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The Influence of Dry Period on Milk Production, Dystocia and Calf Mortality in Simmental Reared Under European Temperate Condition

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1 ABSTRACT

The main objective of the study was to evaluate the effects of dry period length on milk production related traits, incidence of dystocia and calf mortality in Simmental dual-purpose breed, in order to set up "alarm" thresholds for better designing of it according to the multiple influential factors. Data included 1149 lactation records collected between 2017 and 2019 from 375 Simmental cows. The factorial ANOVA protocol showed that the dry period length had a significant increase over consecutive years. No significant influence was observed according to the seasonal conditions. A linear regression model was employed to evaluate the influence of dry period length on milk production, incidence of dystocia and calf mortality. The regression model used to evaluate the effects of dry period length showed a significant influence on milk, fat, protein, dystocia incidence and calf mortality. Milk yield, protein yield, dystocia incidence and calf mortality were significantly influenced by the 61-80 days dry period, whilst a dry period less than 40 or longer than 80 days induced losses in milk and protein yield, also increasing the incidence of dystocia and mortality in calves. Current results suggest that ensuring a dry period of 61-80 days will translate into increased performance in dual-purpose cows, as well as streamlining the financial cycles of the farms.

2 INTRODUCTION

Before calving, a dry period is required for cows in order to regenerate the mammary gland (renewal of udder tissue), both at physical and physiological levels (Kuhn *et al.*, 2005). This recovery period allows maximizing the milk production in the subsequent lactation. Drying off in cows forces the stockholders to accept a certain production loss in the current lactation, which is later offset in the subsequent one. There are numerous methods to dry off cows according to different influential factors such as milk yield, parity, season, cow's body condition, spontaneously ceasing lactation or other farm-specific factors. In addition, numerous influential factors can lead to technical errors such as human-dependent errors, incorrect recording of data or extending the lactation in order to get additional milk yield. Generally, for cows, the dry period means a forced cessation of milk production accompanied by painful udder

pressure, hunger, frustration, changes in metabolic balance and an over-all impaired animal welfare. Most often, the dry period length is established based on milk yield. This criterion does not have to be singular, especially in dual-purpose breeds with reduced milk yield compared to specialized milk-breeds. The metabolic differences between these two productive types require appropriate techniques in order to maximize the breeding efficiency. Numerous studies were aimed at optimizing the dry period length and its impact on production related traits. Contradictory outcomes in different studies generated numerous controversies. Particular emphasis was placed on the effect of the dry period length on productive efficiency, generally neglecting the correlation between it and breed or productive type. In addition, the link between the length of the dry period and animal welfare, represented by the cows' incidence of difficult calving and calf survival rate, has often been omitted. Numerous previous studies have shown that, generally, at least 40 days of dry period is optimal, while an extended dry period over 80 days could lead to a negative impact on milk production and animal welfare. In this respect, the quantification of the effects of days dry on milk production related traits and animal welfare is critical for the setting of dry period length. The effects of extreme lengths of dry periods (less than 40 and over 80 days) were quantified according to milk production, post-partum energy balance or animal welfare condition (Zobel *et al.*, 2015). The results obtained revealed that a dry period less than 40 days or more than 70-80 days was associated with reduced milk yield and amount of chemical components in the subsequent lactation (Annen *et al.*, 2004; Kuhn *et al.*, 2007, Sawa *et al.*, 2012). An increased interest has been expressed in shortening or omitting the dry period in cows. The results were often inconsistent with previous results, creating substantial debates. For example, different studies have shown that shortening the length of the dry period may result in a lower milk production, while improving its chemical composition (Rémond *et al.*, 1997; Andersen *et al.*, 2005; Soleimani *et al.*, 2010). In the subsequent lactation, the milk yield dynamics vary according to the dry period length, decreasing up to 4.5% for short and 19% for no dry period, increasing the protein content, whereas fat content appeared unaffected (Van Knegsel *et al.*, 2013). These were also consistent with other studies, which found a significant decrease in milk yield (25%), fat (24%) and protein content (20%) for cows with no dry period preceding calving (Sawa *et al.*, 2012). Omitting the dry period decreased milk yield and its chemical composition up to 40% (Andersen *et al.*, 2005; Roberto *et al.*, 2010). Other studies recorded no significant adverse effects on milk production and chemical composition for cows with a short dry period (Gulay *et al.*, 2003). The impact of dry period length at the farm level should be evaluated according to multiple factors. Shortening or omitting the dry period improves the metabolic status, health, reduces veterinary costs improves fertility (Inchaisri *et al.*, 2010), improves the calf survival rate and mitigates the environmental impact through reducing the greenhouse gas emissions (Lesschen *et al.*, 2011; Weiss and Leip, 2012; Will *et al.*, 2015). Shortening or omitting the dry period could be accompanied by a decreased milk production with a concomitant change in the food ration. In this respect, a lower milk yield could be matched by a reduction in energy density of the lactation ration (Garnsworthy, 2004). These changes can have an important influence on the level of greenhouse gas emissions produced (Van Middelaar *et al.*, 2013). Shortening or omitting the dry period also improves metabolic health and could lengthen the productive life of cows, which would dilute the greenhouse gas emissions related to the rearing technology applied (Van Middelaar *et al.*, 2014). Studies of the effects of dry period length on production and animal welfare related traits were conducted mainly on specialized dairy breeds. Dual-purpose breeds were somewhat overlooked. Simmental is the second largest cattle breed in the world after the Holstein-

Friesian; moreover, in Romania, it has an important role in the agricultural economy. The main objective of the current research was to evaluate the effects of dry period length on milk production related traits, incidence of dystocia and calf mortality in the Simmental dual-purpose breed, reared under temperate European conditions.

