




## DRY COW ANTIMICROBIALS USE TO CONTROL MASTITIS IN NORTHERN ALGERIA

### Uso de antimicrobianos en vacas secas para controlar la mastitis en el Norte de Argelia

Mohamed Walid Hamlaoui <sup>1,2</sup>, Ahmed Hadeif <sup>2,3\*</sup>, Fawzi Rostane Meklati <sup>4</sup>, Imane Bitat <sup>3</sup>

<sup>1</sup> Institute of Veterinary Sciences, Frères Mentouri University of Constantine, El Khroub, Constantine, Algeria.

<sup>2</sup> Laboratory of Development and Control of Hospital Pharmaceutical Preparations, Faculty of Medicine, Badji Mokhtar University of Annaba, Algeria

<sup>3</sup> Department of veterinary sciences, Faculty of nature and life sciences, University Chadli Bendjedid- El Tarf, El Tarf, Algeria.

<sup>4</sup> Centre de Recherche Scientifique et Technique en Analyses Physico-Chimiques (CRAPC), BP 384, Bou-Ismail, 42004, Tipaza, Algeria

\* Corresponding author: Ahmed Hadeif, e-mail: [hadeif\\_vet@yahoo.fr](mailto:hadeif_vet@yahoo.fr), [hadeif-ahmed@univ-eltarf.dz](mailto:hadeif-ahmed@univ-eltarf.dz)

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#### ABSTRACT

The control of mastitis is a crucial step in the preparation of the next lactation in dairy cows. In order to assess the practices and attitudes surrounding the use of antimicrobials at dry-off, a survey was conducted among veterinary practitioners in fifteen provinces of Northern Algeria. The results revealed that 45.95% of the farms followed by the respondents were rather small in size comprising about ten cows per farm and that a large majority of the farmers practised gradual drying off (72.97%) without adjusting the feed ration (70.27%) to this stage. Antibiotic dry cow therapy (DCT) was a common practice and selectively performed in 86.49% of cases regardless of udder health status. Cefalexin was the most infused intra-mammary (IMM) antibiotic (40.54%), while tylosin was the one favoured for parenteral administration (48.15%). Analysis of factors influencing the antibiotic DCT efficacy showed that a frequent (13.51%) occurrence of new intramammary infections (IMIs) was related to farmers' attitudes (self-medication) and the policy of blanket DCT. Although the use of a teat sealant was uncommon (71.43%) in the farming traditions, the substitution of antibiotics seems to be a plausible prospect, since the majority of participants (89.19%) agreed with the implementation of aromatherapy concept at dry-off, mainly as a complement to antibiotics. This survey gives an overview of risk practices regarding mastitis management in northern Algeria. Hence, further zootechnical, veterinary and organizational efforts need to be made to promote animal production and welfare as well as public health through improved udder health.

**Keywords:** Alternative therapy, Antibiotics, Dry Cow, Mastitis, Survey.

#### RESUMEN

El control de la mastitis es un paso crucial en la preparación de la siguiente lactación en vacas lecheras. Para evaluar las prácticas y actitudes en torno al uso de antimicrobianos en el momento del secado, se llevó a cabo una encuesta entre los veterinarios de quince provincias del norte de Argelia. Los resultados revelaron que el 45,95% de las explotaciones seguidas por los encuestados eran bastante pequeñas, con unas diez vacas por explotación, y que una gran mayoría de los agricultores practicaba el secado gradual (72,97%) sin ajustar la ración alimenticia (70,27%) a este escenario. La terapia de vacas secas (DCT) con antibióticos fue una práctica común y se realizó selectivamente en el 86,49% de los casos, independientemente del estado de salud de la ubre. La cefalexina fue el antibiótico más infundido por vía intramamaria (40,54%), mientras que la tilosina fue la preferida para la administración parenteral (48,15%). El análisis de los factores que influyen en la eficacia de la DCT mostró que la aparición frecuente (13,51%) de nuevas infecciones intramamarias (IMI) estaba relacionada con la actitud de los ganaderos (automedicación) y la política de DCT general. Aunque el uso de un sellador de pezones era infrecuente (71,43%) en las tradiciones ganaderas, la sustitución de los antibióticos parece ser una perspectiva plausible, ya que la mayoría de los participantes (89,19%) estaban de acuerdo con la aplicación del concepto de aromaterapia en el secado, principalmente como complemento de los antibióticos. Esta encuesta ofrece una visión general de las prácticas de riesgo relativas a la gestión de la mastitis en el norte de Argelia. Por lo tanto, es necesario realizar más esfuerzos zootécnicos, veterinarios y organizativos para promover la producción y el bienestar de los animales, así como la salud pública mediante la mejora de la salud de las ubres.

**Palabras clave:** Terapia alternativa, antibióticos, vaca seca, mastitis, encuesta.

## INTRODUCTION

Drying-off practices to control mastitis differ between countries and herds, including the use of antibiotic dry cow therapy (DCT) and teat sealants (Vilar and Rajala-Schultz, 2020). The policy of antimicrobial control of mastitis in the world is an important part of the «One World, One Health» concept (Garcia et al., 2019). As a point of udder health control plans, the use of antibiotics during the dry period aims to eliminate mammary infection developed during lactation and to prevent the occurrence of new intramammary infections (IMIs) during this stage (Bradley and Green, 2001). These new IMIs and the related expenses with antibiotic treatment were considered as important determinants of the cost of mastitis during the dry period (Huijps and Hogeveen, 2007).

Mastitis management during the dry period is based on two essential practices, systematic antibiotherapy named blanket DCT and selective DCT without (Østerås et al., 1991) or with a teat sealant way (Cameron et al., 2015). DCT is an established herd management practice and, although the response to treatment is in some cases lacking or disappointing, and its use nevertheless decreases the infection level and provides an additional tool of reducing the level of exposure to uninfected cows (Blowey and Edmondson, 2010) and it remains effective in mastitis control as reported in Finnish dairy herds (Niemi et al., 2021).

The decision to dry-off cows using either antibiotherapy strategies depends also on the individual farmer's perception and dairy farms economic criterion (Huijps and Hogeveen, 2007).

In Algeria, the policy of antimicrobial control of mastitis during the dry period is not yet well defined. Given that the livestock management of dairy cows is mainly focused in the north of the country (Meklati et al., 2020), the present survey aims to characterize the practice of mastitis antimicrobial control experienced by northern Algeria veterinary practitioners during this critical reproductive stage considering the possible factors influencing the DCT efficacy.

## MATERIAL AND METHODS

### The questionnaire

Due to the confinement imposed in Algeria as a result of the COVID-19 pandemic and the restrictions on movement between the regions involved in this study, and in order to facilitate the proper conduct of our survey among veterinarians in northern Algeria, an online questionnaire was created via Google forms® (<https://forms.gle/ubFUz6zzYq1xNyRA8>).

The survey consists of 31 questions comprising short answers, multiple-choice, dropdown, linear scale and check box questions. The questionnaire was enriched with illustrations to provide information on two indicators, the Body Condition Score (BCS) and the California Mastitis Test (CMT).

