J. Dairy Sci. 103:507–513
https://doi.org/10.3168/jds.2019-16446

Machine milking parameters for Murciano-Granadina breed goats

N. Fernández,[1]* J. V. Martí,[1] M. Rodríguez,[1] C. Peris,[1] and S. Balasch[2]
[1]Instituto de Ciencia y Tecnología Animal, Universitat Politècnica de València, 46022 València, Spain
[2]Departamento de Estadística e Investigación Operativa Aplicadas y Calidad, Universitat Politècnica de València, 46022 València, Spain

ABSTRACT

In dairy ruminants, the combination of milking parameters must ensure good milking performance without harming udder conditions. Commonly, milking conditions for goats are established without having checked the admissible limits for optimal and fast milking. The aim of this study was to establish a limit combination of machine milking parameters that improves machine milking performance without altering milkability or udder status. To this end, we studied the effect of 2 combinations (42 kPa, 120 cpm, 60% vs. 44 kPa, 120 cpm, 60% in terms of kilopascals of vacuum level, cycles per minute of pulsator rate, and percentage of pulsator ratio, respectively) on milk production and composition, milk fractioning during milking, SCC, teat tissue thickness variation after milking, and the milk emission kinetics parameters throughout 1 lactation period (6 mo). The 42 and 44 kPa measured at the vacuum gauge level became average values of 37.5 and 39.3 kPa, respectively, measured at the teat sphincter level during milking. Milk flow significantly increased and total milking time decreased 25 s with the elevation of the vacuum level from 42 to 44 kPa without any adverse effect on milk fractioning at milking. However, the use of 44 kPa also showed an increase in tissue thickness above 5%, and we observed a tendency of average conductivity of milk to increase, although without any adverse effect on SCC. It seems that 44 kPa, 120 cpm, 60% is a possible limit combination of parameters to improve milking performance without altering milkability or udder conditions. We concluded that this combination can be used for milking Murciano-Granadina breed goats in conditions similar to those of this study (mid-level milking system and 1 milking/d), although further studies are necessary to verify its application in the case of 2 milkings/d.

Key words: parameter combination, milkability, udder status, dairy goat

INTRODUCTION

There is recent evidence (Blasco et al., 2016) that mechanical milking of Murciano-Granadina goats is performed excessively slowly, with mean milk flows between 600 and 700 mL/min. This is much lower than the 939 mL/min reported by Le Du and Benmederbel (1984) despite the need for a 35-kPa average vacuum to open the teat sphincter in Saanen goats versus the 30.1-kPa average vacuum (Fernández et al., 2015) for Murciano-Granadina breed goats. In an initial exploratory work (Fernández et al., 2015), we found that the problem of slow milking does not seem to reside in the milking machine materials but rather in the high sphincter strength of the animals and that the solution lay in increasing the vacuum level (kPa) or pulsator rate (cycles per minute; **cpm**) or both. The values of the different parameters commonly used for the mechanical milking of Murciano-Granadina goats range between 40 and 42 kPa, 90 and 120 cpm, and 60 and 66% in terms of kilopascals of vacuum level, cmp of pulsator rate, and percentage of pulsator ratio, respectively (Díaz et al., 2012; Hamzaoui et al., 2013; Blasco et al., 2016). In a mid-level milking system, a combination of 42 kPa and 120 cpm reduced milking time by 22 s per goat compared with 40 kPa and 90 cpm (both with a 60% pulsator ratio), although it was necessary to carry out long-term work with the new milking parameters to check the effect on milking ability and udder status of the animals (Fernández et al., 2015). Later, Domingo (2017) ratified this milking time reduction, and the combination 42 kPa, 120 cpm, and 60% did not negatively affect udder condition in a long-term experiment. To test the hypothesis that a higher vacuum level could reduce milking time much more without adverse effects on milkability, teat condition, and SCC, this study aimed to investigate the long-term effect of 2 milking parameter combinations on milk yield and fractioning, milk characteristics (physical, chemical, and SCC), kinetic milk parameters, and teat

Received February 7, 2019.
Accepted August 29, 2019.
*Corresponding author: nfernand@dca.upv.es

tissue. Reducing milking time leads to lower labor costs and makes milking work less arduous.

MATERIALS AND METHODS

Housing and handling of the experimental animals followed the mandatory principles for care and use of experimental animals in Spain (BOE, 2013).