3 MATERIALS AND METHODS

Use of animals and the procedures performed in this study were approved by the Scientific and Ethics Committee of the Research and Development Station for Bovine Arad of the Academy for Agricultural and Forestry Sciences, Decision no. 51 issued on November 11, 2015. In addition, the research activities were performed in accordance with the European Union's Directive for animal experimentation (Directive 2010/63/EU). Location: The study was carried out at the Research and Development Station for Bovine Arad, Romania (location: 46° 10' 36" N, 21° 18' 4" E, 107 m altitude, 582 mm annual average rainfall 21°C / -1°C average temperature corresponding to summer / winter seasons). Cows that were included in the research herd were managed under a loose system with zero grazing and were between 1st and 5th lactation, with age and parity balanced within the herd. Cows were kept on deep straw bedding, with a space allowance of 9 m^2 in the resting area and free access to forage, water and outside paddocks. They received a daily feed ration made of 15 kg of fresh cut alfalfa, 15 kg of green fodder, 12 kg corn silage, 6 kg of alfalfa hay and 4 kg of concentrates starting from spring until late autumn, and a ration made of 15 kg alfalfa, 25 kg of corn silages, 6 kg of alfalfa hay and 5 kg of concentrates during winter. Cows were fed twice per day and had a feeding space allowance of 70-75 cm / head. They were housed in groups of 70 animals, according to their productivity. Newborn calves are separated from their dams immediately after calving, kept in individual pens up to seven days of age. Between 8 and 90 days, calves are kept in common pens (6 heads / stall) with free access to the resting area (0.5 m^2 / head), moving area (1.1 m^2 / head) and watering area (0.03 m^2 / head). Milk feeding in the first three days is with maternal colostrum and the next four days raw milk from his own mother. From the eighth day, mixed raw milk is administered from the tank. Milk feeding is made in two daily portions, every 12 hours (at 06:00 and 18:00). In parallel, starting from the 4th day of life, calves receive water, alfalfa hay and concentrated feed administered *ad libitum* until day 60, after which the access is restricted for concentrated feed. All cows were included in the Official Performance and Recording Scheme. Cows were milked twice per day (starting at 5:00 and 17:00) in a "herringbone" milking parlour (2 by 14 units). The milking parlour was equipped with AfiMilk 3.076 A-DU software (Afikim, Israel). Furthermore, all cows were fitted with AfiTag pedometers (Afikim, Israel) for production traits, oestrous and specific diseases detection. Production and milk quality data (milk yield, fat yield and percentage, protein yield and percentage) were collected from the results of the official performance recordings, according to the standardized International Committee for Animal Recording (ICAR) guidelines (2012), and with the proprietary recording system AfiMilk 3.076 A-DU software (Afikim, Israel). A data set for 1149 lactations, recorded between 2017 and 2019, was analysed for estimation of the effects of the dry period length on production related traits, incidence of dystocia and calf mortality. Data were cleaned by eliminating human recording errors (outliers), redundant entries and incomplete observations. Data from cows with abortions or with lactation length less than 250 were discarded. Also, cows with parity greater than 5 were eliminated from the analysis, as well as cows with no information for studied traits. Grubbs' test (Grubbs, 1969) was employed in order to detect outliers in a univariate date set that follows an approximately normal distribution.

$$G=\frac{\bar{y}-ymin}{s} \qquad G=\frac{\bar{y}-ymax}{s}$$

where: $\bar{y}$=sample mean; s=standard deviation; ymin=minimum value; ymax=maximum value

When suspecting more than one outlier, the Tietjen-Moore test was used to identify and reject them (Tietjen and Moore, 1972).

$$Lk=\frac{\sum_{i-1}^{n-k}(yi-yk)^2}{\sum_{i-1}^{n}(yi-\bar{y})^2}$$

where: k=exactly *k* outliers in the data set; n=number of data points sorted from smallest to largest; yi=the *i*th largest data value; $\bar{y}$=mean of the full sample; $\bar{y}$k=sample mean with largest *k* point deleted.

The dry period was grouped into 4 classes ≤40, 41-60, 61-80 and >80 days. The effect of year and season on the dry period length was assessed using a factorial ANOVA protocol. Differences were tested using Tukey test.

$$DP = Y_i + S_j + CD_k + e_{ijk}$$

where: DP is the dry period length; Y=effect of year (2017, 2018, 2019); S=effect of season (summer, winter); CD=effect of calving difficulty (eutocia, dystocia).