A non-exhaustive list of marketed antibiotics for local intramammary or systemic administration to dry cows was used to define molecules frequently used by veterinarians. However, for ethical reasons, the analysis and presentation of the results were limited to the International Nonproprietary Names (INNs)

and the name of the antibiotic family without citing the trade names.

### Topics addressed by the questionnaire

The technical questions focused on the following points:

- Dry period management including the feeding status
- Approaches adopted by farmer to control mastitis
- Characteristics of dry cow therapy (DCT practice);
- DCT efficacy;
- Solutions aimed to reduce the use of antibiotics through alternatives or complements to antibiotic therapy (teat sealant, phytotherapy and aromatherapy).

### Target population

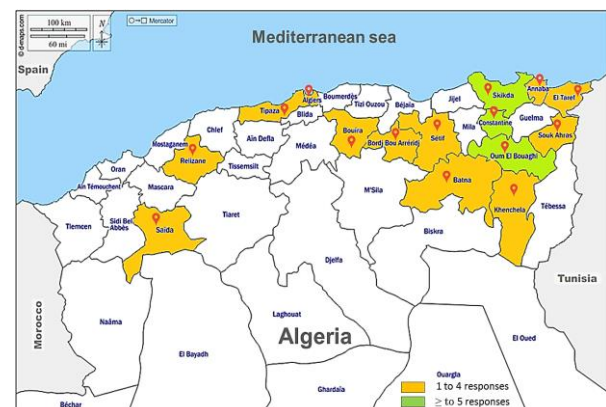
The target population was veterinarians practicing in mixed or rural areas only, some of whose Electronic addresses are collected from the provinces' agricultural services directorate. This selection is justified by the possibility of access to several farms by a single veterinarian and consequently, hundreds of dairy farms will be covered by this questionnaire.

### Participation rate

The number of responses obtained after 18 months (first response received on 15 April 2020, last response received on 7 October 2021) was 37. All respondents completed at least 96 % of the questionnaire.

### Participant's localization

The survey covered the whole of northern Algeria where 15 provinces are represented. The majority of the veterinarians who filled in the survey are located in the northeast of Algeria. Constantine, Skikda and Oum El Bouaghi are the most represented districts (Figure 1).



**Figure 1.** Geographic location of respondents in northern Algeria.

### Statistical analysis

Responses of participants in the survey were analysed using IBM SPSS Statistics 26 software. Descriptive analysis of categorical variables involving the frequencies and confidence intervals of each category was established by the binomial nonparametric test. The estimate will be the observed proportion.

The relationship between qualitative variables categories (Dry period management, DCT practice, and DCT efficacy) was explored using the Multiple-correspondence analysis (MCA) demonstrating the results in graphical dimensions. Furthermore,

the discrimination measures were developed and the category quantification plots were applied to identify category associations.

Hierarchical Cluster analysis (HCA) was performed to classify all Responders (v1 to v37) into groups. These clusters were obtained from the two MCA dimensions object scores using the method of squared Euclidean distance. The cluster solution was selected considering the solution explained equals or exceeds 5% of the dependent variables compared to the previously applied solution. The relevant variables in the MCA discriminating the dimensions 1 and 2 were compared between and within derived clusters comprising at least two subjects using Crosstabulations.

## RESULTS AND DISCUSSION

### Dry period management

### Herd size

The dairy herds covered by the veterinarians who contributed to the survey vary in size, from less than 10 cows per farm (45.95%) to more than 100 cows for the largest farm (2.70%). The national milk production is ensured up to 70% by the bovine livestock, with the implementation of a semi-intensive production system (modern dairy cattle) which provides most of the production through a herd consisting of high genetic potential imported cows. On the other hand, the extensive production system (Enhanced dairy cattle) is ensured by crossbreeding between local and imported cows, distributed in small-size dairy farms (1-6 cows) as reviewed by Meklati et al. (2020). The characterization and typology of dairy farming systems studied through the survey of Boukhechem et al. (2019), involving 217 dairy farms located in northern Algeria, revealed an average of 18.6 cows/farm. The high average (35.14%) herd size (10-20 cows/farm) recorded in our findings is in agreement with these authors.

**Table 1.** Characteristics of dry period management in the herds covered by the survey participant in northern Algeria.

Dry period management	Question choices	Missing data	Frequency (n)	Estimate (%)	95% Confidence Interval	
					Lower	Upper
Herd size			37			
	< 10 cows		17	45.95	29.49	63.08
	10 to 20 cows		13	35.14	20.21	52.54
	20 to 40 cows		4	10.81	3.03	25.42
	50 to 70 cows		2	5.41	0.66	18.19
	> 100 cows		1	2.70	0.07	14.16
Separation of dry cows from lactating cows			37			
	Never		13	35.14	20.21	52.54
	Rarely		20	54.05	36.92	70.51
	Often		3	8.11	1.70	21.91
	Always		1	2.70	0.07	14.16
Drying off management			37			
	Abruptly		10	27.03	13.79	44.12
	gradual cessation		27	72.97	55.88	86.21
Milk cessation length		12	25			
	0-7 days		11	44.00	24.40	65.07
	10 days		4	16.00	4.54	36.08
	15 days		4	16.00	4.54	36.08
	20 days		3	12.00	2.55	31.22
	25 days		1	4.00	0.10	20.35
	30 days		2	8.00	0.98	26.03
Ration adapted to the dry period			37			
	No		26	70.27	53.02	84.13
	Yes		11	29.73	15.87	46.98
BCS at drying off		1	36			
	BCS = 2		4	11.11	3.11	26.06
	BCS = 3		25	69.44	51.89	83.65
	BCS = 4		5	13.89	4.67	29.50
	BCS = 5		2	5.56	0.68	18.66

**Table 2.** Approaches adopted by farmer to control mastitis in surveyed area.

Dry approaches for mastitis control	Question choices	Missing data	Frequency (n)	Estimate (%)	95% Confidence Interval	
					Lower	Upper
Use of infectious diseases vaccination by farmers	Never		37			
	Rarely		10	27.03	13.79	44.12
	Often		20	54.05	36.92	70.51
	Always		6	16.22	6.19	32.01
Knowledge of marketed mastitis vaccines			1	2.70	0.07	14.16
	No		37			
	Yes		30	81.08	64.84	92.04
			7	18.92	7.96	35.16
Farmers use of Mastitis vaccination		1	36			
	No		33	91.67	77.53	98.25
	Yes, but infrequently		3	8.33	1.75	22.47
Recommendation of mastitis vaccination		1	36			
	No		14	38.89	23.14	56.54
	Yes		22	61.11	43.46	76.86
Farmers' request for intramammary antibiotics dry cow therapy			37			
	Never		5	13.51	4.54	28.77
	Rarely		16	43.24	27.10	60.51
	Often		13	35.14	20.21	52.54
	Always		3	8.11	1.70	21.91

#### Gradual and abrupt cessation of milking at dry-off

The results of the survey show that only 27.03% of the farmers in the study area ceased milking abruptly while 72.97% practiced a gradual drying off. This important part of breeding practices in relation to udder health remains lower than that obtained (95.65%) by Kebbal et al. (2020) from a descriptive study conducted on 92 farms located in Blida, a province in northern Algeria not covered by the present survey. This drying off management is also widespread (73%) in Germany, according to the questionnaire conducted by Bertulat et al. (2015) and filled in by 91 farmers.