Goats and General Procedures

We used 48 multiparous (2.8 ± 0.4 births; mean ± SD) Murciano-Granadina breed goats (46 ± 1.8 kg) at the experimental farm of the Universitat Politècnica de València (Spain). Mating was synchronized using intravaginal sponges (30 mg of fluorogestone acetate and 450 IU of pregnant mare serum gonadotropin; Chrono-Gest, CEVA Salud Animal, Barcelona, Spain), and all births took place over a 19-d period. At parturition, all goats were separated from their kids, kept together in the same pen (size = 1.5 m^2/goat; feeder = 0.5 m/goat; 5 bowl water troughs) and, during the first month postkidding, milked under the same conditions: 42 kPa of vacuum measured at vacuum gauge, 120 cpm of pulsator rate, and 60% of pulsator ratio. Later, goats were assigned at random to 2 groups [n = 24; 42 kPa of vacuum measured at vacuum gauge, 120 cpm of pulsator rate, and 60% of pulsator ratio (referred to as the 42-kPa group) or 44 kPa of vacuum measured at vacuum gauge, 120 cpm of pulsator rate, and 60% of pulsator ratio (referred to as the 44-kPa group)] until the end of the lactation (6 mo postkidding) according to production level, sphincter strength, and SCC. Groups were separated into 2 pens under the same conditions cited above. All goats received the same total mixed feed ration twice daily (at 0900 and 1800 h) and were subjected to once-a-day milking throughout lactation. The ration consisted of (1) a basal diet to meet minimum recommendations for maintenance plus 1.0 L of milk/d (8.71 MJ of NE_L, 99 g of MP, 8.7 g of Ca, and 4.9 g of P) including alfalfa hay (30% as DM), barley straw (26%), beetroot pulp (18%), and orange pulp (26%), and (2) a commercial concentrate for dairy goats (6.78 MJ of NE_L, 135 g of MP, 9 g of Ca, and 4 g of P/kg of DM) to meet a total average milk yield of 3.1 and 2.5 L of milk/goat per day at different stages of the lactation curve. Rations were formulated according to Sauvant et al. (2007) and offered to the dams in an amount 10% higher than the calculated voluntary feed intake. A mid-level milking system (2 platforms, 12 ewes/platform, 6 milking units) was used. Dams were machine milked without any udder preparation using the following routine: machine milking (**MM**), machine stripping (**MST**), and postmilking teat dipping (Proactive Plus, DeLaval, Madrid, Spain). Machine stripping involved a vigorous udder massage just before the teat cups were removed. Milk production, composition, and SCC for the different stages of lactation were calculated based on the monthly testing. In addition, milk emission kinetics and teat thickness change after milking on the 48 goats were studied once a month throughout the trial (6 mo), whereas udder morphology was examined only during the first month after parturition.

Experimental Data and Sample Collection

Actual milk yield was recorded once a month, at 0800 h on Tuesdays. Separate measurements of the milk obtained by MM and MST were recorded. Immediately afterward, goats were injected once with 3 IU of oxytocin (Hormonipra; Laboratorios Hipra S. A., Valencia, Spain) into the jugular vein, and the udder was emptied by machine to obtained residual milk. Samples (50 mL) of actual (MM + MST) milk yield were collected and immediately analyzed for milk composition and SCC. Milk composition (fat and protein) was analyzed with an infrared analyzer (Milkoscan FT6000 Foss Electric A/S, Hillerød, Denmark), and SCC was determined with the fluoro-opto-electronic method (ISO, 2006; Fossomatic 5000, Foss Electric A/S). Milk yield was expressed as FCM at 3.5% fat milk using the equation proposed by Sauvant et al. (2007) for goats: FCM yield = milk yield × {1 + [0.0075 × fat (g/L) − 35/0.4]}.

Udder Morphology

On d 20 postkidding, the udder characteristics (teat length, teat diameter at the base, teat diameter at the central section, implantation angle from the rear, implantation angle from the lateral, and udder height; Labussière, 1984) and teat–floor distance were measured. Teat sphincter strength (**SS**) was measured twice, on d 20 and 21 postkidding. Measurement of SS was performed acting on the regulator to increase the level of vacuum, from 0 kPa and without pulsation, applied at the end of the teat cup until the appearance of the first spurt of milk (Marnet et al., 2001). Average values of SS measurements were recorded.

