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# Cephapirin usage at dry-off in Holstein and Simmental cows in relation to udder health, parity, and production level

**Boris Ljubojević[1], Ranko Gantner[2], Marko Samardžija[3], Klemen Potočnik[4], Nino Maćešić[3], Dragan Solić[5] and Vesna Gantner[2*]**

[1] Croatian Forests Ltd., Zagreb, Croatia
[2] Faculty of Agrobiotechnical Sciences Osijek, J. J. Strossmayer University of Osijek, Osijek, Croatia
[3] Faculty of Veterinary Medicine Zagreb, University of Zagreb, Zagreb, Croatia
[4] Department of Animal Science, Biotechnical faculty, University of Ljubljana, Domžale, Slovenia
[5] Croatian Agency for Agriculture and Food, Osijek, Croatia

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**ABSTRACT**

The research aimed to evaluate cephapirin usage at dry-off in Holstein and Simmental dairy cows, with respect to udder health status, parity, and milk production level. The analysis was based on a large dataset derived from routine milk records. The cows were classified by mastitis status (clinical, subclinical, and healthy), parity, and average production level. The results indicate that a considerable proportion of cephapirin was administered unnecessarily to healthy cows, those without clinical signs of mastitis or elevated somatic cell counts. Across both breeds, over 55% of the total antibiotic quantity was used in cows classified as healthy. This practice was especially prevalent among primiparous cows and those in lower production groups, reflecting a widespread reliance on blanket dry cow therapy (BDCT). Furthermore, breed-specific differences were also observed: Holstein cows demonstrated a more pronounced shift toward therapeutic antibiotic use as parity and production level increased, whereas Simmentals showed a more gradual transition. Nevertheless, across all parity and production categories, substantial antibiotic application in uninfected cows persisted regardless of breed. These results, based on a 10-year analysis of test-day records, indicate the need to implement selective dry cow therapy (SDCT), which targets only cows likely to have intramammary infections, on the basis of somatic cell counts and clinical indicators. Two refined datasets were prepared for this purpose, including over 2.5 million test-day records for Holstein cows and more than 2.8 million for Simmental cows. Adjusted antibiotic use according to cow parity, production level and breed could reduce unnecessary antimicrobial treatments without compromising udder health or milk production in subsequent lactations. This approach promotes rational antibiotic use and supports sustainable dairy production in line with EU Regulation 2019/6 and broader efforts to combat antimicrobial resistance (AMR).

**Key words:** mastitis; antibiotic use; somatic cell count (SCC); selective dry cow therapy (SDCT)

*Corresponding author:
Prof. dr. sc. Vesna Gantner, Faculty of Agrobiotechnical Sciences Osijek, J. J. Strossmayer University of Osijek, Osijek, 31000, Croatia, Vladimira Preloga 1, 31000 Osijek, e-mail: vgantner@fazos.hr

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## Introduction

Bovine mastitis is one of the most prevalent and economically significant diseases in dairy cattle worldwide. It is a complex inflammatory disorder of the mammary gland, most commonly caused by intramammary bacterial infections, and is classified as either clinical or subclinical on the basis of the manifestation of clinical signs (SCHUKKEN et al., 2003; ARGAW, 2016). Clinical mastitis presents with visible symptoms, including udder swelling, heat, pain, and abnormalities in the appearance or consistency of the milk. In contrast, subclinical mastitis is asymptomatic and typically diagnosed through indirect indicators such as elevated somatic cell count (SCC) or bacteriological analysis of milk samples (PETZER et al., 2017). Although lacking overt clinical signs, subclinical mastitis poses a significant challenge in dairy herd management due to its chronic nature and potential for long-term detrimental effects. It contributes to reduced milk yield and altered milk composition, negatively impacts udder health, and increases the risk of early culling, thereby leading to substantial economic losses at the herd level (SEEGERS et al., 2003; HALASA et al., 2007).

The dry period, defined as the non-lactating interval between two successive lactations, represents a crucial stage for the prevention of intramammary infections and the restoration of udder health. This phase is marked by pronounced physiological transformations within the mammary gland, including active involution, recruitment of immune cells, and regeneration of the epithelial lining. These processes, when optimally supported, significantly enhance the gland's resistance to new intramammary infections (OLIVER and MURINDA, 2012). Despite these protective mechanisms, the mammary gland remains particularly vulnerable to new infections during the early involution and prepartum phases of the dry period. To mitigate this risk, the routine use of intramammary antimicrobials at dry-off has become a widespread practice in dairy herd management.Historically,thishasbeenimplementedthrough blanket dry cow therapy (BDCT), in which all cows receive antibiotic treatment at the end of lactation, regardless of their infection status. Although BDCT has contributed to a reduction in the incidence of clinical mastitis and has supported udder health in subsequent lactations, it has simultaneously led to the unnecessary administration of antibiotics in uninfected animals (HOGEVEEN et al., 2019; MCCUBBIN et al., 2022). This practice raises concerns regarding antimicrobial stewardship and the rational use of antibiotics in food-producing animals