Milk cessation is a crucial process to consider, mainly in high-producing animals (Gott et al., 2017). Indeed, high risks of new IMIs in the cow at the beginning of the dry period have been associated with dilation within the udder cisterns due to the high pressure exerted by the excessive accumulation of milk following abrupt drying off; especially since high producing cows undergoing this type of drying off are more susceptible to milk leakage (Vilar and Rajala-Schultz, 2020). This can be limited by a gradual decrease in milking to reduce the occurrence of IMIs during the dry period and at the early new lactation (Gott et al., 2017).

The survey shows a non-separation of dry and lactating cows in 35.14% of the farms, which is lower than the 65.22% obtained by Kebbal et al. (2020). Furthermore, the majority of farmers (70.27%) did not respect a ration adapted to the dry cows requirements, which could be explained by the fact that most farmers distributed to animals a feed ration without any formulation or nutritional strategy adapted to their real needs

and physiological state (Meskini et al., 2021). Although this, dry cows often (69.44%) had an adequate body condition score (BCS = 3), indicating the preservation of the animal's welfare in terms of feeding at this period compared to those recorded ( $2.73 \pm 0.43$ ) in Holstein dairy cows during the second month of the dry period in north-eastern Algeria by Hadeif et al. (2021).

#### Farmers' approaches to mastitis control

##### Farmers' request for dry cow intramammary antibiotic (self-medication)

Respondents noted that 27.03% of farmers are totally uninterested in vaccination campaigns for cattle, while 54.05% of farmers rarely participate. These campaigns, which are generally free of charge, were mainly initiated in recent years following the resurgence of cases of foot-and-mouth disease and because of the economic losses incurred (Meklati et al., 2020; Meskini et al., 2021). This recalcitrance of farmers is also reflected in the fact that a large majority of them do not vaccinate against mastitis (91.67%). This is probably explained by the lack of marketing of this type of vaccine on the veterinary medicine market, as observed by practitioners (81.08%).

The survey showed the significant presence of mastitis at dry-off on the dairy farms covered by the veterinarians interviewed since about 43.25% of the farmers request intramammary antibiotics (IMM ATB) to control mastitis at this period, nevertheless, the assessment of its prevalence through

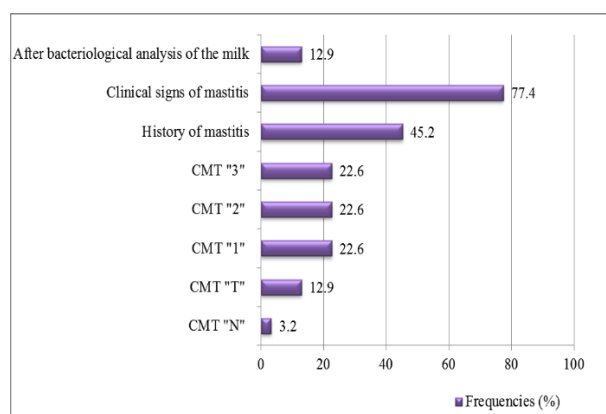
epidemiological studies at dry-off in Algerian dairy herds has not often been published.

However, more than half (56.75%) of the respondents stated that farmers claim little or no antibiotic treatment at dry-off. This result is very close to the one noted (52.17%) by Kebbal et al. (2020). It can be explained by the abusive use of self-medication. This practice is unfortunately very frequent in emerging countries and more particularly in Africa where veterinary drugs are sold over the counter, encouraging the development of antibiotic resistance (Ssajjakambwe et al., 2017; Titouche et al., 2019). These results reported in our survey reflect a marked lack of farmer training (Kebbal et al., 2020; Layada et al., 2016), compounded by insufficient veterinary awareness about the importance of managing dry-off and the use of antibiotic therapy during this period.

### The dry cow therapy

The results resumed in Table 3 showed that only 13.51% of the veterinarians surveyed treat dry cows systematically regardless of their udder health status (blanket DCT), while the majority (86.49%) select cows for treatment at dry-off (selective DCT). These results are similar to those found in the survey conducted by Vilar et al. (2018) in Finnish dairy herds with a dominance of selective DCT (78%) over the use of blanket DCT. This is in contrast to what has been observed in some industrialized countries such as Germany (Bertulat et al., 2015) where 79.6% of the dairy farms studied apply the blanket antibiotic DCT.

Among respondents using selective DCT, 77.4% of treat cows for obvious clinical signs of mastitis (e.g. presence of lumps in the milk); 32.26% based on the CMT score corresponding to a somatic cell count greater than or equal to 400,000 cells/mL. Furthermore, dry cows with recurrent mastitis were in the selected group in 45.16% of cases (Figure 2). However, the use of bacteriological tests for selective therapy was low (12.9%). Field and financial considerations related to sampling and examination of milk from all dry cows may explain this poor use of bacteriological testing. The very limited use of this practice is supported by the results (31%) obtained by Bertulat et al. (2015). Conversely, in Finnish dairy farms characterized by a selective DCT, microbiological testing was the preferred method for selecting cows before treatment at the dry-off (82%), followed by other selection criteria, clinical mastitis history and high somatic cell count (Vilar et al., 2018).



**Figure 2.** Selection criteria for the dry cow therapy. CMT "N": negative, CMT "T": trace, CMT "1": weakly positive, CMT "2": clearly positive with high score, CMT "3": strongly positive.

### Beginning of antibiotic therapy at dry-off

The survey showed that 62.50% of the veterinarians questioned start antibiotic therapy during the first week of dry-off, while only 25% initiate it on the first day allowing them to take advantage of this approach (Table 3). In addition, 44% of the farms covered by the survey practised milk cessation length within one week (Table 1). Conceptually, according to these findings, treatment of cows at the beginning of the dry period should not result in high levels of antibiotic residues in colostrum or milk if the manufacturer's instructions and dosages were respected. However, encouraged in Algeria by their low cost, an excessive use noticed within a self-medication framework by some farmers in the lack of any veterinary supervision (Layada et al., 2016) and without the slightest respect of withdrawal periods (Titouche et al., 2013), had the effect of favouring their presence in milk with a major risk for human health as a consequence (Titouche et al., 2019). The non-separation of animals, as reported in this survey (Table 1), increases the risk of accidental entry into the milking parlour of cows under antibiotherapy resulting in contamination of the milk (Lievaert et al., 2005). Other hazardous practices conducted by some farmers demonstrated that the contaminated milk collected during antibiotic DCT was not discarded by these latter, but rather fed to calves with a risk at the animal scale but also at the end of the food chain for Humans (EFSA Panel on Biological Hazards (BIOHAZ) et al., 2017).

