from the antibiotic application despite their low levels of SCC, or alternatively the increase in SCC could be attributed to the dilution/concentration effect. As per Boland et al.,[20] when the mean SCC for TS cows, who produced less milk (1.5kg per day) was divided by the mean SCC for A+TS cows the estimate was greater than 1 (1.04) which may indicate a small

dilution/concentration effect. Despite the increase in SCC in the TS group, the cows in the A+TS group had a numerically increased risk of experiencing a case of mastitis in the subsequent lactation (95% CI: 0.80 to 3.01). However, this was not statistically significant – likely due to the low numbers of cows experiencing a case of mastitis (17 cows out of 155 in TS and 24 cows out of 130 in A+TS). Huxley et al. [8], also reported no significant difference in intra-mammary infections in the first 100 days of lactation of low risk cows treated with either teat sealant only or Conventional DCT (10.5% and 12.8%, respectively). In the current study bacterial pathogens were not investigated, but as SCC was not different between months two and five, non-antibiotic DCT was not determined to increase the risk of subclinical infection compared to the antibiotic DCT group.

This study contains important findings that should help reduce farmer concerns about the adoption of SDCT when conducted properly under the correct conditions. For example, the research herd where the study was undertaken had a mean bulk-tank SCC of 112, 000 cells/ml during the two year period over which the study was conducted, indicating a good overall level of udder health, meeting both the prerequisite suggested by Ruegg[21] (<250,000 cells/ml) and the criteria adopted locally (<200,000 cells/ml) for a herd to adopt SDCT. For individual cows, previous research has documented that a SCC ≥200,000 cells/ml in the last 90 days before drying-off is associated with increased incidence of clinical mastitis post-calving [22], while a number of authors have suggested that to improve the effectiveness of selection criteria for the adoption of SDCT, milk SCC should be considered alongside health data such as mastitis incidence [23, 24]. In this study, selection criteria for individual cows was broadly in line with Ruegg[21], who suggested that the cow-level milk SCC should be <200,000

297 cells/ml, with no cases of mastitis in the last three months prior to dry-off, and that all
298 quarters should have a California milk test score <2. While it is acknowledged that
299 selection thresholds for SDCT should be herd specific, the selection criteria used in
300 this study is similar to the protocol used within the wider European dairy industry [25].
301
302 While this paper only presents the results for low risk cows, 30% of the cows in the
303 research herd were considered high risk on the basis of SCC or mastitis incidence
304 during the three month period prior to drying off. These cows were found to have a
305 higher lactation number (4.0, s.d. 1.4) compared to the low risk group and had a
306 greater SCC (285,000 cells/ml) and a greater incidence of mastitis (39%) during the
307 five months post calving. This is unsurprising as previous research shows that older
308 cows are more likely to have mastitis [26,] and that higher parity is a potential risk factor
309 for new dry period infections [27]. With uninfected cows, milk SCC can also increase
310 slightly with parity [28] likely due to higher yields and incomplete teat closure [29]. In
311 addition, dairy cattle breeding programmes have continued to work towards genetic
312 progress, for mastitis resistance, and as such older cows that remain in the herd may
313 be more genetically prone to high milk SCC than younger cows.
314
315 In the present study, cows that were managed on the TS treatment produced 0.8 kg
316 less milk than those managed on the A+TS treatment (95% CI: -0.14 to 1.70 kg)
317 although this difference was not significant (P = 0.097). Wittek et al. [30] reported that
318 cows treated with antibiotics at drying-off produced 91 kg more milk in the subsequent
319 lactation than cows dried-off without antibiotics. This is in contrast to McParland et al.[18]
320 who found that cows treated with antibiotics and internal teat sealant at drying-off had
321 a lower daily milk yield in the subsequent lactation (0.67 kg per day less milk)

compared to cows treated with an internal teat sealant alone. However, other studies have shown no difference in milk yield when cows were managed on either antibioitic or non-antibiotic DCT[19, 31]. It is possible that these conflicting findings can be attributed to differences in pathogens involved, the antibiotic treatment applied and subclinical mastitis rates of the herds involved [18].