Antibiotics, particularly those administered intramammary at the end of lactation, have traditionally constituted a cornerstone in mastitis prevention and control strategies. Among these, first-generation cephalosporins, such as cephapirin, remain widely used owing to their proven efficacy against Gram-positive pathogens, and their favourable distribution and persistence within the mammary gland (RAJALA-SCHULTZ et al., 2021). While such antimicrobial treatments offer measurable benefits in reducing the incidence of new intramammary infections during the dry period, increasing attention is being directed toward their widespread and frequently prophylactic use. The routine administration of antibiotics to all cows at dry-off, irrespective of their infection status, has raised concerns regarding its contribution to the emergence and dissemination of antimicrobial resistance (AMR). This practice not only promotes resistance among mastitis-causing pathogens but also among commensal bacterial populations, which may serve as reservoirs and vectors for resistance genes (OLIVER and MURINDA, 2012; BENNANI et al., 2020; BABACAN, 2025).

The presence of antibiotic residues in milk, the environmental dissemination of antimicrobial-resistant bacteria, and the potential for horizontal gene transfer between animal and human microbial populations constitute significant public health and ecological challenges (CHRISTA- KI et al., 2020; HAILU et al., 2021). These con- cerns are particularly pronounced in intensive dairy production systems, where antimicrobial use is often frequent and prophylactic in nature. In response to these risks, regulatory frameworks, such as EU Regulation 2019/6, have been introduced, restricting the use of antibiotics in food-producing animals to situations where infection is either diagnosed or strongly suspected. Consequently, there is a growing imperative to implement more targeted and judicious antimicrobial strategies that comply with both evidence-based veterinary practices and current legal requirements. This shift underscores the need for sustainable approaches to mastitis control that minimize unnecessary antibiotic exposure, while safeguarding animal health and milk quality.

Selective dry cow therapy (SDCT) represents a scientifically supported and ethically justified alternative to blanket dry cow therapy (BDCT). This approach targets antibiotic treatment exclusively at cows identified as at risk, on the basis of criteria such as somatic cell count (SCC) thresholds, prior mastitis episodes, or bacteriological culture results, while healthy cows receive either no antimicrobial treatment or are treated solely with internal teat sealants (MCCUBBIN et al., 2022; LIPKENS et al., 2023). Recent studies showed that SDCT can substantially reduce overall antibiotic consumption without increasing the incidence of clinical or subclinical mastitis during the subsequent lactation (MCPARLAND et al., 2019; MÜLLER et al., 2023). Despite these benefits, blanket dry cow therapy remains prevalent in many regions, even where farms have the necessary infrastructure and data management systems to enable selective treatment protocols.

Since dairy farming is moving toward more sustainable practices, it is important to understand how antibiotics are used in cows with different udder health conditions. Therefore, this study aimed to examine the use of cephapirin at dry-off in relation to the udder health status of cows, as well as their parity and production level, using test-day records of dairy Simmental and Holstein cows.

## Materials and methods

The statistical analysis was conducted using test-day records from Simmental and Holstein dairy cows in Croatia, covering a ten-year period from January 2013 to Deceber 2022 These data were collected as part of the routine national milk recording system. Milk recording followed the alternative methods AT4 and BT4, in line with the guidelines of the International Committee for Animal Recording (ICAR, 2017). According to this protocol, milk yield and samples were collected from individual cows during either the morning or evening milking, approximately every four weeks. Data collection under the AT4 method was carried out by trained officers from the Croatian Agency for Agriculture and Food (HAPIH). While, in the BT4 method trained farm personnel were respon- sible for sample collection and record-keeping. Following collection, milk samples were transported to HAPIH's accredited Central Laboratory for Milk Quality Control (SLKM). There, the chemical composition of the milk was analyzed using MilkoScan infrared spectrophotometers, following the ICAR standards (ICAR, 2017). Somatic cell counts were determined using Fossomatic analyzers, which apply a fluoro-opto-electronic detection method.

The initial dataset provided by the Croatian Agency for Agriculture and Food (HAPIH) included more than 9.5 million test-day records. Descriptive statistics were conducted using SAS/STAT software, version 9.4 (SAS Institute Inc., Cary, NC, USA). Prior to statistical analysis, a logical control of data was applied thoroughly to ensure accuracy and uniformity, and to exclude outliers. This involved the exclusion of records that did not comply with the standards set by the International Committee for Animal Recording (ICAR, 2017). In addition to technical inconsistencies, records were removed if they contained incomplete or incorrect information related to key variables such as: breed, farm identification, breeding region, lactation stage, parity, age at first calving, calving date, or test-day date. After applying these logical control procedures, two refined datasets were prepared for further analysis: one comprising 2,509,222 test-day records for Holstein cows, and the other containing 2,835,101 records for Simmental dairy cows.