The analysed data were expressed as least square means and standard error of mean. Incidence of dystocia and stillborn calves were recorded according to dry period class in order to set up "alarm" thresholds for better designing the optimal dry period length according to the multiple influential factors. The proportion of difficult calving and stillbirths according to dry period length was investigated using Chi-squared test. All the statistical inferences were carried out using the software package Statistica (StatSoft Inc., Tulsa, OK USA) (Hill and Lewicki, 2007). Decisions about the acceptance or rejection of statistical hypothesis have been made at the 0.05 level of significance. A linear regression model was employed to evaluate the influence of dry period length on milk production traits, incidence of dystocia and calf mortality.

$$Y = a + b \times DP$$

where: Y is either one of the milk production traits (milk yield, fat/protein yield, fat/protein percentage); dystocia incidence percentage; or calf mortality percentage.

To determine the effects of dry period on performance, the trait of interest would be set up as the dependent variable and the dry period as an independent variable in the model. To determine how various influential factors affect the length of dry period, the opposite is done: the dry period becomes the dependent variable and the influential factors included in the study are the independent variables of interest.

4 RESULTS

The assessment of the productive parameters at the herd level was presented in Table 1.

Table 1 Least squares means (LSM) ±standard errors (St. Err.) for dry period length and production

Trait	Number of records	LSM±Std. Err.	Coefficient of variation (%)
Dry period (days)	1149	65.97±0.42	21.72
Milk yield (kg)	1149	6265.42±33.77	18.27
Fat yield (kg)	1149	283.4±1.74	20.89
Protein yield (kg)	1149	212.18±1.43	22.97
Fat percentage (%)	1149	4.53±0.01	11.75
Protein percentage (%)	1149	3.38±0.01	13.37

The current research was conducted on 1149 dry period records, out of which 3.65% had less than 40 days length, 33.42% had 41-60 days, 44.21% had 61-80 days and 18.72% had more than 80 days, respectively. However, both dry period intervals, too short (≤40 days) and too long (>80 days), were less frequent. Statistical analyses regarding dry period length were performed

according to year and season (Table 2). The results highlighted differences ($P \leq 0.01$, F=24497.84) over the years (64.35±0.72, 66.23±0.72 and 67.39±0.74 days for years 2017, 2018 and 2019, respectively). The shortest dry period was recorded in year 2017, compared to year 2018 ($P \leq 0.01$, F=3.36) and year 2019 ($P \leq 0.01$, F=8.58). No influence was recorded according to the season in order to induce differences in dry period length, 65.89±0.57 *vs.* 66.42±0.62 days ($P > 0.05$, F=0.94) for summer and winter, respectively.

Table 2 Least squares means (LSM) ±standard errors (St. Err.) for dry period length according to influential factors

Source of variation	Number of records	LSM±Std. Err
Year		
2017	388	64.35±0.72[a]
2018	391	66.23±0.72[ba]
2019	370	67.39±0.74[ca]
Season		
Summer	599	65.89±0.57[a]
Winter	550	66.42±0.62[a]

[a,b,c] Mean values with different superscripts differ significantly at $P \leq 0.05$

In order to establish the potential influence of dry period length on productive traits, incidence of dystocia and calf mortality, a linear regression model was employed (Table 3). Statistical analyses showed that the dry period exerted influence on milk ($P \leq 0.001$, F=10.58), total fat ($P \leq 0.01$, F=7.2) and protein yields ($P \leq 0.01$, F=6.29), on dystocia incidence ($P \leq 0.05$, F=3.85) and calf mortality ($P \leq 0.01$, F=9.12), in the subsequent production-reproduction cycle. No obvious effects were found in terms of fat ($P > 0.05$, F=0.053) and protein ($P > 0.05$, F=0.02) percentages.

Table 3: Regression model for estimate of the dry period length effect on milk traits, calving difficulty and calf mortality

N=1149	b*	Std. Err. Of b*	t	*P*-value
Intercept			24.95	0.001
Milk yield	0.096	0.029	2.28	0.001
Fat yield (kg)	0.078	0.029	2.683	0.007
Protein yield (kg)	0.073	0.024	2.508	0.01
Fat percentage (%)	-0.067	0.02	-0.23	0.81
Protein percentage (%)	-0.0042	0.02	-0.144	0.88
Incidence of dystocia	0.064	0.18	2.714	0.037
Calf mortality	0.055	0.11	1.455	0.004

Dynamics of productive traits, incidence of dystocia and calf mortality were assessed according to dry period length (Table 4).

Table 4 Effect of dry period length on milk production traits, calving difficulty and calf mortality

Dry period length (days)	Dry period length	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat (%)	Protein (%)	Dystocia calvings (%)	Calf mortality (%)
≤40	37.54±2.58	6039.7±157.64^{a}	278.45±8.08^{a}	202.1±6.43^{a}	4.61±0.06^{a}	3.36±0.08^{a}	11.9^{a}	2.33^{a}
41-60	53.39±5.96	6142.11±60.08^{ba}	277.32±2.97^{b}	208.1±2.6^{b}	4.53±0.02^{a}	3.38±0.02^{a}	15.6^{ba}	2.34^{b}
61-80	68.53±5.48	6347.48±46.52^{cab}	286.9±2.51^{cab}	214.85±2.05^{cab}	4.52±0.02^{a}	3.38±0.01^{a}	16.9^{ca}	2.36^{c}
>80	87.91±4.86	6335.84±88.54^{dab}	286.96±4.57^{dab}	215.15±3.47^{dab}	4.54±0.04^{a}	3.39±0.02^{a}	21.8^{dabc}	3.25^{dabc}