In the current study there was no association between drying-off treatment and milk fat and protein percentage during the first five months post-calving. Similarly, McParland et al.[18] reported drying-off treatment (antibiotic and internal teat sealant or teat sealant alone) to have no effect on milk composition (milk fat and protein %) during a full lactation period. The absences of an effect on milk composition is likely due to the lack of, or limited effect of drying-off treatment on milk yield. However to-date, relatively few studies have examined the effect of drying off treatment on milk composition in the subsequent lactation.

Furthermore, there was no association between drying-off treatment and colostrum quality, with colostrum fat, protein and lactose content similar to values presented in the literature [32]. Furthermore, average colostrum IgG concentrations were unaffected by treatment (between 123 and 131 g/L across the treatment groups), with good quality bovine colostrum considered to have an IgG concentration of >50 g/L [33]. Although a number of factors influence colostrum quality, previous research has suggested that colostrum from cows with mastitis may differ in quality from that from uninfected cows [34, 35]. Lack of treatment effect on colostrum quality in this study is not unsurprising as less than 5% of cows in either treatment groups were considered to have a dry period mammary infection, as indicated by a SCC of > 200,000 cells/ml at

the first test-day milk recording post-calving. Thus the findings from this study suggest that drying-off 'low risk' cows without antibiotics will not negatively impact the nutritional and immunological quality of colostrum produced.

Conclusions

The results of this study, which involved cows housed in a cubicle house and offered grass silage based diets, indicate that non-antibiotic DCT can be adopted with cows deemed to have low risk for intra-mammary infections, with no negative implications for performance or udder health during the subsequent lactation. Indeed, targeting low risk cows for non-antibiotic DCT will allow farms to reduce antibiotic use and farmers to gain confidence in drying cows off without antibiotics. In conclusion, non-antibiotic DCT provides an opportunity for the dairy industry to dramatically reduce intra-mammary antimicrobial use.

Acknowledgments

The authors thank the staff of the Dairy Unit at AFBI Hillsborough for care of experimental animals and conducting measurements, and the staff of the Virology branch at AFBI Veterinary Science Division for conducting colostrum IgG analysis. This project was carried out in partnership with Animal Health and Welfare NI, Livestock and Meat Commission and Farm Vet Systems as part of the Strategic antimicrobial use in beef, lamb and dairy production (STAMP) project.

Funding

This work was co-funded by the Department of Agriculture, Environment and Rural Affairs (DAERA) and AgriSearch through the Research Challenge Fund (RCF).

Competing interests

The authors declare no conflicts of interest.

Data availability statement

Datasets generated and analysed as part of this study are available upon request from the authors.

Author contributions

Anna Lavery: Data curation, Investigation, Writing – original draft, **Aimee-Louise Craig:** Investigation, Writing – Review and Editing, **Alan Gordon**: Formal analysis **Conrad Ferris**: Visualization, Conceptualization, Methodology, Supervision, Project administration, Funding acquisition.

References

1. WHO. Global action plan on antimicrobial resistance. WHO Geneva; 2015.
2. O'Neill J. Tackling drug-resistant infections globally: final report and recommendations. 2016.
3. Bradley A, Green M. A study of the incidence and significance of intramammary enterobacterial infections acquired during the dry period. Journal of dairy science. 2000;83(9):1957-65.
4. Dodd F, Westgarth D, Neave F, Kingwill R. Mastitis—the strategy of control. Journal of Dairy Science. 1969;52(5):689-95.
5. Biggs, A. Update on dry cow therapy 1. antibiotic v non-antibiotic approaches. In Practice. 2017; 39 (7):328-332.
6. CHAWG. Third Report GB Cattle Health & Welfare Group 2016.
7. AHDB. Dairy Mastitis Control Plan 2021. [Online]. Available from: https://ahdb.org.uk/mastitis-control-plan [Accessed 17th May 2021].
8. Huxley J, Green M, Green L, Bradley A. Evaluation of the efficacy of an internal teat sealer during the dry period. Journal of Dairy Science. 2002;85(3):551-61.
9. Berry E, Hillerton J. The effect of selective dry cow treatment on new intramammary infections. Journal of Dairy Science. 2002;85(1):112-21.
10. Berry E, Hillerton J. The effect of an intramammary teat seal on new intramammary infections. Journal of Dairy Science. 2002;85(10):2512-20.