Somatic cell count (SCC) was used as the indicator of subclinical and clinical mastitis in dairy cows. On the basis of SCC values, animals were classified into three health status groups: healthy cows with SCC below 200,000 cells/ml, cows with subclinical mastitis showing SCC be- tween 200,000 and 400,000 cells/ml, and cows with clinical mastitis exceeding 400,000 cells/ ml. Furthermore, accordingly to parity, the cows were grouped into four parity classes: first (I), second (II), third (III), and fourth or higher (IV+). Additionally, according to their daily milk production the cows were categorised into four production groups; Holstein cows: Group I (<16 kg), Group II (16–24 kg), Group III (24–32 kg), and Group IV (>32 kg); and Simmental cows Group I (<12 kg), Group II (12–16 kg), Group III (16–20 kg), and Group IV (>20 kg). The classification into production groups was based on distribution analysis, allowing for balanced representation across categories.

The number and the prevalence of healthy cows, as well as those affected by subclinical or clinical mastitis, were determined at the last milk recording beforethebeginningofthedryperiod.Foreachmastitis category, prevalence was expressed as a percentage of the total number of cows included in the analysis. Furthermore, prevalence rates were calculated separately according to parity, production level, and for Simmental and Holstein breed.

The usage of the antibiotic cephapirin was estimated by multiplying the total number of cows by the standard dose administered per treatment as shown in equation:

*Antibiotic use = n of cows * 300 mg of cephapirin * 4 udder quarters*

This calculation was performed separately for cowscategorizedashealthy,aswellasthosediagnosed with subclinical or clinical mastitis, on the basis of their health status at the final milk recording prior to the dry period. Furthermore, antibiotic use was calculated separately according to parity, production level, and for Simmental and Holstein breed. Cefa-Safe 300 mg is an intramammary suspension designed for use in dairy cows at the time of drying-off. Each 10 ml syringe contains 300 mg of cephapirin, formulated in a creamy oily base with aluminium stearate and refined arachis oil. The product is manufactured by Intervet International B.V. in the Netherlands.

## Results

Table 1 presents the distribution of cephapirin usage in Holstein cows at the last milk recording before the dry period, with the focus on antibiotic application in relation to udder health status and parity. The total amount of cephapirin administered across all Holstein cows was 369,037.2 grams, of which 204,241.2 grams (55.34%) were used in cows classified as healthy, 96,910.8 grams (26.26%) in cows with clinical mastitis, and 67,885.2 grams (18.40%) in those with subclinical mastitis.

A noticeable trend was observed across parity groups. Primiparous Holstein cows exhibited the

Table 1. The number, prevalence, and cephapirin use in healthy, subclinical, and clinical mastitis cows at last test-day before dry-off, by parity (1st to 4th+) in Holstein breed

| Parity | Health | | | Clinical mastitis | | | Subclinical mastitis | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | AB, g | % | N | AB, g | % | N | AB, g | % | N | AB, g | % |
| **1.** | 71450 | 85740.0 | 68.30 | 17478 | 20973.6 | 16.71 | 15678 | 18813.6 | 14.99 | 104606 | 125527.2 | 100.00 |
| **2.** | 46583 | 55899.6 | 57.10 | 19522 | 23426.4 | 23.93 | 15480 | 18576.0 | 18.97 | 81585 | 97902.0 | 100.00 |
| **3.** | 26250 | 31500.0 | 48.05 | 16887 | 20264.4 | 30.91 | 11491 | 13789.2 | 21.04 | 54628 | 65553.6 | 100.00 |
| **4.+** | 25918 | 31101.6 | 38.85 | 26872 | 32246.4 | 40.28 | 13922 | 16706.4 | 20.87 | 66712 | 80054.4 | 100.00 |
| **Total** | 170201 | 204241.2 | 55.34 | 80759 | 96910.8 | 26.26 | 56571 | 67885.2 | 18.40 | 307531 | 369037.2 | 100.00 |

* AB – antibiotic (cephapirin) use expressed in grams (g)

Table 2. The number, prevalence, and cephapirin use in healthy, subclinical, and clinical mastitis cows at last test-day before dry-off, by parity (1st to 4th+) in Simmental breed

| Parity | Health | | | Clinical mastitis | | | Subclinical mastitis | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | AB, g | % | N | AB, g | % | N | AB, g | % | N | AB, g | % |
| 1. | 61625 | 73950.0 | 67.45 | 16008 | 19209.6 | 17.52 | 13735 | 16482.0 | 15.03 | 91368 | 109641.6 | 100.00 |
| 2. | 47460 | 56952.0 | 60.28 | 17122 | 20546.4 | 21.75 | 14146 | 16975.2 | 17.97 | 78728 | 94473.6 | 100.00 |
| 3. | 35401 | 42481.2 | 54.98 | 16521 | 19825.2 | 25.66 | 12471 | 14965.2 | 19.37 | 64393 | 77271.6 | 100.00 |
| 4.+ | 69453 | 83343.6 | 46.70 | 48603 | 58323.6 | 32.68 | 30663 | 36795.6 | 20.62 | 148719 | 178462.8 | 100.00 |
| Total | 213939 | 256726.8 | 55.83 | 98254 | 117904.8 | 25.64 | 71015 | 85218.0 | 18.53 | 383208 | 459849.6 | 100.00 |