Milk Emission Kinetics

Milk emission kinetics was used to evaluate the effect of the 2 combinations of milking parameters on milk fractioning, milk flow, milking time, and other milk characteristics (temperature and conductivity). A milk meter (LactoCorder, Balgach, Switzerland) was used. The kinetic characteristics were taken from these records: MM milk volume, MST milk volume, milk volume in the first minute, MM average flow, MM maximum flow, MST average flow, MST maximum flow, latency (time elapsed from teat cup attachment to milk flow appearance in the claw), time of emission of the MM milk volume, time of occurrence of the MM maximum flow, time of emission of the MST milk volume, time of occurrence of the MST maximum flow, and total milking time (time elapsed from teat cup attachment to the end of milking).

Vacuum Level Under the Teat

The vacuum levels cited (42 and 44 kPa) for both experimental groups are measured in the vacuum gauge. However, what is important is the level of vacuum that occurs under the teat. To measure it, a VaDia device (BioControl, Rakkestad, Norway) was used once in the first month of the experimental period on goats with different milk flow. The average values obtained for each experimental group were recorded.

Teat Thickness

Teat-end edema created by the milking machine was estimated with a cutimeter (no. 33865; Hauptner, Solingen, Germany), measuring the teat thickness change immediately after milking according to Hamann et al. (1996). Teat thickness was defined as the distance (mm) between the cutimeter jaws for a given applied pressure. The cutimeter had a new spring that exerted a force of 6.7 N (400 mm^2, 0.01675 N/mm^2). Measurements of each teat were taken before and after milking as the difference between the readings taken (postmilking reading − premilking reading) and expressed as a percentage of the value measured before milking. Measurements were taken in duplicate; after the first application, the cutimeter was opened and the thickness was gauged again without changing the device's position (Isaksson and Lind, 1992).

Table 1. Mammary morphology (means ± SD) of the Murciano-Granadina goat breed used in 2 combinations of milking parameters

Trait	Milking parameters[1] 42, 120, 60	44, 120, 60
Teat (mm unless noted)		
Length	62.9 ± 4	63.1 ± 4
Diameter at base	54.5 ± 4	53.8 ± 4
Diameter at midpoint	37.9 ± 3	37.5 ± 3
Angle from behind	45.5 ± 4	45.9 ± 5
Angle from the lateral	44.5 ± 3	45.6 ± 4
Sphincter strength (kPa)	29.9 ± 1	30.1 ± 1
Udder (mm)		
Distance from base to floor	185 ± 8	183 ± 7
Height	280 ± 2	283 ± 3

[1]Parameters are given in terms of kilopascals of vacuum level, cycles per minute of pulsator rate, and percentage of pulsator ratio, respectively.

Statistical Analysis

Milk yield and fractioning, milk composition and SCC, variables from kinetic milk emission (milk yield and fractioning, flows and times, milk conductivity and temperature), and percentage of teat-end edema were analyzed using the MIXED procedure of SAS (SAS Institute, 2011), a repeated-measures model that included the fixed effects of lactation period (6 mo) and experimental group (42 kPa and 44 kPa), the random effect of animal nested in the experimental group, the interaction between experimental groups and lactation stage, and residual error. The SCC $\log_{10}$ was used to normalize SCC distribution (Ali and Shook, 1980). Separation of means, if appropriate, for the determination of a significant ($P < 0.05$) main effect was performed using pairwise contrasts (PDIFF option of SAS). When interaction was nonsignificant, the corresponding interaction was pooled with the error. The relationship between variables was carried out following the CORR procedure of SAS.

Table 2. Least squares means of milk yield and milk parturition for 2 combinations of milking parameters with the Murciano-Granadina goat breed

Trait	Milking parameters[1] 42, 120, 60	44, 120, 60	SEM	*P*-value
Milk yield (mL)	2,297	2,403	74	0.52
Machine milk (mL)	2,103	2,189	70	0.63
Machine stripping milk (mL)	188	200	18	0.49
Residual milk (mL)	247	314	46	0.65
Machine milk (%)	91.4	91.7	0.7	0.75
Machine stripping milk (%)	8.9	9.0	0.8	0.77
Residual milk (%)	11.3	13.1	2	0.52

[1]Parameters are given in terms of kilopascals of vacuum level, cycles per minute of pulsator rate, and percentage of pulsator ratio, respectively.

Table 3. Least squares means of the composition and SCC in milk for 2 combinations of milking parameters with the Murciano-Granadina goat breed

	Milking parameters[1]			
Trait	42, 120, 60	44, 120, 60	SEM	*P*-value
Fat (%)	5.0 ± 1.0	5.1 ± 1.0	1.0	0.72
Protein (%)	3.5 ± 0.6	3.6 ± 0.6	0.6	0.63
Log_{10} SCC	5.7 ± 0.1	5.7 ± 0.1	0.1	0.61

[1]Parameters are given in terms of kilopascals of vacuum level, cycles per minute of pulsator rate, and percentage of pulsator ratio, respectively.