11. McDougall S. A randomised, non-inferiority trial of a new cephalonium dry-cow therapy. N Z Vet J. 2010;58(1):45-58.

12. Scherpenzeel C, Den Uijl I, van Schaik G, Riekerink RO, Keurentjes J, Lam T. Evaluation of the use of dry cow antibiotics in low somatic cell count cows. Journal of Dairy Science. 2014;97(6):3606-14.

13. Woolford MW, Williamson JH, Day AM, Copeman PJA. The prophylactic effect of a teat sealer on bovine mastitis during the dry period and the following lactation. N Z Vet J. 1998;46(1):12-+.

14. Rabiee AR and Lean IJ. The effect of internal teat sealant products (Teatseal and Orbeseal) on intramammary infection, clinical mastitis, and somatic cell counts in lactating dairy cows: A meta-analysis. Journal of Dairy Science. 2013:96(11):6915-6931.

15. Compton CWR, Emslie FR, McDougall S. Randomised controlled trials demonstrate efficacy of a novel internal teat sealant to prevent new intramammary infections in dairy cows and heifers. N Z Vet J. 2014;62(5):258-66.

16. Orpin, P. What can we learn from farmers experiences and attitudes to Selective Dry Cow Therapy? Cattle Practice, 2017; 25 (3): 130-139.

17. FAWC. Report on the welfare of dairy cattle. . Surbiton, Surrey, UK: Ministry of Agriculture, Fisheries and Food 1997.

18. McParland S, Dillon P, Flynn J, Ryan N, Arkins S, Kennedy A. Effect of using internal teat sealant with or without antibiotic therapy at dry-off on subsequent

somatic cell count and milk production. Journal of dairy science. 2019;102(5):4464-75.

19. Rajala-Schultz PJ, Torres AH, DeGraves FJ. Milk yield and somatic cell count during the following lactation after selective treatment of cows at dry-off. The Journal of dairy research. 2011;78(4):489.

20. Boland F, O'Grady L, More SJ. Investigating a dilution effect between somatic cell count and milk yield and estimating milk production losses in Irish dairy cattle. Journal of Dairy Science. 2013; 96:1477-1484.

21. Ruegg P. Selecting herds and cows for selective dry cow therapy. [Video]. 2016. Available from: https://www.youtube.com/watch?v=997GZFWwJ0A [Accessed 16th July 2021].

22. 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. Journal of dairy science. 2007;90(8):3764-76.

23. Golder H, Hodge A, Lean I. Effects of antibiotic dry-cow therapy and internal teat sealant on milk somatic cell counts and clinical and subclinical mastitis in early lactation. Journal of dairy science. 2016;99(9):7370-80.

24. Torres AH, Rajala-Schultz PJ, DeGraves FJ, Hoblet KH. Using dairy herd improvement records and clinical mastitis history to identify subclinical mastitis infections at dry-off. The Journal of dairy research. 2008;75(2):240.

25. Bradley A, De Vliegher S, Farre M, Jimenez LM, Peters T, Schmitt-van de Leemput E, et al. Pan-European agreement on dry cow therapy. Veterinary Record. 2018;182(22):637-.

26. Dohoo IR, Meek A, Martin S, Barnum D. Use of total and differential somatic cell counts from composite milk samples to detect mastitis in individual cows. Canadian Journal of Comparative Medicine. 1981;45(1):8.

27. Dingwell R, Leslie K, Schukken Y, Sargeant J, Timms L, Duffield T, et al. Association of cow and quarter-level factors at drying-off with new intramammary infections during the dry period. Preventive veterinary medicine. 2004;63(1-2):75-89.

28. Natzke R, Everett R, Postle D. Normal milk somatic cell counts. Journal of Milk and Food Technology. 1972;35(5):261-3.

29. Niemi R, Hovinen M, Vilar M, Simojoki H, Rajala-Schultz P. Dry cow therapy and early lactation udder health problems—Associations and risk factors. Preventive Veterinary Medicine. 2021;188:105268.

30. Wittek T, Tichy A, Grassauer B, Egger-Danner C. Retrospective analysis of Austrian health recording data of antibiotic or nonantibiotic dry-off treatment on milk yield, somatic cell count, and frequency of mastitis in subsequent lactation. Journal of dairy science. 2018;101(2):1456-63.