* AB – antibiotic (cephapirin) use expressed in grams (g)

highest total cephapirin use (125,527.2 grams), with 68.3% of this amount administered to cows without any clinical or subclinical signs of mastitis. Among second-parity cows, healthy individuals continued to account for the majority of cephapirin administration (57.10%), although this share declined compared to primiparous animals. As parity increased, a shift was observed in the distribution of antibiotic use. In fourth and higher parity Holstein cows, those diagnosed with clinical mastitis received the greatest proportion of antibiotics (40.28%), marginally surpassing the share allocated to healthy cows (38.85%).

A considerable quantity of antibiotics is still administered to cows classified as healthy, particularly within lower parity groups. Such practices highlight the need for more judicious antibiotic use, and reinforce the rationale for broader implementation of selective dry cow therapy (SDCT) protocols. This is especially relevant for younger Holstein cows, where the potential to reduce unnecessary antimicrobial exposure is greatest.

Table 2 presents the distribution of cepha- pirin usage in Simmental cows at the last milk recording before the dry period. The analysis was performed in relation to udder health status and parity class. A total of 459,849.6 grams of cephapirin was administered. Of this amount, 256,726.8 grams (55.83%) were given to cows classified as healthy, 117,904.8 grams (25.64%) to those diagnosed with clinical, and 85,218.0 grams (18.53%) to cows with subclinical mastitis.

Among the primiparous cows, total cepha- pirin use amounted to 109,641.6 grams, with 67.45% administered to clinically healthy animals. This distribution suggests that antibiotics were often used even when no clear signs of infection were present, consistent with the conventional blanket dry cow therapy (BDCT) approach. A similar pattern was evident in second-parity cows, where 60.28% of the 94,473.6 grams used were administered to healthy animals. As parity increased, a noticeable shift in antibiotic allocation was observed. In cows in their third lactation, healthy individuals accounted for 54.98% of the total cephapirin administered, while in cows of fourth or greater parity, this share declined to 46.70%. At the same time, the share of antibiotics given to cows with clinical mastitis increased with parity, rising from 17.52% in first-lactation cows to 32.68% in cows of fourth lactation or higher. A parallel but less pronounced trend was noted in cows affected by subclinical mastitis, with usage increasing from 15.03% in first-parity cows to 20.62% in the oldest group.

These results indicate a progressive transition from primarily prophylactic antibiotic use in early lactations to more targeted, therapeutic applications in older cows, where mastitis prevalence is higher.

This practice raises important questions regarding the rational use of antimicrobials and the potential for contributing to antimicrobial resistance. Furthermore, these results strongly support the implementation of selective dry cow therapy (SDCT) in Simmental herds. By identifying cows with elevated somatic cell counts or confirmed intramammary infections, it is possible to reduce unnecessary antibiotic use significantly, without compromising udder health or subsequent milk production.

In Holstein cows, antibiotic usage was high- est in primiparous individuals, with a substantial proportion of cephapirin administered to clinically healthy animals, indicating widespread prophylactic treatment irrespective of infection status. With increasing parity, the proportion of antibiotics used in cows diagnosed with clinical mastitis increased, reflecting higher susceptibility to mastitis in older animals. Simmentalcowsexhibitedasimilarbutmore gradual trend. These findings suggest breed-specific differences in mastitis susceptibility and management strategies, with Simmentals potentially experiencing lower clinical mastitis prevalence or differing management practices over successive lactations.

Table 3 presents the use of cephapirin in Holstein cows at the last milk recording before the dry period, analysed according to udder health status and production level. The total amount of cephapirin used was 369,037.2 grams. Of this, 204,241.2 grams (55.34%) was administered to healthy cows, 96,910.8 grams (26.26%) to cows with clinical mastitis, and 67,885.2 grams (18.40%) to those with subclinical mastitis.

In the lowest production group (APL 1), healthy cows accounted for 57.95% of the total antibiot- ic use, while cows with clinical and subclinical mastitis received 28.44% and 13.61%, respectively. Similar distribution patterns were ob- served in APL 2, with 54.43% of cephapirin applied to healthy cows, 31.15% to clinically affected cows, and 14.42% to those with sub- clinical infections. In APL 3, healthy cows received 57.43% of the 104,598.0 grams adminis- tered, whereas clinical and subclinical cases account- ed for 25.12% and 17.45%, respectively. Among the highest production group (APL 4+), the proportion of antibiotics given to healthy cows declined moderately to 54.02%, while clinical cases accounted for 25.74% and subclinical cases for 20.23% of the total. Across all production levels, healthy cows consistently received more than half of the total cephapirin, in- dicating widespread antimicrobial use during the dry period.