^{a,b,c,d} Mean values with different superscripts differ significantly at $P \leq 0.05$

A strong and positive correlation was found between dry period length and milk production associated with the subsequent lactation. Statistical analyses highlighted an increased milk yield related to prolonged dry period for the first three intervals. Thus, the lowest milk production was associated with the shortest dry period. Milk yield was maximized with 61-80 days dry. Cows with 61-80 days dry produced 307.78 kg more milk compared to cows with less than 40 days dry (P=0.007, F=4.22) and 205.37 kg more milk compared to cows with 41-60 dry ($P \leq 0.01$, F=5.09). Prolonging the dry period to more than 80 days lead to a slight decrease in milk production (-11.6 kg, $P>0.05$, F=0.041), highlighting a downward trend in this respect. o differences were observed in terms of fat ($P>0.05$, F=0.053) and protein ($P>0.05$, F=0.02) percentages, despite a slight increase in terms of protein percentage for cows framed in over 40 days dry intervals. The fat percentage followed an opposite tendency compared to milk production. Lower milk production associated with cows with less than 40 days dry allowed an increased fat percentage compared to others, however, the differences proved to be insignificant ($P>0.05$, F=0.022). Dynamics of milk production led to significant differences in terms of fat and protein yields, according to dry period length. Thus, fat and protein yields were maximized at 61-80 and over 80 days dry periods, whereas cows with dry period intervals less than 60 days recorded decreased values for these traits. The lowest fat yield was recorded for cows having 41-60 days dry. Short dry periods (less than 60 days) led to a loss of 9.58 kg fat compared to cows with 61-80 days dry period ($P \leq 0.05$, F=7.58) and 9.64 kg fat less compared to cows with over 80 days dry period ($P \leq 0.05$, F=11.27). A very similar trend was observed in terms of protein yield. The lowest value was recorded for cows with less than 40 days of dry period compared to those with 61-80 days and over 80 days dry period, respectively. The interval between 61-80 days allowed an increased protein yield (12.75 kg, $P \leq 0.05$, F=9.11). Also, a dry period over 80 days allowed a similar increase of 13.05 kg ($P \leq 0.05$, F=9.76) compared to cows with a very short dry period. No significant differences were recorded in terms of protein yield between cows with 61-80 and cows with over 80 days dry period, except for a slight decrease in milk production, which did not justify the extension of the dry period. The current study found that the most advantageous length of dry period in term of milk, fat and protein in the subsequent lactation, was 61-80 days period. There is limited information on the effect of dry period length on the incidence of dystocia and calf mortality, because large animal

numbers are required in order to have sufficient statistical information to detect the treatment differences. The current study was devised in order to provide initial data regarding these issues. Incidence of dystocia was assessed according to dry period length. Statistical analyses found a significant effect of dry period length on this parameter. The incidence of dystocia increased with the dry period length. The lowest incidence of dystocia was associated with the shortest dry period length, while cows with more than 40 days of dry period recorded an increased incidence of dystocia. The incidence of dystocia associated with 61-80 days dry period increased by 0.16% and 0.08% compared to cows with less than 40 days and 41-60 days dry periods, respectively. Prolonged dry periods longer than 80 days led to an increased incidence of dystocia by 0.25% per day. The rate of dystocia did not differ for cows with 41-60 days and 61-80 days of dry period (P>0.05, F=0.027). However, dystocia was more frequent in cows with dry periods longer than 80 days compared to those with shorter dry periods (P≤0.01, F=5.367), probably due to the increased size of the calves. In terms of calf mortality, no differences were recorded (P>0.05, F=0.522) for less than 40 days, 41-60 days and 61-80 days dry period lengths, respectively. Prolonged dry periods longer than 80 days led to an increased mortality in calves by 0.001 to 0.04% per day.

5 DISCUSSION

The average dry period length found in this study was higher (65.97 days) than the one found by Boujenane (2019), who established an average of 49.8 days (Boujenane, 2019). The current average dry period length falls in the prescribed intervals (50-70 days), with respect to proper practices for dual-purpose breeds and in the accepted average of dry period length used in practice in order to maximize the milk production (Sorensen & Enevoldsen, 1991). In this respect, the average dry period length turned out to be comparatively shorter than the average value associated to milk specialized breeds found by Hossein and Mohit (2013), that is over 100 days length in Holstein cows (Hossein and Mohit, 2013). Both, shortening or prolongation of dry period led to serious problems in terms of production, gestation and mammary disease, metabolic stress and not the least to an inappropriate genetic evaluation of animals which have dealt with a standard 305-days lactation model (Jensen, 2001). During recent years, studies have shown health benefits due to an improved metabolic balance (Rastani *et al.*, 2005; Van Knegsel *et al.*, 2013) and economic benefits based on shortening or even omitting the dry period. Milk yield has not been affected in some of these studies (Bachman and Schairer, 2003); while in others a shorter dry period has resulted in lower milk yield (Steeneveld *et al.*, 2014). Compared to a usual dry period, shortening and omitting it could increase the milk protein content, whereas fat content appears unaffected. Generally, the production losses due to inappropriate dry period length could be compensated by management procedures such as increased milking frequency or feeding techniques able to modulate the mammary cell proliferation. The negative effects of omission of the dry period decreased when no dry period was applied over multiple subsequent lactations (Kok *et al.*, 2017). However, the optimum dry period length was based on previous studies, so the data are not free from criticism. In terms of breed, the most studies of short dry period effects have been performed on Holstein cows, while outcomes about the effects of a short dry period in dual-purpose breeds need to be further studied. Inbreeding in cows led to an increased production performance over the studied years. Improved management and feeding conditions could be serious reasons for this milk yield dynamic. It could be argued that the differences among years may be related to management and the differences in management among years could be the most important factor affecting milk yield, lactation and dry period lengths. In order to plan the length of dry