31. Vasquez A, Nydam D, Foditsch C, Wieland M, Lynch R, Eicker S, et al. Use of a culture-independent on-farm algorithm to guide the use of selective dry-cow antibiotic therapy. Journal of dairy science. 2018;101(6):5345-61.

32. Puppel K, Gołębiewski M, Grodkowski G, Slósarz J, Kunowska-Slósarz M, Solarczyk P, et al. Composition and factors affecting quality of bovine colostrum: a review. Animals. 2019;9(12):1070.

33. McGuirk SM, Collins M. Managing the production, storage, and delivery of colostrum. Veterinary Clinics: Food Animal Practice. 2004;20(3):593-603.

34. Maunsell F, Morin D, Constable P, Hurley W, McCoy G, Kakoma I, et al. Effects of mastitis on the volume and composition of colostrum produced by Holstein cows. Journal of Dairy Science. 1998;81(5):1291-9.

35. Ferdowsi Nia E, Nikkhah A, Rahmani H, Alikhani M, Mohammad Alipour M, Ghorbani G. Increased colostral somatic cell counts reduce pre-weaning calf immunity, health and growth. Journal of animal physiology and animal nutrition. 2010;94(5):628-34.

36. Muñoz C, Hube S, Morales JM, Yan T, Ungerfeld EM. Effects of concentrate supplementation on enteric methane emissions and milk production of grazing dairy cows. Livestock Science. 2015;175:37–46.

488 **Table 1**. Average performance of experimental cows in the lactation previous to being
489 subjected to either non-antibiotic DCT (teat sealants only) or antibiotic DCT.

	Non-antibiotic DCT (TS)	Antibiotic DCT (A+TS)	SED	P-value
Previous lactation performance				
305 day milk yield	8,291	8,282	291.1	0.980
305 day fat %	4.04	4.15	0.071	0.137
305 day protein %	3.38	3.42	0.033	0.278
305 day SCC ('000 cells/ml)	67	60	-	-
Dry period length (days)	58	59	1.65	0.360
Calving interval (days)	365	365	5.47	0.947

490

491 **Table 2**. Mean daily milk yield (kg/day), during the first 150 days of lactation, mean
492 monthly milk composition (%), somatic cell count (SCC, '000 cells/ml) and energy
493 corrected milk yield (kg/day) during the first five test-day milk recordings post-calving
494 for 'low risk' cows subject to either non-antibiotic DCT (teat sealants only) or antibiotic
495 DCT.

	Non-antibiotic DCT (TS)	Antibiotic DCT (A+TS)	SED	P-value
Lactation no.	3.1	3.0	0.21	0.520
Milk yield (kg/day)	38.0	38.8	0.47	0.097
Fat (%)	3.93	3.92	0.039	0.832
Protein (%)	3.35	3.36	0.018	0.630
Energy corrected milk yield (kg)[1]	38.7	39.3	0.44	0.132
SCC ('000 cells/ml)	84	81	-	-
$SCC\log_e$ ('000 cells/ml)	3.78	3.61	0.083	0.047

496 *[1] ECM = ((0.0376×Fat + 0.0209×Protein + 0.948)× Milk Yield)/3.1; Munoz et al.[36]*

Table 3. Number and percentage of cows on each treatment considered to have dry period protection or infection and rate of cure, as indicated by milk SCC at point of dry-off and the first test-day milk recording, post-calving.

	Non-antibiotic DCT (TS)	Antibiotic DCT (A+TS)
Cows with complete data*	150	128
Of which had no infection[1]	$140/150$ (93%)	$124/150$ (97%)
Of which were infected[2]	$10/150$ (7%)	$4/150$ (3%)
Of which cured[3]	$3/10$ (30%)	$1/4$ (25%)
Of which did not cure[4]	$6/10$ (60%)	$3/4$ (75%)

*A small number of cows missed samples at first-test day recording post-calving; TS n = 5 cows, A+TS n = 2 cows.

[1] As indicated by a milk SCC of ≤200,000 cell/ml at final sample prior to drying-off and ≤200,000 cells/ml at the first test-day milk recording post-calving.

[2] As indicated by a milk SCC of >200,000 cell/ml at final sample prior to drying-off.