Despite a slight increase in antibiotic use among clinically affected cows at higher production levels,results indicate the continued predominance of non-selective dry cow therapy.Implementing selective dry cow therapy (SDCT) across all production groups, particularly by identifying cows

Table 3. The number, prevalence, and cephapirin use in healthy, subclinical, and clinical mastitis cows at last test-day before dry-off, by production level (1st to 4th+) in Holstein breed

| Parity | Health | | | Clinical mastitis | | | Subclinical mastitis | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | AB, g | % | N | AB, g | % | N | AB, g | % | N | AB, g | % |
| **1.** | 61625 | 73950.0 | 67.45 | 16008 | 19209.6 | 17.52 | 13735 | 16482.0 | 15.03 | 91368 | 109641.6 | 100.00 |
| **2.** | 47460 | 56952.0 | 60.28 | 17122 | 20546.4 | 21.75 | 14146 | 16975.2 | 17.97 | 78728 | 94473.6 | 100.00 |
| **3.** | 35401 | 42481.2 | 54.98 | 16521 | 19825.2 | 25.66 | 12471 | 14965.2 | 19.37 | 64393 | 77271.6 | 100.00 |
| **4.+** | 69453 | 83343.6 | 46.70 | 48603 | 58323.6 | 32.68 | 30663 | 36795.6 | 20.62 | 148719 | 178462.8 | 100.00 |
| **Total** | 213939 | 256726.8 | 55.83 | 98254 | 117904.8 | 25.64 | 71015 | 85218.0 | 18.53 | 383208 | 459849.6 | 100.00 |

* AB – antibiotic (cephapirin) use expressed in grams (g); PL – animals' production levels

with elevated somatic cell counts or confirmed intramammary infections in high-yielding animals, could optimize antibiotic use. An evidence-based approach like this would help reduce the unnecessary use of antibiotics without negatively impacting milk production or udder health in the next lactation.

Table 4 presents the distribution of cephapirin use in Simmental cows at the last milk recording before the dry period, analysed according to udder health status and production level.

In the lowest production group (APL 1), healthy cows accounted for 56.23% of the total antimicrobial administration, while cows with clinical mastitis and subclinical mastitis received 29.23% and 14.54%, respectively. In APL 2, healthy animals received 53.79% of the total, followed by 30.05% for clinical cases and 16.16% for subclinical cases. In the third production group (APL 3), the distribution showed that 57.19% of the 170,224.8 grams was administered to healthy cows, with clinical and subclinical mastitis cases accounting for 24.39% and 18.41%, respectively. The highest production level (APL 4+) displayed a comparable pattern, with 55.12% of the total cephapirin administered to healthy individuals, 25.26% to clinically affected cows and 19.62% to subclinically affected cows.

Table 4. The number, prevalence, and cephapirin use in healthy, subclinical, and clinical mastitis cows at last test-day before dry-off, by production level (1st to 4th+) in Simmental breed

| APL | Health | | | Clinical mastitis | | | Subclinical mastitis | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | AB, g | % | N | AB, g | % | N | AB, g | % | N | AB, g | % |
| 1. | 13204 | 15844.8 | 56.23 | 6863 | 8235.6 | 29.23 | 3415 | 4098.0 | 14.54 | 23482 | 28178.4 | 100.00 |
| 2. | 19794 | 23752.8 | 53.79 | 11057 | 13268.4 | 30.05 | 5946 | 7135.2 | 16.16 | 36797 | 44156.4 | 100.00 |
| 3. | 81133 | 97359.6 | 57.19 | 34599 | 41518.8 | 24.39 | 26122 | 31346.4 | 18.41 | 141854 | 170224.8 | 100.00 |
| 4.+ | 99808 | 119769.6 | 55.12 | 45735 | 54882.0 | 25.26 | 35532 | 42638.4 | 19.62 | 181075 | 217290.0 | 100.00 |
| Total | 213939 | 256726.8 | 55.83 | 98254 | 117904.8 | 25.64 | 71015 | 85218.0 | 18.53 | 383208 | 459849.6 | 100.00 |

* AB – antibiotic (cephapirin) use expressed in grams (g); PL – animals' production level

At all production levels, healthy cows consistently received the largest proportion of cephapirin, reflecting the predominant application of dry cow therapy irrespective of mastitis status. These results indicate the implementation of selective dry cow therapy (SDCT) across all production categories. This strategy could decrease antibiotic usage while preserving udder health and production performance in the subsequent lactation.

When classified by production, healthy Holstein cows consistently received a greater proportion of antibiotics, although their share declined slightly in the highest production group (APL 4+), where mastitis treatments increased. A comparable but less pronounced pattern was oserved in Simmental cows, suggesting that production level modulates mastitis incidence and treatment protocols differently across the two breeds.