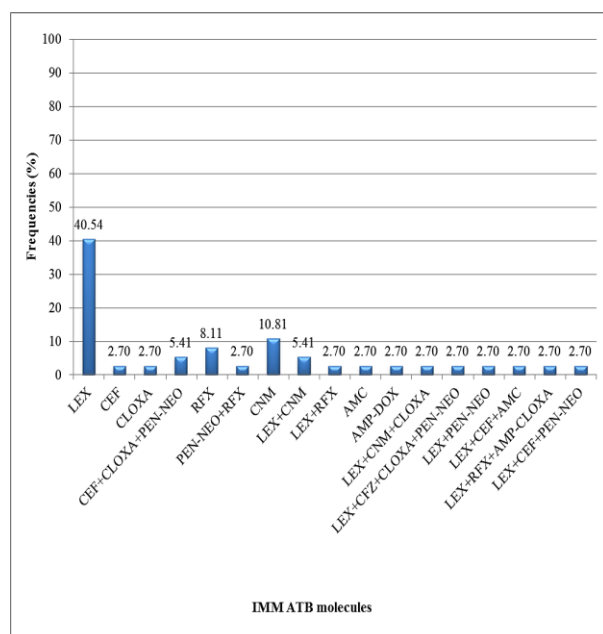
Applying antibiotic treatment on the day of drying off can significantly reduce the proliferation of mastitis pathogens (Krömker and Leimbach, 2017).

### Intramammary and parenteral dry cow antibiotherapy

The number of veterinarians using exclusively the intramammary route for the treatment of mastitis in dry cows, even in the presence of clinical mastitis was low (18.92%), as was that of 13.51% veterinarians who combined the systemic and local routes despite the absence of clinical mastitis (Table 3). The combination of these two routes has a positive effect and can eliminate more germs than the local route alone. The association between these two modalities revealed in the present investigation seemed to be conditioned by the impairment of the general condition of the animals during clinical mastitis in 32.43% of cases. These disparities in the answers provided could be explained by differences in mastitis management from one farm to another. Indeed, few farmers initiate treatment as soon as the first symptoms appear, but rather when the signs of clinical mastitis are accompanied by a decline in the animal's general condition. This was also confirmed by the work of Kebbal et al. (2020) who noted that mastitis was a serious problem in the Algerian studied farms. However, our survey showed that the intra-mammary infusion was the preferred route alone or in combination with systemic administration and regardless of the form of the disease, which is consistent with the results of a survey conducted in France among 523 farms (Gay et al., 2002). These authors reported the use of the intramammary route in combination with the parenteral route independently of the clinical picture in less than 40% of cases. Also, in the United Kingdom, Fujiwara et al. (2018) found that a large majority (95.9%) of the surveyed farms use antibiotic dry cow intramammary tubes at dry-off including 82.2% in combination with internal and/or external sealants.

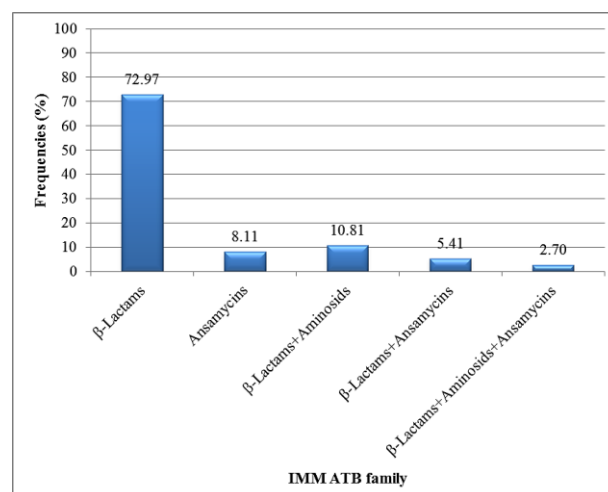
### Frequency of molecules and family of antibiotics used as IMM dry cow therapy

The results revealed that 40.54% of veterinarians used exclusively cefalexin (LEX) for intramammary treatments (Figure 3), which was combined with other molecules by 24.32% of respondents. Cefalonium (CNM) is the second most used molecule through the local route (10.81%). The rate of infusion of one molecule or another varies according to the region (country) and the physiological stage (drying off or lactation). For example, in England and Wales the survey conducted by Brunton et al. (2012) in 2010/2011 at the dairy farm level showed that 96% used intramammary antibiotics at dry-off where cefalonium, a first-generation cephalosporin, was the most frequently used molecule (43%). Considering the physiological stage, dry-cow antibiotics are long-acting and are intended for animals that are not expected to produce milk. According to the survey conducted in France (between June 1999 and January 2001), the most commonly used product to treat clinical mastitis in dairy cows by the intra-mammary route was a commercial product that combined three antibiotics (tetracycline, neomycin and bacitracin) and an anti-inflammatory (prednisolone). This combination was used by 57.2% of respondents, followed by the two-antibiotic combination amoxicillin and clavulanic acid (AMC) with a frequency of 15% (Gay et al., 2002). However, the study of the prevalence of lactating intramammary (IMM) antibiotics conducted by Burke and Adley (2021) revealed that the AMC combination was preferred at the first intention in 34% of Irish dairy farmers. They also reported that aminoglycosides with formulations marketed as a combination of two products, the first one combined novobiocin, dihydrostreptomycin and neomycin; the second one contained kanamycin and cefalexin, completed the ranking with 31% and 16% respectively.



**Figure 3.** Molecules of intra-mammary antibiotics dry cow therapy. AMC : Amoxicilline + acide clavulanique ; AMP-CLOXA: Ampicillin+cloxacillin ; CEF- DOX : Ampicillin+Dicloxacillin ; CEF: Cefquinome; CFZ: Cefazoline; Cl: Colistine; CLOXA : Cloxacillin ; CNM: Cefalonium; LEX: Cefalexine; PEN-NEO: Benzylpenicilline + Neomycin; RFX: Rifaximin.