periods, the most common system applied in most of the farms is based on production performance. Taking into account that the current study was performed on 1149 records from 375 cows, over several consecutive years, cows changed their parity within this period. Changing cows' parity proved to be the main cause of the differences recorded regarding the dry period length between the studied years. These results are consistent with other previous studies (Kuhn *et al.*, 2007), which observed that the most notable effect of parity on dry period length was 3 to 5 fewer days for primiparous than multiparous cows. Conversely, Funk *et al.*, (1987) have investigated whether the effect of dry period length on the subsequent lactation depends on parity and recorded either no or only small interactions (Funk *et al.*, 1987). Also, Watters *et al.*, (2008) found that, as cows increase in lactation number, fewer days dry are required to maximize milk yield during the subsequent lactation (Watters *et al.*, 2008). The differences between the dry period length in the first and later lactations could be due to the greater persistency of first lactation (Rekik *et al.*, 2003). However, increasing the cow's productive performances with the parity led to a prolonged dry period over the years, with negative effect on calving interval and efficiency of the farm. It is well known that milk production is very sensitive to seasonal variations, with significant differences between warm and cold seasons. Moreover, the seasonal variation affects the lactation length. According to season, the milk yield is, generally, significantly higher in winter compared to the summer season. In order to renew the cows' udder function and favour the mammary cell proliferation, a longer dry period was required. Cows that calved from October to March had a longer dry period than cows calved from April to September. An insignificant difference of 0.53 days longer dry period of cows calved in winter was observed. The results are similar to previous studies, which found that summer calved cows had a shorter dry period than winter calved cows (Kuhn *et al.*, 2007, Boujenane, 2019). Conversely, Naceur *et al.*, (2012) found similar lengths of dry period according to season (Naceur *et al.*, 2012). No interaction between parity and dry period length on postpartum milk yield was recorded in a study conducted by Andrée *et al.*, (2018). In the current study, the dynamic of dry period length matched the drying off system applied, based on productive performances. There is a strong connection between the magnitudes of mammary turnover, apoptosis and milk loss, in shortening or omitting the dry period. The cell turnover proved to be essential in order to reach the high milk yield. Apoptosis proved to be the process that best explains the milk yield decrease (Accorsi *et al.*, 2002). An inappropriate process of apoptosis leads to a reduction in milk yield and persistency of lactation, due to greater numbers of older mammary cells that get into the subsequent lactation with fewer chances to survive longer during the whole lactation. In this respect, an optimal dry period length is required. It is commonly accepted that a reduction of the dry period exerts adverse effects on milk yield. An accentuated individuality in terms of cows' adaptability and response to the dry period length was highlighted. Generally, cows with reduced dry period length recorded loss in milk, the lowest milk production being associated to the shortest dry period. These results proved to be in agreement with other studies, which found similar tendencies. In this sense, a study conducted by Annen *et al.*, (2004) on partial lactation recorded 24% loss milk yield (Annen *et al.*, 2004). Different losses in milk yield were reported, 9.2% (Bernier-Dodier *et al.*, 2010), 18.9% (Gulay *et al.*, 2005), or 10% (Church *et al.*, 2008). Also, prolonged dry period led to a decrease in milk yield (Sawa *et al.*, 2012). However, the decreasing milk yield tendency remains obvious, as there are no studies that recorded an increasing trend. In contrast, other studies recorded no significant adverse effects of shorter dry period length on milk yield (Jolicoeur *et al.*, 2009; Klusmeyer *et al.*, 2009). There have been many recent discussions about whether the dry period is necessary, with studies showing that omitting the dry period improves energy