## Discussion

The results point to the widespread and persistent use of antibiotics in cows that show no clinical or subclinical signs of mastitis at dry-off. In both Holstein and Simmental herds, over half of the total cephapirin administered, 204,241.2 g and 256,726.8 g, was used on cows classified as healthy (Table 1 and 2). This trend was also coherent across production levels, with between 53.79% and 57.95%

of the total antibiotic use given to cows that were not diagnosed with infection (Table 3 and 4). Since each treated cow received a fixed dose of around 1.2 grams, this pattern reflects a blanket treatment approach that does not consider infection status. Applying dry cow therapy non-selectively in this way runs contrary to the current principles of responsible antimicrobial use, and suggests that blanket dry cow therapy (BDCT) remains a common practice, even where it is no longer necessary (MCCUBBIN et al., 2022; LIPKENS et al., 2023). In contrast, selective dry cow therapy (SDCT) offers a more targeted and sensible approach by reserving antibiotic treatment for cows with higher somatic cell counts or confirmed intramammary infections (RAJALA-SCHULTZ et al., 2021).

The noticeable change in the way antibiotic use was distributed across parity groups adds further weight to these findings. In Holstein cows in their first lactation, 68.3% of the cephapirin administered was used on healthy cows, but that figure drops sharply to 38.85% in animals with four or more lactations (Table 1). Simmental cows followed a similar pattern: 67.45% of the antibiotic use in first-parity cows was in healthy animals, compared to 46.70% in the oldest group (Table 2). At the same time, antibiotic treatment of cows with clinical mastitis increased continually with parity. This progression is consistent with earlier studies showing that susceptibility to mastitis rises with age due to long-term exposure to pathogens, teat-end changes, and weakening of the immune system (BLACKBURN, 1966; SHARMA et al., 2018). While the increased use of antimicrobials in older, clinically affected cows may be justified, the routine treatment of healthy young cows, each receiving the same dose as their infected counterparts, calls into question whether such use is medically necessary or appropriate. The data clearly highlight the need to rethink current protocols and move toward more selective, evidence-based antibiotic use.

A consistent pattern emerged linking production level with how cephapirin was distributed across health statuses. In both Holstein and Simmental cows, those in higher production groups received more treatments for clinical and subclinical mastitis. Still, more than half of all the antibiotics administered went to cows without mastitis. Even in the top production category (APL 4+), healthy cows accounted for 54.02% and 55.12% of total cephapirin use in Holstein and Simmental herds, respectively (Table 3 and 4). This suggests that antibiotic use was not guided strictly by infection risk or clinical diagnosis, but rather applied uniformly across the herd. Since each cow received a standard dose of around 1.2 grams, the extent of unnecessary antimicrobial use becomes clear, especially in animals that showed no signs of disease. While it is well established that high-yielding cows are under more metabolic stress and may be more prone to udder infections due to immune suppression (SEEGERS et al., 2003; GANTNER et al., 2017), this alone cannot justify routine antibiotic treatment of all cows, regardless of their actual health status.

When both parity and production level are examined together, the need for more selective treatment protocols becomes even more apparent. It is expected that older cows with higher parity and production levels receive more antibiotics due to their increased susceptibility to intramammary infections (TURK et al., 2012; YANG et al., 2013). However, the data also show that cows in lower-risk categories continue to receive the same fixed 1.2 g dose of cephapirin, whether or not infection is present. For instance, first-lactation cows in the lowest production group were treated at similar rates, despite the absence of clinical justification. This blanket approach overlooks key tools, such as somatic cell count (SCC) data and historical mastitis records, both of which can offer reliable guidance for targeted treatment. Treating infected and uninfected cows alike, without regard for diagnostic information, undermines both animal health management and antimicrobial stewardship efforts.

The growing body of evidence from field research and herd-level studies strongly supports the adoption of selective dry cow therapy (SDCT) as a safe and effective alternative to blanket protocols. Unlike conventional approaches, SDCT involves treating only those cows that are at demonstrable risk, typically identified using SCC thresholds or microbiological culture, while leaving healthy cows untreated or using inter- nal teat sealants alone (MCCUBBIN et al., 2022;

LIPKENS et al., 2023). Numerous studies have demonstrated that SDCT can substantially reduce total antibiotic use without negatively affecting udder health, milk production, or clinical mastitis rates (MCPARLAND et al., 2019; MÜLLER et al., 2023). Success stories from countries such as Sweden, Finland, and Denmark, where preventive antibiotic use has been almost entirely phased out, clearly show that stringent antimicrobial policies can coexist with high standards of milk quality and animal welfare (RAJALA-SCHULTZ et al., 2021). Considering that each unnecessary treatment adds 1.2 grams of antibiotics to the total usage, the cumulative impact across thousands of healthy cows represents a serious concern, both for responsible farm management and for slowing the spread of antimicrobial resistance.