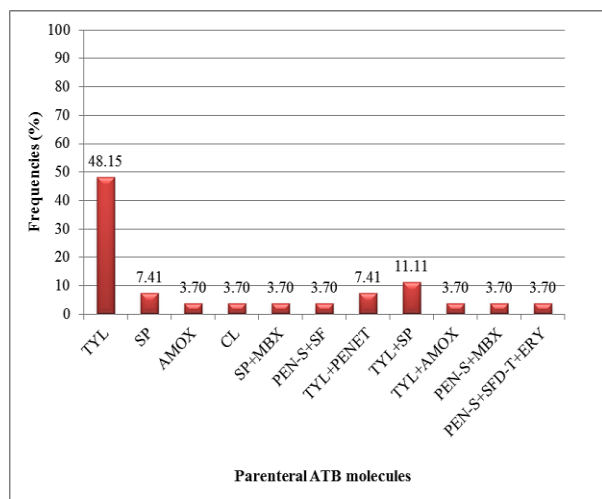
As shown in Figure 4,  $\beta$ -lactams were the most commonly used antibiotics at drying off by the veterinarians questioned with a frequency of 72.97%. Concerning the combination of two or more families of antibiotics, the results show that the combination of  $\beta$ -lactam and aminoglycosides was the most frequently formulated with a percentage of 10.81%. In a survey conducted in Pennsylvania (USA) on antibiotics used for the treatment of various diseases in dairy cows, beta-lactams were the most used antibiotics for the treatment of mastitis in dry cows (Sawant et al., 2005). The nature of the majority antibiotic range is largely determined by the attitudes of veterinarians and farmers. In the Netherlands, there has been an increasing trend in recent years to reduce the use of drugs by Dutch dairy veterinarians for the treatment of mastitis (Scherpenzeel et al., 2018). However, it was noted in this country from 2005 to 2012, that farmers were reluctant to reduce the use of molecules such as narrow-spectrum penicillins (narrow-spectrum) or certain combinations (Procaine benzylpenicillin-aminoglycoside) during the dry period (Kuipers et al., 2016). The latter reported low use of beta-lactams such as third and fourth generation cephalosporins (0.21% in 2005-2010 to 1.17% in 2011) against an evolution towards the penicillin-aminoglycoside combination as DCT between 2005-2010 (14.17%) and 2012 (22.91%).



**Figure 4.** Family of intra-mammary antibiotics dry cow therapy.

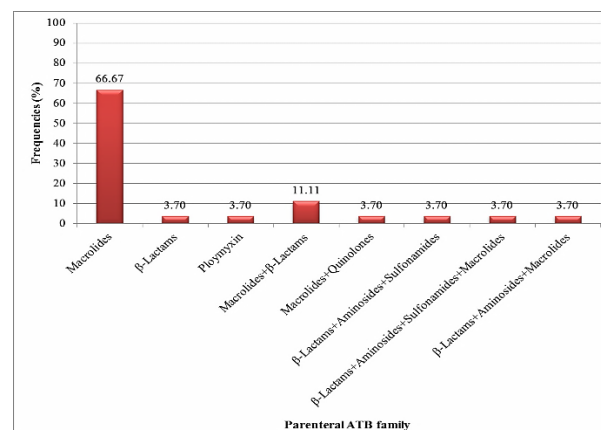
### Frequency of molecules and family of antibiotics used as parenteral dry cow therapy

Regarding parenterally administered molecules, tylosin is the most frequently used alone (48.15%) or in combination with other molecules such as spiramycin and penethamate, 11.11% and 7.41% respectively. Spiramycin, ranked second, was used alone by only 7.41% of the vets surveyed (Figure 5). These results are similar to those obtained by Brunton et al. (2012), as tylosin was most frequently (27.4%) cited by respondents using a system antibiotic, followed by the combination of dihydrostreptomycin, procaine penicillin (PEN-S) with a 20.7%. Conversely, according to a survey conducted in France, spiramycin is the most commonly used systemic antibiotic for the treatment of mastitis followed by tylosin (Gay et al., 2002). As also noted in this survey, the use of sulphadiazine-trimethoprim (SFD-T) (3.9%), amoxicillin (2.7%) and cefalexin (0.7%) was found by Brunton et al. (2012) to be rather limited.



**Figure 5.** Molecules of parenteral antibiotics dry cow therapy. AMOX : Amoxicillin ; CL: Colistine; ERY: Erythromycin; LEX: Céfalexine; PENET: Penethmate; PEN-S: Benzylpenicillin+Dihydrostreptomycin; SF : Sulfamide ; SFD-T: Sulfadimidine- Triméthoprim; SP: Spiramycin; TYL: Tylosine.

For antibiotics DCT administered via parenteral route, macrolides are the most frequently used family (66.67%), while the combination of a macrolide with a  $\beta$ -lactam was formulated by 11.11% of the practitioners surveyed (Figure 6). The combination of a systemic antibiotic, notably belonging to the macrolide family, with an antibiotic DCT has been reported by Breen et al. (2011) as a veterinarian-recommended approach to improve the success rate of treatment of an existing IML.



**Figure 6.** Family of parenteral antibiotics dry cow therapy.

**Table 3.** Characteristics of dry cow therapy in the herds covered by the survey participant in northern Algeria.

Dry cow therapy characteristics	Question choices	Missing data	Frequency (n)	Estimate (%)	95% Confidence Interval	
					Lower	Upper
Dry cow therapy policy	Selective therapy		37			
	Blanket therapy		32	86.49	71.23	95.46
			5	13.51	4.54	28.77
Dry cow therapy commencement	drying off first day	5	32			
	during the first week of drying off		8	25.00	11.46	43.40
	one week before the drying off		20	62.50	43.69	78.90
			4	12.50	3.51	28.99
Dry cow therapy modality	IMM Infusion + parenteral injection with or without clinical mastitis		37			
	IMM Infusion + parenteral injection if clinical mastitis		5	13.51	4.54	28.77
	IMM Infusion + parenteral injection with or without clinical mastitis with general symptoms		13	35.14	20.21	52.54
	IMM Infusion only		12	32.43	18.01	49.79
Teat cleaning and scrubbing before IMM infusion	No		37			
	Yes		2	5.41	0.66	18.19
Partial insertion at infusion	No	3	34			
	Yes		24	70.59	52.52	84.90
			10	29.41	15.10	47.48
Teat-dip after IMM infusion and or sealant use	No		37			
	Yes		30	81.08	64.84	92.04
			7	18.92	7.96	35.16

### Dry cow therapy practice

The results show that cleaning and scrubbing of teats before infusion of antibiotics is followed by the majority of practitioners (94.59%). However, only 29.41% of the vets took care that the tube cannula was partially inserted during treatment, while the application of a teat-dip after infusion and/or sealant use was not a regular practice (18.92%). These findings are markedly different from those recorded by McDougall (2003) involving 158 dairy herd owners in the Waikato region (New Zealand), who found that two thirds (65.8%) of them practised a partial insertion of DCT syringe cannula. Furthermore, this author noted that only 15.2% of the farmers did not perform any teat preparation before infusion of DCT, while the vast majority (82.9%) used a teat spray after infusion. The deep insertion of the syringe cannula into the teat canal can cause erosion of the keratin layer inside and thus reduce the effectiveness of the natural defences of the mammary gland. This natural barrier is of vital importance in preventing infections. In addition, some compounds (fatty acids, proteins) naturally present in the keratin layer serve to safeguard the teat canal (Gruet et al., 2001).

### Dry cow therapy efficacy

DCT efficacy should always be tackled according to a holistic approach and take into account various factors related to the management of the drying-off period on the one hand and the environment of dry cows, the presence of microorganisms and the risk of emergence of bacterial resistance on the other hand (Petzer et al., 2009). It is most commonly measured by cure and incidence of new IMIs rates (Bradley et al., 2010).