balance, health and fertility in the next lactation (Andersen *et al.*, 2005). The relationships between dry period length and metabolic status, disease incidence and fertility have rarely been evaluated. The potential that cow health and fertility could be improved by shortening or even omitting the dry period require a re-evaluation for modern cows with improved metabolism and high milk yield. A significant 5-25% loss in milk yield for cows with very short or no dry period was recorded (Sawa *et al.*, 2012). Shortening the dry period resulted in improved energy balance in early lactation whereas omitting the dry period resulted in absence of a negative balance during the first 2 months of lactation compared to a conventional dry period (Rastani *et al.*, 2005). Several studies have reported improved body condition scores (Gulay *et al.*, 2003; Schlamberger *et al.*, 2010) or reduced body condition score loss (Rastani *et al.*, 2005; Pezeshki *et al.*, 2008) for cows with shortened or omitted dry period, with effects on milk yield. However, significant changes in feed intake of cows after short or no dry period have not been observed according to Gulay *et al.*, 2003 and Rastani *et al.*, 2005, which concluded that a significant increase in milk yield is not mandatory. Our results are in agreement with those obtained by Sorensen and Enevoldsen (1991) and Kuhn *et al.*, 2006 who reported significant loss of fat and protein yields for cows with short dry period (20-30 days) (Sorensen and Enevoldsen, 1991; Kuhn *et al.*, 2006). Moreover, Sorensen and Enevoldsen (1991) found no difference in fat and protein yield between cows with optimal and prolonged dry period length, being in the same line with our results (Sorensen & Enevoldsen, 1991). In this respect, daily losses of 0.03 kg fat and 0.04 kg protein were recorded. Our results proved to be lower than those of Kuhn *et al.*, (2006), who found a daily loss of 0.22 kg for fat yield in cows with 20 days of dry period (Kuhn *et al.*, 2006). A slight increase in fat percentage was recorded for cows with less than 40 days of dry period compared to their counterparts with longer intervals, the differences being insignificant. Contrary to our results, Gulay *et al.*, (2003) reported no difference in milk fat percentage and milk fat yield for cows with 30 and 60 days of dry period (Gulay *et al.*, 2003). Remond *et al.*, (1992) reported no difference in milk fat yield from cows with no dry period compared to a 60 days dry period (Remond *et al.*, 1992). Also, they reported an increase in milk protein yield from cows with no dry period compared to cows with 60-days of dry period. Based on our data, shortening the dry period does not appear to affect fat and protein percentages, but a smaller volume of secreted milk induces the current differences in fat and protein yield. A strong and significant correlation was found between the length of dry period and body condition losses in numerous studies (Gulay *et al.*, 2003; Rastani *et al.*, 2005). In this respect, cows averaging 60 days of dry period lose more body condition postpartum compared to those with 30 days of dry period length. The lower loss in body condition could be the main reason in order to a similar level of milk components both for cows with short or prolonged dry period lengths. In this situation, the differences recorded in terms of fat and protein yields occurred only due to the milk production. Moreover, Remond *et al.*, (1997) found that cows with no dry period gained 24 kg of body weight compared to cows with 60 days of dry period, which lost 28 kg of body weight, being unable to produce more milk, fat and protein (Remond *et al.*, 1997). Previous studies on disease incidence in cows in the subsequent lactation after a short or no dry period referred to risk of ketosis, mastitis, metritis and retained placenta. For cows with a short dry period, the incidence of these diseases was not significantly different from those cows with a conventional dry period (Rastani *et al.*, 2005; Schlamberger *et al.*, 2010). Atashi *et al.*, (2013) recorded a relationship between dry period length, calf birth weight and incidence of dystocia. Cows with short dry period length delivered calves with smaller birth weight compared to cows with longer dry periods, even if the differences were not significant (Atashi *et al.*, 2013). Also, the highest incidence of dystocia

was associated with cows with prolonged dry period, over 60 days. Enevoldsen & Sorensen (1992) reported similar results, associating an increased incidence of dystocia to cows with 70 days dry period compared to cows with conventional (49 days) or short dry period (28 days) (Enevoldsen & Sorenses, 1992). Prolonged dry period is most often associated to both short lactation length and gestation length. Also, there was a linear relationship between gestation length and calf birth weight. Nogalski & Piwczyński (2012) reported a linear relationship between gestation length and calf birth weight (Nogalski & Piwczyński, 2012). The longer the gestation, the greater the birth weight of the calf, which could lead to serious difficulty of calving. Prolonged dry period associated to a short lactation may increase dystocia through foetal oversize. Conversely, Pezeshki *et al.*, (2007) found no differences regarding the incidence of dystocia in cows with short or longer dry period (Pezeshki *et al.*, 2007). An increased incidence of dystocia is known to lead to an increased rate of mortality in the calf, which is in agreement with our results.

6 CONCLUSION

The dry period length averaged 65.97 days in Simmental dual-purpose breed reared under temperate European conditions. Year of calving exerted a significant effect on dry period length, while no interaction between season of calving and dry period length was recorded. However, the winter calving cows had the longer dry period. The length of dry period had a significant influence on milk, fat and protein yield, and on the incidence of dystocia and rate of calf mortality. No significant influences were recorded on fat and protein percentages. The most favourable dry period length in terms of milk, fat and protein yield was 61-80 days. Shortening and extending the dry period led to a decrease in milk yield. Shortening the dry period led to a significant decrease in terms of fat and protein yield, while extended dry period led to slight but insignificant increasing of these parameters. The incidence of dystocia rises as the dry period length increases, becoming critical for intervals of over 80 days. Mortality in calves proved to be similar for dry periods shorter than 80 days, being considered critical in cows with over 80 days dry period. The impact of dry period length according to breed, rearing conditions, environmental conditions and production level must be further investigated in order to establish results that are more accurate.

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8 Conflict of interest declaration

The authors declare no conflict of interest.

9 REFERENCES

Accorsi PA., Pacioni B., Pezzi C., Forni M., Flint DJ. and Seren E. 2002. Role of prolactin, growth hormone and insulin-like growth factor I in mammary gland involution in the dairy cow. J. Dairy Sci. 85: 507–513.