The routine use of antibiotics in cows that show no clinical or subclinical signs of mastitis represents a growing concern in the context of antimicrobial resistance (AMR). When healthy animals are administered a full 1.2-gram dose of cephapirin at dry-off, bacterial populations within the herd are exposed unnecessarily. This repeated, herd-wide exposure creates ideal conditions for the emergence of resistant strains, not only among mastitis-causing pathogens but also among com- mensal bacteria, which may persist in the envi- ronment or enter the food chain (OLIVER and MURINDA, 2012; HAILU et al., 2021). Horizontal gene transfer can spread resistance traits across species, further compounding the problem. Resistant organisms such as *Staphylococcus au- reus*, *Escherichia coli*, and *Streptococcus uberis* have been frequently isolated from farms where blanket dry cow therapy is standard practice (BENNANI et al., 2020; CHRISTAKI et al., 2020).

The issue extends beyond livestock production: as resistant bacteria or resistance genes move from farm to human populations, the public health consequences become more severe. For these reasons, applying antibiotics to healthy cows must be seen not just as ineffective but as a broader biological and ethical risk in the global fight against AMR

Somatic cell count (SCC) offers one of the most practical and widely adopted tools for iden- tifying cows that may benefit from antibiotic therapy at dry-off. A cutoff of 200,000 cells/mL in the most recent milk recording is commonly used to detect subclinical infections (PETZER et al., 2017). When combined with prior mastitis history or results from bacteriological culture, SCC-based protocols can help determine which cows genuinely require treatment. Several large-scale studies have demonstrated that cows below this thresh- old do not gain additional protection from antibi- otic use, and can instead be dried off safely using internal teat sealants alone (MCCUBBIN et al., 2022; LIPKENS et al., 2023). Beyond reducing unnecessary antimicrobial use, this approach helps preserve udder health and productivity. Nevertheless, implementation of SCC-guided protocols remains uneven. Barriers, such as habit, lack of farmer training, or perceived financial risk, continue to hinder broader adoption. Still, given SCC's reliability and affordability, its role as a frontline screening method in mastitis control should be firmly established in all herds aiming to reduce antibiotic reliance.

Of course, infection status is not the only factor influencing mastitis risk. Cow-level variables, such as parity and breed, as well as herd-level conditions, such as season and management, also play important roles in determining whether antibiotic treatment is justified. Older cows or those exposed to heat stress or inadequate hygiene are known to have an elevated risk of intramammary infection, and may appropriately receive treatment at dry-off (GANTNER et al., 2011; TURK et al., 2012). In the present study, Simmental cows tended to have slightly lower rates of clinical mastitis compared to Holsteins, especially in higher-parity groups. This observation is in line with findings from other studies noting breed-specific resistance to udder infections (ATASEVER and ERDEM, 2008.; GIRMA and TAMIR, 2022). Incorporating such variables into herd health protocols enables more tailored treatment strategies that avoid overuse while protecting vulnerable animals. When reliable milk recording systems are in place, integrating individual cow data with broader epidemiological factors provides a solid foundation for moving from routine, one-size-fits-all therapy to a more targeted, precision-based approach to antimicrobial use.

The breed-level differences identified in this study add further weight to the argument for a more modified approach to dry cow therapy. While both Holstein and Simmental cows received anti- biotics in high proportions, regardless of infection status, Simmental cows showed a somewhat low- er prevalence of clinical mastitis, particularly at higher parities. This trend reflects earlier research indicating that Simmentals may possess stron- ger natural defenses against intramammary infec- tions than Holsteins (ATASEVER and ERDEM, 2008; GIRMA and TAMIR, 2022). Yet, despite these differences in disease susceptibility, treat- ment strategies appeared largely uniform across both breeds. This suggests that protocols do not sufficiently account for breed-specific risk factors. In herds with mixed genetics, such an over- sight can lead to overtreatment of more resilient cows. Adjusting protocols to reflect differences in mastitis susceptibility, especially when combined with cow-level data and robust herd monitoring, could reduce unnecessary antibiotic exposure without compromising udder health or productivity

Equally important is the growing disconnect between blanket dry cow therapy and the evolving regulatory landscape. The European Union's Regulation 2019/6 (EU, 2019) explicitly prohibits the prophylactic use of antibiotics in animals that do not show signs of infection, a policy rooted in the need to safeguard both animal welfare and public health. Despite this, findings from the present study show that many cows without any indication of mastitis continue to receive the full 1.2 g dose of cephapirin at dry-off. This practice not only undermines the intent of the regulation, but also exposes farms to legal risks, particularly in jurisdictions where regulatory enforcement is tightening. Moving away from one-size-fits-all treatment toward selective dry cow therapy is not just supported by scientific evidence; it is rapidly becoming a regulatory and ethical necessity. Implementing more precise, risk-based antimicrobial use policies marks an essential step toward building a more sustainable and compliant dairy production system.