### Mastitis occurrence after therapy

The results of the survey indicated that healthy cows receiving an antibiotic infusion at dry-off displayed few or no mastitis cases during the dry period and in the first days postpartum (94.6% and 91.9% respectively). However, the frequent occurrence of new IMIs thereafter in cows with mastitis that had been dried off with an antibiotic infusion was assessed by 13.5% of respondents (Table 4).

According to Blowey and Edmondson (2010), when more than one out of twelve cows (8.33%) in the first four weeks of lactation or if somatic cell counts are raised (above 200 000 cells) among heifers at the time of calving and develop mastitis, it is recommended that a screening test be performed, as these results would indicate an environmental origin of infections during the dry period.

In a UK study involving four dairy herds, no clinical mastitis was observed at dry-off in dry-treated cows whereas untreated cows had a significant number of clinical mastitis cases at dry-off and calving (Berry and Hillerton, 2002). According to the investigation conducted by Godden et al. (2003), cows treated on the first day of dry-off with an antimicrobial and an internal teat sealant exhibited a lower prevalence of new IMI after calving compared to those treated with antibiotics alone.

### Performance of bacteriological analyses

The results showed that bacteriological analyses after antibiotic treatment failure were performed systematically by only 5.56% of the surveyed vets while the remainder rarely (25%) or never (58.33%) carried them out. According to the investigation findings of Bertulat et al. (2015), a majority (64.9%) of the farmers revealed that antibiotic treatments undertaken during dry-off were conducted without prior bacteriological examination.

**Table 4.** Efficacy of dry cow therapy on occurrence and recurrence of mastitis during dry and postpartum periods.

Dry cow therapy efficacy	Question choices	Missing data	Frequency (n)	Estimate (%)	95% Confidence Interval	
					Lower	Upper
Occurrence of mastitis at dry-off in healthy cows receiving an IMM infusion of antibiotic	Never		3	8.11	1.70	21.91
	Rarely		32	86.49	71.23	95.46
	Often		2	5.41	0.66	18.19
Occurrence of mastitis during early postpartum in healthy cows receiving an IMM antibiotic infusion at drying-off	Never		6	16.22	6.19	32.01
	Rarely		28	75.68	58.80	88.23
	Often		3	8.11	1.70	21.91
Occurrence of new IMI in mastitic cow receiving an IMM antibiotic infusion at drying-off	Never		6	16.22	6.19	32.01
	Rarely		26	70.27	53.02	84.13
	Often		5	13.51	4.54	28.77
Use of bacteriological analysis in case of mastitis recurrence		1	36			
	Never		21	58.33	40.76	74.49
	Rarely		9	25.00	12.12	42.20
	Often		4	11.11	3.11	26.06
	Always		2	5.56	0.68	18.66



### Factors related to the occurrence and recurrence of mastitis in dry cow infused by intramammary antibiotics (IMM ATB)

To summarize and graphically display the relationship between all variables a two-dimensional diagram (Figure 7) was created using multiple correspondence analysis (MCA). Responses in the same category are plotted close to each other but those in different categories are plotted as far apart as possible.

The two axes retained for the presentation of the data reflect a total inertia of 0.482 (48.25%) of the information contained in the data set submitted to the MCA, 25.67% by dimension 1, 22.58% by dimension 2. The Cronbach's alpha, 0.84 for dimension 1 and 0.81 for dimension 2 (Table 5) exceed the lower limit (0.70) of the acceptable values of alpha Cronbach's alpha, ranging from 0.70 to 0.95 (Tavakol and Dennick, 2011). To represent the intensity with which the variable explains each of the two axes, discrimination measures were established and resumed in Table 5.

**Table 5.** Contributions of variables to the discrimination measures.

Discrimination Measures		Dimension		Mean
		1	2	
Cronbach's Alpha		0.84	0.81	0.83
DCT efficacy	Dry-off occurrence	0.09	0.43	0.26
	Postpartum occurrence	0.21	0.59	0.40
	New IMI	0.34	0.03	0.18
Dry period management	Herd size	0.34	0.54	0.44
	Separation	0.08	0.10	0.09
	Management	0.01	0.06	0.04
	Milk cessation length	0.32	0.25	0.29
	Adapted Ration	0.13	0.16	0.14
Dry approaches for mastitis control	BCS	0.20	0.15	0.18
	Mastitis vaccination use by Farmers	0.14	0.04	0.09
DCT practice	Farmers' request for IMM ATB DCT	0.42	0.23	0.32
	IMM ATB type	0.69	0.80	0.74
DCT practice	Parenteral ATB type	0.73	0.29	0.51
	DCT policy	0.39	0.07	0.23
	DCT commencement	0.30	0.21	0.25
	DCT modality	0.39	0.20	0.30
	Teat cleaning before IMM	0.01	0.11	0.06
	Partial insertion	0.02	0.03	0.03
	Teat-dip after IMM	0.07	0.00	0.03
Active Total		4.88	4.29	4.58

There were no strong differentiating values allocated to each of the obtained dimensions (Table 5 and Figure 7); all discrimination measures were below 0.6 except the maximum value of 0.69 for the first dimension and 0.80 for the second dimension presented both by IMM ATB type and those of Parenteral ATB type (0.73) for the first dimension. Hierarchically, for dimension 1, Parenteral ATB type, Farmers' request for IMM ATB DCT, DCT policy, DCT modality and New IM infection were the most discriminant variables. These variables have large discrimination measures on the first dimension conversely to the second one.

It can be noted that the variables describing the DCT practices, namely Parenteral ATB type, Farmers' request for IMM ATB DCT, DCT policy and DCT modality were discriminating for the occurrence of new cases of mastitis in affected cows that treated with an intramammary infusion of ATB (New IMI).

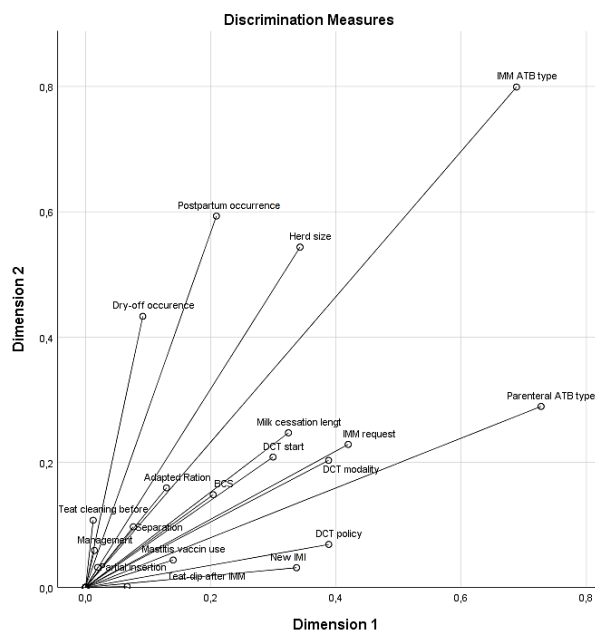
Dimension 2 was mainly influenced by the IMM ATB type (0.80), Postpartum occurrence (0.59), Herd size (0.54) and Dry-off occurrence (0.43). Postpartum occurrence, Herd size and Dry-off occurrence have a large value on the second dimension but

a small value on the first one. However, IMM ATB type has also large value on the first dimension (0.69).