Andersen JB., Madsen TG., Larsen T., Ingvartsen KL. and Nielsen MO. 2005. The effects of dry period versus continuous lactation on metabolic status and performance in periparturient cows. J. Dairy Sci. 88: 3530-3541.

Andrée OE., Omazic A., Olsson I., Båge R., Emanuelson U. and Holtenius K. 2018. Effects of dry period length on milk production and energy balance in two cow breeds. Animal, 12(3): 508-514.

4. Annen EL., Collier RJ., McGuire MA., and Vicini JL. 2004. Effects of dry period

length on milk yield and mammary epithelial cells. J. Dairy Sci. 87: 66-76.

Atashi H., Zamiri MJ., and Dadpasand M. 2013. Association between dry period length and lactation performance, lactation curve, calf birth weight, and dystocia in Holstein dairy cows in Iran. J. Dairy Sci. 96(6): 3632-3638.

Bachman KC. and Schairer ML. 2003. Invited review: Bovine studies on optimal lengths of dry periods. J. Dairy Sci. 86: 3027-3037.

Bernier-Dodier P., Delbecchi L., Wagner GF., Talbot BG. And Lacasse P. 2010. Effect of milking frequency on lactation persistency and mammary gland remodeling in mid-lactation cows. J. Dairy Sci., 93: 555-564.

Boujenane I. 2019. Factors Affecting the Dry Period Length and Its Effect on Milk Production and Composition in Subsequent Lactation of Holstein Cows. Iran. J. Appl. Anim. Sci. 9(2): 229-234.

Church GT., Fox LK., Gaskins CT., Hancock DD. and Gay JM. 2008. The effect of a shortened dry period on intramammary infections during the subsequent lactation. J. Dairy Sci., 91: 4219-4225.

Enevoldsen C. and Sørensen JT. 1992. Effects of dry period length on clinical mastitis and other major clinical health disorders. J. Dairy Sci. 75: 1007-1014.

Funk DA., Freeman AE. and Berger PJ. 1987. Effects of previous days open, previous days dry, and present days open on lactation yield. J. Dairy Sci. 70: 2366-2373.

Garnsworthy PC. 2004. The environmental impact of fertility in dairy cows: a modelling approach to predict methane and ammonia emissions. Anim. Feed Sci. Technol. 112(1): 211-223.

Grubbs F. 1969. Procedures for Detecting Outlying Observations in Samples, Technometrics, 11(1): 1-21.

Gulay MS. Hayen MJ., Bachman KC., Belloso T., Liboni M. and Head HH. 2003. Milk production and feed intake of Holstein cows given short (30-d) or normal (60-d) dry periods. J. Dairy Sci. 86: 2030-2038.

Gulay MS., Hayen MJ., Head, HH., Wilcox CJ. and Bachman KC. 2005. Milk production from Holstein half udders after concurrent thirty- and seventy-day dry periods. J. Dairy Sci., 88: 3953-3962.

Hill T. and Lewicki P. 2007. Statistics: Methods and Applications, Stat Soft, Tulsa, OK, USA

Hossein-Zadeh NG. and Mohit A. 2013. Effect of dry period length on the subsequent production and reproduction in Holstein cows. Span. J. Agric. Res. 11(1): 100-108.

Inchaisri C., Jorritsma R., Vos PLAM., van der Weijden GC. and Hogeveen H. 2010. Economic consequences of reproductive performance in dairy cattle. Theriogenology. 74: 835–46.

Jensen J. 2001. Genetic evaluation of dairy cattle using test-day models. J. Dairy Sci. 84: 2803–2812.

Jolicoeur MS., Brito AF. Pellerin D., Lefebvre D., Berthiaume R. and Girard CL. 2009. Short dry period management improves peripartum ruminal adaptation in dairy cows. J. Dairy Sci., 92 (E-Suppl. 1): 333.

Klusmeyer TH., Fitzgerald.C., Fabellar AC., Ballam JM., Cady RM. and Vicini JL. 2009. Effect of recombinant bovine somatotropin and a shortened or no dry period on the performance of lactating dairy cows. J. Dairy Sci., 92: 5503-5511.

Kok A., van Knegsel ATM., van Middelaar CE., Engel B., Hogeveen H., Kemp B., and de Boer IJM. 2017. Effect of dry period length on milk yield over multiple lactations. J. Dairy Sci. 100: 1–11.

Kuhn MT., Hutchison JL., and Norman HD. 2005. Minimum days dry to maximize milk yield in subsequent lactation. Anim. Res. 54: 351–367.

Kuhn TM., Jana LH. and Norman HD. 2006. Effects of length of dry period on yields of milk fat and protein, fertility and milk somatic cell score in the subsequent

lactation of dairy cows. J. Dairy Res. 73: 154–162.

Kuhn MT., Hutchison JL., and Norman HD. 2007. Dry period length in US Jerseys: Characterization and effects on performance. J. Dairy Sci. 90: 2069-2081.

Lesschen JP., van den Berg M., Westhoek HJ., Witzke HP. and Oenema O. 2011. Greenhouse gas emission profiles of European livestock sectors. Anim. Feed Sci. Technol. 166–167: 16–28.