This study did not include monitoring of clinical outcomes in the subsequent lactation, such as mastitis incidence, milk yield, or culling rate, which limits its ability to assess the long-term effects of different treatment strategies. Although some analyses of the economic aspects of SDCT are available, further evaluations are needed that take into account specific biological, environmental, and production factors. Such analyses would help clarify the cost-effectiveness and practical feasibility of SDCT under real-life farm conditions, and support more informed decision-making at the herd level.

## Conclusions

The obtained results indicate that a considerable proportion of cephapirin usage at dry-off is administered unnecessarily to healthy cows, with over 55% of total antibiotics given to animals without clinical or subclinical mastitis. This practice was particularly pronounced in primipa- rous cows and those in lower production groups, across both Holstein and Simmental breeds. Differences between breeds were also evident: Holsteins showed a more marked increase in an- tibiotic use for clinical mastitis cases as parity and production level rose, whereas Simmentals exhibited a more gradual shift from preventive to therapeutic use. Regardless of breed, the trend of substantial antibiotic application in healthy cows persisted across all parity and production catego- ries, highlighting a widespread reliance on blanket dry cow therapy. The results also underline the need to use selective dry cow therapy (SDCT), which treats only cows that actually have or are likely to have infections on the basis of udder health tests such as somatic cell counts and clinical signs. By adjusting treatment according to parity, production level, and breed, it is possible to reduce unneces- sary antibiotic use without harming udder health or milk production in the next lactation. This approach supports better antibiotic use and helps make dairy farming more sustainable by lowering the risk of antibiotic resistance.

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**LJUBOJEVIĆ, B., R. GANTNER, M. SAMARDŽIJA, K. POTOČNIK, N. MAĆEŠIĆ, D. SOLIĆ, V. GANTNER: Povezanost primjene cefapirina sa zdravljem vimena, paritetom i proizvodnjom mlijeka pri zasušenju krava holštajnske i simentaske pasmine Vet. arhiv 96, 212-225, 2026.**

**SAŽETAK**

Cilj istraživanja bio je procijeniti primjenu cefapirina pri zasušenju mliječnih krava holštajnske i simentalske pasmine u odnosu na zdravlje vimena, paritet i proizvodnju mlijeka. Analiza je zasnovana na opsežnom skupu podataka dobivenom iz rutinskih zapisa o kontroli mliječnosti. Krave su klasificirane prema statusu mastitisa (klinički, supklinički i zdrave), redoslijedu parenja i prosječnoj proizvodnji mlijeka. Rezultati pokazuju da je znatan udio cefapirina primijenjen nepotrebno – u zdravih krava, krava bez kliničkih znakova mastitisa i krava s povećanim brojem somatskih stanica u mlijeku. U obje je pasmine više od 55% ukupne količine antibiotika primijenjeno u krava koje su klasificirane kao zdrave. Takva je praksa osobito učestala kod prvotelki i krava s manjom proizvodnjom, što upućuje na široko rasprostranjenu ovisnost o rutinskoj terapiji svih krava pri zasušenju (engl. *blanket dry cow therapy*, BDCT). Osim toga, uočene su i razlike među pasminama: u holštajnskih je krava zabilježen izraženiji pomak prema terapijskoj primjeni antibiotika s porastom pariteta i razinom mliječnosti, dok je u simentalki prijelaz bio postupniji. Ipak, u svim kategorijama pariteta i proizvodnje zadržala se znatna primjena antibiotika u neinficiranih krava, neovisno o pasmini. Rezultati, zasnovani na desetogodišnjoj analizi podataka s kontrolnih mužnji, upućuju na potrebu uvođenja selektivne terapije pri zasušenju (engl. *selective dry cow therapy*, SDCT), koja cilja samo krave za koje se, na osnovi broja somatskih stanica i kliničkih pokazatelja, sumnja da imaju intramamarne infekcije. U tu su svrhu pripremljena dva detaljno obrađena skupa podataka – s više od 2,5 milijuna zapisa o kontrolnim mužnjama holštajnskih krava i više od 2,8 milijuna zapisa za simentalske krave. Prilagođena primjena antibiotika koja je usklađena s paritetom, razinom proizvodnje mlijeka i pasminom mogla bi smanjiti nepotrebne antimikrobne tretmane bez ugrožavanja zdravlja vimena ili proizvodnje mlijeka u sljedećim laktacijama. Takav pristup potiče racionalnu upotrebu antibiotika i pridonosi održivoj proizvodnji mlijeka u skladu s Uredbom EU 2019/6 i širim naporima u borbi protiv antimikrobne rezistencije (AMR).

**Ključne riječi:** mastitis; upotreba antibiotika; broj somatskih stanica (SCC); selektivna terapija pri zasušenju krava (SDCT)