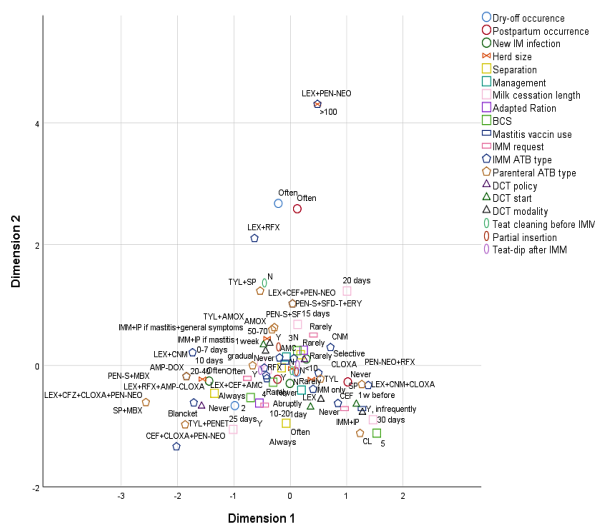
The other variables such as dry management, partial insertion, teat dip after IMM, located very close to the origin, did not discriminate at all in the first two dimensions.

From the joint plot of category points (figure 8), it appears that for the variable New IMI the categories (Never and Often) are far apart. For DCT policy, the category "Blanket" is very far from the category "selective" and yields a large negative discrimination measure along the first dimension. These two variables discriminate better the first dimension than the variables Parenteral ATB type, DCT modality and IMM request with categories that are close together.

The variables Dry off occurrence and Postpartum occurrence with categories (Never and often) that are distant discriminate the dimension 2 better than the variable herd size with categories that are approximate.



**Figure 7.** Discrimination measures plot using Multiple Correspondence Analysis. DCT: dry cow therapy; Dry-off occurrence: Occurrence of mastitis at dry-off in healthy cows receiving an IMM infusion of antibiotic; Postpartum occurrence: Occurrence of mastitis during early postpartum in healthy cows receiving an IMM antibiotic infusion at drying-off; New IMI: Occurrence of new IMI in mastitic cow receiving an IMM antibiotic infusion at drying-off.

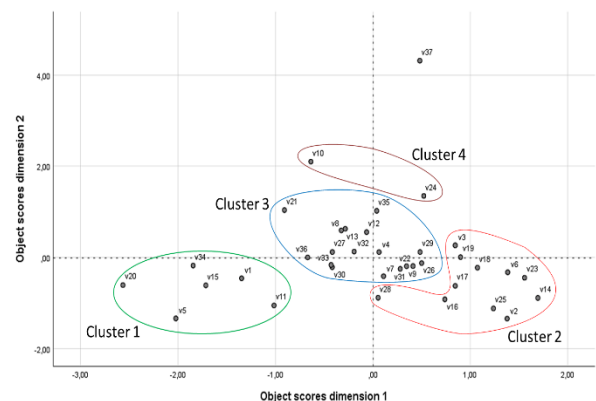


**Figure 8.** Contribution of the questions modalities in the discrimination measures using a two-dimensional Multiple Correspondence Analysis solution.

The use of HCA (Table 6, figure 9) to classify hierarchically the responses into clusters involving the correspondence between categories of variables revealed a notable divergence between the two clusters 1 and 2, which group together different practices including the DCT policy, blanket (66.67% of cluster 1) and selective (100% du cluster 2). These practices are associated with two divergent efficacy statuses of

intramammary infusion of antibiotic to cows with mastitis (rare observation of recurrences in 81.82 of the cases by the vets grouped in cluster 2 compared to the frequent observation of recurrences by the 50% from cluster 1).

Selective DCT has been found to increase the risk of developing intramammary infections (IMI) compared to blanket treatment (RR = 1.34, 95% CI = 1.13, 1.16), if not combined with the use of internal teat sealants (Winder et al., 2019). Similarly, a recent study showed that, in the absence of combination with internal teat sealant, selective DCT was more associated than blanket DCT with the risk of developing new IMI during the dry period and its persistence until calving (Kabera et al., 2021). The meta-regression performed by these authors revealed that the risk of developing IMI during the dry period and at calving, and the risk of developing clinical mastitis in early lactation, as well as the level of milk production and somatic cell count in early lactation did not differ between selective DCT and Blanket DCT as long as an internal teat sealant (65% bismuth subnitrate) was administered to healthy untreated quarters at dry-off. Halasa et al. (2009) reported that the selective DCT, compared to Blanket DCT, provided less protection against new IMI, but better than that observed in cows not receiving a DCT. In addition, the use of internal teat sealants can enhance protection against new IMI during drying off. Furthermore, selective DCT has the advantage of reducing the use of antibiotics during the dry period (Kabera et al., 2021).



**Figure 9.** Clusters of objects scores labeled by respondents using ACH method.

In cluster 1, 66.7% of the veterinarians reported frequent self-medication (requesting IMM antibiotics) by farmers (Table 6). The relationship between this attitude of farmers and mastitis incidence has been reported by Kayitsinga et al. (2017) in eastern USA. These authors found that increased use of intramammary administration (IMA) of antimicrobial drugs by farmers at dry-off and the belief that "bad luck" plays a role in mastitis problems were associated with improvement in the IMA frequency for the treatment of clinical mastitis. As well, Jansen et al. (2009) suggested that mastitis incidence and variation in milk quality (somatic cell count) in Dutch dairy farms were linked to farmers' attitudes. However, the HCA did not confirm a strong relationship between the incidence of new IMI infection and mastitis during the dry period and early lactation with the other variables highlighted by MCA such as DCT modality, antibiotics molecules used as IMM and systemic treatment and herd size (Table 6, Figure 9). In German Holstein dairy cows receiving dry cow therapy, the antibiotic type and

udder tissue status was associated with the bacteriological cure rates while age and health status of the udder seemed to be the major determinants of new IMI infection and clinical mastitis during the dry period and early lactation (Gundelach et al., 2011).

In this section, the analysis of factors influencing the efficacy of antibiotic dry-off therapy (DCT) has been limited to the data acquired from intervening vets and deserves to be extended to more farms and farmers displaying self-medication to provide factual conclusions on possible risk factors for DCT inefficacy.