Naceur M., Mahdi B., Saoussen, F., Yosra R., Satinder KB. and Mohamed BH. 2012. Effects of Environmental Factors on Milk Yield, Lactation Length and Dry Period in Tunisian Holstein Cows, Milk Production - An Up-to-Date Overview of Animal Nutrition, Management and Health, Narongsak Chaiyabutr, IntechOpen.

Nogalski Z. and Piwczyński D. 2012. Association of length of pregnancy with other reproductive traits in dairy cattle. Asian-Australas. J. Anim. Sci. 25(1): 22-7.

Pezeshki A., Mehrzad J., Ghorbani GR., Rahmani HR., Collier RJ. and Burvenich C. 2007. Effects of short dry periods on performance and metabolic status in Holstein dairy cows. J. Dairy Sci. 90: 5531-5541.

Pezeshki A., Mehrzad J., Ghorbani GR., De Spiegeleer,B., Collier RJ. and Burvenich C. 2008. The effect of dry period length reduction to 28 days on the performance of multiparous dairy cows in the subsequent lactation. Can. J. Animal Sci. 88: 449–456.

Rastani RR., Grummer RR., Bertics SJ., Gumen A., Wiltbank MC., Mashek DG. and Schwab MC. 2005. Reducing dry period length to simplify feeding transition cows: milk production, energy balance, and metabolic profiles. J. Dairy Sci. 88: 1004–1014.

Rekik B., Gara A.B., Hamouda M.B. and Hammami H. 2003. Fitting lactation curves of dairy cattle in different types of herds in Tunisia. Livest. Prod. Sci. 83: 309–315.

Rémond B., Kérouanton J. and Brocard V. 1997. The effect of reducing or omitting the dry period on the performance of dairy cows. INRA Prod. Anim 10: 301–333.

Remond B. Ollier A. and Miranda G. 1992. Milking of cows in late pregnancy: milk production during this period and during the succeeding lactation. J. Dairy Res. 59: 233–241.

Roberto M., Lieta M., Lucia B., Gianfranco G. and Giovanni B. 2010 Omission of dry period and effects on the subsequent lactation curve and on milk quality around calving in Italian Holstein cows. Ital. J. Anim. Sci. 9(1): 101-108.

Sawa A., Bogucki M. and Neja W. 2012. Dry period length and performance of cows in the subsequent production cycle. Arch. Tierz. 55(2): 140-147.

Schlamberger G., Wiedemann S., Viturro E., Meyer HH. and Kaske M. 2010. Effects of continuous milking during the dry period or once daily milking in the first 4 weeks of lactation on metabolism and productivity of dairy cows. J. Dairy Sci. 93: 2471–2485.

Soleimani A., Moussavi AH., Mesgaran MD. and Golian A. 2010. Effects of dry period length on, milk production and composition, blood metabolites and complete blood count in subsequent lactation of Holstein dairy cows. World Acad. Sci. Eng. Technol. 44: 1072-1077.

Sorensen JT. and Enevoldsen C. 1991. Effect of dry period length on milk production in subsequent lactation. J. Dairy Sci. 74: 1277-1283.

Steeneveld W., Ariette TM., van Knegsel A., Gerrit R., Henk H., Bas K., Johannes CM. and Vernooij HH. 2014. Cow characteristics and their association with production performance with different dry period lengths. J. Dairy Sci. 97(8): 4922-4931.

Tietjen GL. and Moore RH. 1972. Some Grubbs-Type Statistics for the Detection of Outliers, Technometrics, 14(3): 583-597.

Van Knegsel ATM., van der Drift SGA., Cermakova J. and Kemp B. 2013. Effects of shortening the dry period of dairy cows on milk production, energy balance, health, and fertility: A systematic review. Vet. J. 198: 707-713.

Van Middelaar CE., Berentsen PBM., Dijkstra J. and de Boer IJM. 2013. Evaluation of a feeding strategy to reduce greenhouse gas emissions from dairy farming: The level of analysis matters. Agric. Syst. 121: 9–22.

Van Middelaar CE., Berentsen PBM., Dijkstra J., van Arendonk JAM. and de Boer IJ.M. 2014. Methods to determine the relative value of genetic traits in dairy cows to reduce greenhouse gas emissions along the chain. J. Dairy Sci. 97: 1–15.

Watters RD., Guenther JN., Brickner AE., Rastani RR., Crump PM., Clark PW. and Grummer RR. 2008. Effects of Dry Period Length on Milk Production and Health of Dairy Cattle, J. Dairy Sci. 901 (7): 2595-2603.

Weiss F. and Leip A. 2012. Agriculture, Ecosystems and Environment Greenhouse gas emissions from the EU livestock sector: A life cycle assessment carried out with the CAPRI model. Agriculture, Ecosyst. Environ. 149: 124–134.

Will S., Katherine R., Johan R., Sarah EC., Ingo F., Elena MB., Reinette B., Stephen RC., Wim V., Cynthia AW., Carl F., Dieter G., Jens H., Georgina MM., Linn MP., Veerabhadran R., Belinda, R. and Sverker S. 2015. Planetary boundaries: Guiding human development on a changing planet. Science. 347(6223): 736-748.

Zobel G., Weary DM., Leslie KE. and von Keyserlingk MAG. 2015. Invited review: Cessation of lactation: Effects on animal welfare. J. Dairy Sci. 98: 8263–8277.