RESULTS

The udder characteristics are presented in Table 1. The sample of Murciano-Granadina goats used had teats with an average length of 63 mm, a diameter of 54.2 mm at the base and 37.7 mm in the middle, and moderate sloping (45.7° from behind and 45.1° from the side) and an udder with an average height of 281.5 mm and a distance from the floor of 184 mm.

The 42 and 44 kPa measured at the vacuum gauge level became average values of 37.5 and 39.3 kPa, respectively, measured under the teat and with milk flow. Milking parameters did not affect milk production and fractionation at milking (Table 2) or the composition, physical characteristics, and SCC of milk (Table 3), whereas the opposite occurred for lactation period. The interaction of experimental group and lactation status was not significant in any case except average milk conductivity ($P = 0.04$). However, we observed that the milking parameters of the 44-kPa group increased (Table 4) the difference in teat thickness before and after milking compared with 42-kPa group. Likewise, there were statistically significant differences between the 42- and 44-kPa groups for latency, maximum flow for the machine milk, total milking time, and average milk temperature (Figure 1), whereas average milk conductivity was not significant (Table 5; Figure 1). None of the variables of production, composition, SCC, teat thickness variations before and after milking, or milk emission kinetics were significantly correlated with teat SS except those presented in Table 6.

DISCUSSION

According to Such (1990), udder morphology, milk fractionation during milking, residual milk, and kinetic milk emission are some of the useful parameters to evaluate milkability. In our case, the mean value of the teat diameter at its midpoint (37.7 mm) places our herd in the immediately preceding score (36.6–41.5 mm) in relation to teats considered to be extremely wide (41.6–46.5 mm) in the morphological evaluation of Murciano-Granadina goats (Ruiz, 2008). The other parameters measured are considered as means in the aforementioned morphological evaluation. In the same breed, Peris et al. (1997) obtained mean values of 28.5 mm for teat length (63.0 mm in this experiment) and 26.8° for mean angle of the teats seen from behind (45.7° in this experiment), whereas Arrebola et al. (2006) observed a mean diameter of the teat in its middle part of 16 mm. This means that the goats used in our experiment have a large teat size compared with those used by other authors for the same breed but are within the values considered normal for the Murciano-Granadina breed according to Ruiz (2008).

The fact that lactation status was statistically significant over most of the studied variables of production and composition seems logical given that milk production decreases and the composition of milk increases as lactation progresses, both in sheep (Requena et al., 2010) and in goats (Delgado-Pertíñez et al., 2009). In this experiment, the increase of the vacuum level from 42 to 44 kPa did not have a negative effect on milk fractionation during milking. Values of 91 and 9% for

Table 4. Least squares means of the thickness of the teat tissues before and after milking for 2 combinations of milking parameters with the Murciano-Granadina goat breed

	Milking parameters[1]			
Trait	42, 120, 60	44, 120, 60	SEM	*P*-value
Thickness before milking (mm)				
Right teat	4.4	4.3	0.09	0.42
Left teat	4.4	4.4	0.10	0.61
Thickness after milking (mm)				
Right teat	4.5	4.5	0.11	0.63
Left teat	4.5	4.6	0.10	0.62
Thickness variation (%)				
Right teat	3.4	6.0	0.86	0.05
Left teat	4.1	7.3	1.06	0.04

[1]Parameters are given in terms of kilopascals of vacuum level, cycles per minute of pulsator rate, and percentage of pulsator ratio, respectively.