**Table 6.** Comparison of relevant variables categories within clusters in the two dimensions.

DIMENSIONS	Variables	Categories	Within clusters frequencies (%)				Total (%)
			Cluster 1	Cluster 2	Cluster 3	Cluster 4	
DIMENSION 1	New IMI	Never	16.67	18.18	17.65	0.00	16.67
		Rarely	33.33	81.82	70.59	100	69.44
		Often	50.00	0.00	11.76	0.00	13.89
	Parenteral ATB type	TYL	0.00	66.67	50.00	50.00	48.15
		SP+MBX	25.00	0.00	0.00	0.00	3.70
		TYL+PENET	50.00	0.00	0.00	0.00	7.41
		TYL+SP	0.00	0.00	16.67	50.00	11.11
		PEN-S+MBX	25.00	0.00	0.00	0.00	3.70
	DCT modality	IMM+IP	0.00	45.45	0.00	0.00	13.89
		IMM+IP if mastitis	50.00	0.00	52.94	0.00	33.33
		IMM+IP if mastitis+general symptoms	33.33	9.09	41.18	100	33.33
		IMM only	16.67	45.45	5.88	0.00	19.44
	IMM request	Often	66.67	9.09	47.06	0.00	36.11
		Always	33.33	9.09	0.00	0.00	8.33
DCT policy	Selective	33.33	100	94.12	100	86.11	
	Blanket	66.67	0.00	5.88	0.00	13.89	
DIMENSION 2	Dry-off occurrence	Never	33.33	0.00	5.88	0.00	8.33
		Rarely	66.67	100	88.24	100	88.89
		Often	0.00	0.00	5.88	0.00	2.78
	Postpartum occurrence	Never	0.00	36.36	11.76	0.00	16.67
		Rarely	100	63.64	88.24	0.00	77.78
		Often	0.00	0.00	0.00	100	5.56
	Herd size	<10	16.67	63.64	52.94	0.00	47.22
		10-20	16.67	36.36	47.06	0.00	36.11
		20-40	50.00	0.00	0.00	50.00	11.11
		50-70	16.67	0.00	0.00	50.00	5.56
	IMM ATB type	LEX	16.67	63.64	41.18	0.00	41.67
		CEF	0.00	9.09	0.00	0.00	2.78
		CLOXA	0.00	0.00	5.88	0.00	2.78
		RFX	16.67	0.00	11.76	0.00	8.33
		CNM	0.00	18.18	5.88	50.00	11.11
		AMC	0.00	0.00	5.88	0.00	2.78
		AMP-DOX	16.67	0.00	0.00	0.00	2.78

### Alternatives to antibiotics for dry cow therapy

#### Teat sealants use

A large majority of respondents (71.43%) stated that they did not use teat sealants in their practices, while only 22.86% would use it as a complement to antibiotic therapy. The finding of limited use of this preventive measure in our survey is supported by the results of Bertulat et al. (2015), as only 33.3% of the farmers replied that they had already used internal teat sealants during drying-off. However, the results are in contrast to those obtained by Fujiwara et al. (2018), as 84.9% of the investigated farms used teat sealants during dry-off, with a predominant use of internal sealants alone, by 86.3% of these farms.

A recent Brazilian study carried out by Freu et al. (2020), revealed that the combination of an internal teat sealant with dry cow antibiotic proved its effectiveness in preventing new IMI during the dry period and thus reducing the risk of clinical mastitis occurrence up to 60 days postpartum.

#### Herbal and essential oil use in mastitis therapy

Concerning the substitution of antibiotics by another way of fighting mastitis, the results showed that 77.78% of the veterinarians agreed with the concept of replacing these drugs by an alternative means (Table 7). Indeed, according to the investigation conducted in England, reducing antimicrobial use, as well as the choice of which molecule to adopt for a better

livestock management performance was the second most formulated response by farmers (Higham et al., 2018).

In addition, most of the participants (89.19%) were in favour of using essential oils (aromatherapy) to treat mastitis, with 35.14% replacing antibiotics and 54.05% complementing antibiotic therapy. These results indicate a growing openness to herbal use in preventing and treating mastitis, due to the promising results achieved and the benefits conferred by the absence of side effects (Hamlaoui et al., 2021; Mullen et al., 2014). Nevertheless, this questionnaire highlighted a flagrant lack of knowledge about essential oil-based products marketed in Algeria, since only 29.73% are aware of these products. Furthermore, according to the observations of the vets, the use of plants to treat mastitis was frequently employed by only 5.71% of the farmers (Table 7). In a similar observation

by Higham et al. (2018), out of 135 survey respondents, only 3% referred to natural remedies as alternatives to treatments to reduce or replace the usage of antibiotics. Several studies, nevertheless, have demonstrated the interest and effectiveness of essential oils in the treatment of mastitis in dairy cows. For their part, Neculai-Valeanu et al. (2021) noted that essential oils can be used in the treatment of mastitis in combination with other products because of their ability to cross the skin barrier and thus prove their effectiveness in the field of mastitis treatment.

In conclusion, the application of complementary medicine in the field is not widespread due to limited knowledge and unavailability of regulated preparations.

**Table 7:** Opportunity to apply an alternative to antibiotics in northern Algerian herds.

Alternatives to antibiotics for dry cow therapy	Question choices	Missing data	Frequency (n)	Estimate (%)	95% Confidence Interval	
					Lower	Upper
Use of a teat sealant		2	35			
	No		25	71.43	53.70	85.36
	Yes, sometimes to compliment antibiotics		8	22.86	10.42	40.14
	Yes, to replace antibiotics		1	2.86	0.07	14.92
	Yes, systematically as a compliment to antibiotics		1	2.86	0.07	14.92
Acceptance of an alternative to replace the use of antibiotics in mastitis control	No	1	36	8	22.22	10.12
	yes			28	77.78	60.85
Use of phytotherapy by farmers to control mastitis		2				
	Not at all frequently		18	51.43	33.99	68.62
	Somewhat frequently		4	11.43	3.20	26.74
	Rather infrequently		11	31.43	16.85	49.29
Information on products containing Essential Oil marketed in Algeria for mastitis control			37			
	Yes		11	29.73	15.87	46.98
Acceptance of the use of aromatherapy in mastitis control			37			
	No		4	10.81	3.03	25.42
	Yes, to compliment antibiotics		20	54.05	36.92	70.51
	Yes, to replace antibiotics		13	35.14	20.21	52.54

## CONCLUSION

This survey identified significant deficiencies in the antimicrobial control of mastitis at dry-off. This concerns the non-compliance with advisable zootechnical practices during this period, which could increase the risk of occurring new IMIs. In addition, the poor adherence of farmers to apply proper management practices of antibiotic DCT underlines the urgent requirement for awareness these latter by veterinarians in the areas covered by this study. The use of teat sealants in combination with the antibiotic DCT should be promoted as effective approaches to improve the udder health. This study also highlights the importance of restricting the uncontrolled and selective use of some antibiotic drugs, mainly  $\beta$ -lactams,

exacerbated by farmers' attitudes such as self-medication. The separation of treated animals at drying off from those undergoing lactation would help to avoid the occurrence of antibiotic residues in the collected milk. Finally, there are some interesting prospects for using herbal and aromatherapy as a complementary or palliative approach to control mastitis and reduce antibiotic overuse.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## AUTHOR CONTRIBUTIONS

AH conceptualized the study. MWH, AH and IB carried out the study, AH formally analysed the data, MWH, AH and FRM interpreted the results. MWH, AH and FRM wrote the manuscript. All authors approved the final version of the paper.

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