[3] As indicated by a milk SCC of >200,000 cell/ml at final sample prior to drying-off and <200,000 cells/ml at the first test-day milk recording post-calving.

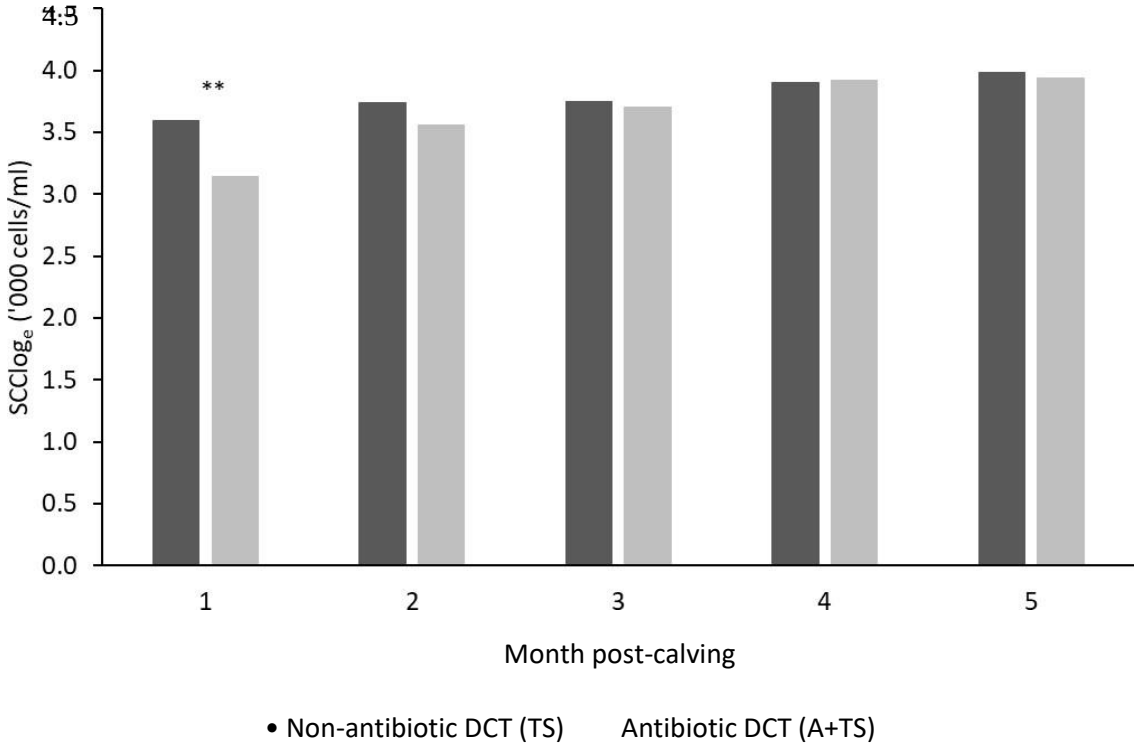
[4] As indicated by a milk SCC of >200,000 cell/ml at final sample prior to drying-off and >200,000 cells/ml at the first test-day milk recording post-calving.

509 **Table 4.** Mean fat, protein and lactose content (%) and immunoglobulin G (IgG)
510 concentration (mg/ml) of colostrum samples collected in year 2 for 'low risk' cows
511 subject to either non-antibiotic DCT (teat sealants only) or antibiotic DCT.

	Non-antibiotic DCT (TS)	Antibiotic DCT (A+TS)	SED	P-value
Fat (%)	5.75	5.55	0.481	0.679
Protein (%)	17.15	17.53	0.645	0.551
Lactose (%)	2.37	2.31	0.084	0.522
IgG (mg/ml)	123.3	131.1	7.096	0.272

512

513 **Figure 1.** Milk somatic cell count (SCC) expressed as $\log_e$ ('000 cells/ml) over the first
514 five test-day milk recordings for 'for 'low risk' cows subject to either non-antibiotic DCT
515 (teat sealants only) or antibiotic DCT. Statistical differences are noted as follows, * =
516 P<0.05, ** = P<0.01, *** P<0.001)
517


4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
**
SCCloge ('000 cells/ml)
1
2
3
4
5
Month post-calving
• Non-antibiotic DCT (TS)
Antibiotic DCT (A+TS)