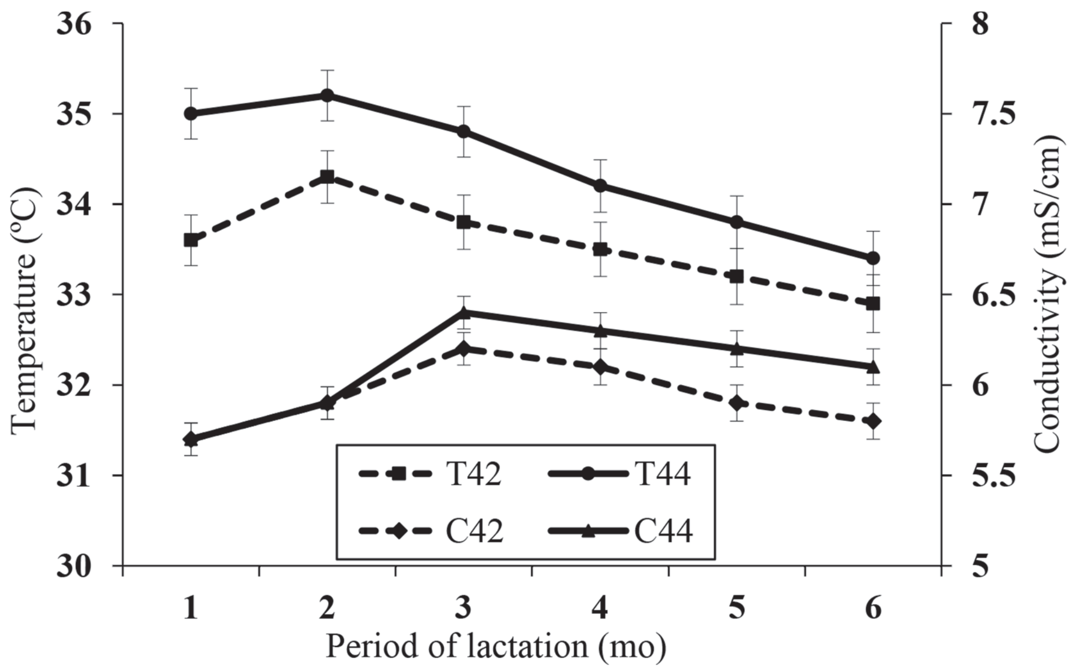

Figure 1. Least squares means (± SEM) of milk temperature and conductivity for 2 combinations of machine milking parameters (42 kPa, 120 cpm, and 60% vs. 44 kPa, 120 cpm, and 60% in terms of kilopascals of vacuum level, cycles per minute (cpm) of pulsator rate, and percentage of pulsator ratio, respectively) with the Murciano-Granadina goat breed. Month 1 corresponds to the pre-experimental period. T42 = average temperature for the 42-kPa group; T44 = average temperature for the 44-kPa group; C42 = average conductivity for the 42-kPa group; C44 = average conductivity for the 44-kPa group.

MM and MST, respectively, appear to indicate a good aptitude and milking conditions; they are better than those of Peris et al. (1997) in the same breed (83 and 17%) and those of Caja et al. (1999) in the Tenerife goat breed (80 and 20%). In addition, no statistically significant differences were found for residual milk between combinations of milking parameters.

We observed that increasing the vacuum level to 44 kPa increased milk flow and reduced total milking time by 25 s, achieving the objective of the work. Teat SS was negatively correlated with milk flow and positively correlated with milking time, which confirms the importance of the former trait in milking speed.

Milk temperature and conductivity are 2 parameters commonly used to evaluate the presence of mastitis in cows and goats (Gil, 1988; Mein et al., 2004; Norberg and Korsgaard, 2004; Díaz et al., 2011, 2012). Average milk temperature of the goats in the 44-kPa group was not important in this case because this difference existed at the beginning of the experiment (month 1; Figure 1). Therefore, the interaction between lactation period and experimental group is not significant. Díaz

Table 5. Least squares means of the emission kinetic variables for 2 combinations of milking parameters with the Murciano-Granadina goat breed

Trait	Milking parameters[1] 42, 120, 60	44, 120, 60	SEM	*P*-value
Latency[2] (min)	0.35	0.28	0.02	0.03
Machine milking maximum flow (mL)	660	780	40	0.03
Total milking time (min)	4.07	3.65	0.13	0.04
Average milk conductivity (mS/cm)	5.80	5.90	0.07	0.22
Average milk temperature (°C)	33.60	34.40	0.23	0.03

[1]Parameters are given in terms of kilopascals of vacuum level, cycles per minute of pulsator rate, and percentage of pulsator ratio, respectively.

[2]Time elapsed between teat cup attachment and the milk flow appearance in the claw.

Table 6. Correlation and *P*-value of the sphincter strength with some variables of the milk emission kinetics with the Murciano-Granadina goat breed

Item	Correlation	*P*-value
Milk volume in min 1	−0.516	<0.009
Machine milking average flow	−0.535	<0.007
Machine milking maximum flow	−0.521	<0.009
Time for occurrence of machine milking maximum flow	0.618	<0.001
Time of emission of machine milking milk volume	0.600	<0.002
Total milking time	0.522	<0.009

et al. (2011, 2012) concluded that the use of a system based on daily readings of electrical conductivity could be useful in IMI detection in Murciano-Granadina goats. In our experiment, increasing the vacuum from 42 to 44 kPa in the 44-kPa group did not affect average milk conductivity compared with the 42-kPa group, although a tendency for it to increase was observed in the 44-kPa group as lactation progressed (Figure 1).

Díaz et al. (2013) demonstrated a high correlation between ultrasound and cutimeter methods for measuring teat-end edema after milking. In our experiment, the combination of milking parameters with a higher vacuum level (44 kPa) resulted in greater edema of the teat end after milking (>5%), although this did not lead to a higher SCC in milk. In the same breed of goats used in this experiment, Díaz et al. (2013) obtained a mean increase of 4.6% for the teat edematization after the milking, with the combination of milking parameters 40 kPa, 90 cpm, and 60%, which was slightly higher than that obtained in this work for 42 kPa (3.4–4.1%). Zecconi et al. (1992) indicated that sudden changes in teat thickness after milking (either >5% or <5% indicating excessive edema or compressive load of the liner, respectively) led to risk situations for the establishment of an IMI in cattle. Also in cattle, Neijenhuis et al. (2001) observed that the teat does not recover its initial thickness until 6 h after the end of milking, and they affirmed that when the level of edematization is high, some substances of high molecular weight (e.g., albumin) can exude from the capillaries, requiring more time for their elimination. Alejandro et al. (2014), working with Murciano-Granadina breed goats, concluded that at least 10 h is required for teat walls and canal to return to their physiological conditions before milk removal. These findings seem to indicate that, given that in our work the milking interval was 24 h, the teat tissues had sufficient time to regenerate and return to a normal situation before the next milking. Therefore, the results of this work could be valid for herds with 1 daily milking but not necessarily 2 daily milkings due to the possibility that regeneration might not take place completely at the beginning of one of the daily milkings with a milking interval of 12 h (or even shorter, if the intervals between the morning and afternoon were different). Therefore, it seems that 44 kPa, 120 cpm, and 60% is a limit combination parameter that could improve milking performance without altering milkability or udder conditions.

CONCLUSIONS

For virtually all milkability parameters (milk production and milk fractionation), milk composition, and SCC, increasing vacuum level from 42 kPa to 44 kPa, with 120 cpm of pulsation rate and 60% of pulsation ratio, did not cause any statistically significant modification but reduced total milking time by 25 s. This positive contribution to milking speed without adverse effects on SCC leads us to recommend use of the combination of parameters 44 kPa, 120 cpm, and 60% for Murciano-Granadina breed goats for a mid-level milking system and 1 milking/d. However, further studies are needed to clarify the application of these parameters in the case of 2 milkings/d.

REFERENCES

Alejandro, M., A. Roca, G. Romero, and J. R. Díaz. 2014. Effects of milk removal on teat tissue and recovery in Murciano-Granadina goats. J. Dairy Sci. 97:8. (Abstr.) https://doi.org/10.3168/jds.2014-7934.

Ali, A., and G. E. Shook. 1980. An optimum transformation for somatic cell concentration in milk. J. Dairy Sci. 63:487–490.

Arrebola, F. A., B. J. González, M. Beltrán, M. Gil, M. Sánchez, and A. M. Dueñas. 2006. Caracterización zoométrica mediante calificación morfolineal del ganado caprino lechero de raza Murciano-Granadina en el Valle de los Pedroches. Pages 198–201 in Proc. XXXI Jornadas Científicas de la Sociedad Española de Ovinotecnia y Caprinotecnia, Córdoba, Spain. SEOC, Córdoba, Spain.

Blasco, E., E. A. Gómez, C. Vicente, G. Vidal, and C. Peris. 2016. Factors affecting milking speed in Murciano-Granadina breed goats. J. Dairy Sci. 99:10102–10108. https://doi.org/10.3168/jds.2016-10869.

BOE (Boletín Oficial del Estado). 2013. Real Decreto 53/2013, de 1 de febrero, por el que se establecen las normas básicas aplicables para la protección de los animales utilizados en experimentación y otros fines científicos, incluyendo la docencia.

Caja, G., J. Capote, J. L. López, S. Peris, X. Such, and A. Argüello. 1999. Milk partitioning and milk flow rate of Canarian dairy goats under once daily or twice daily milking frequencies. Pages 274–280 in Proc. 6th International Symposium on Milking of the Small Ruminants, Athens, Greece. EAAP Publication, Wageningen Pers., the Netherlands.

Delgado-Pertíñez, M., J. L. Guzmán-Guerrero, Y. Mena, J. M. Castel, P. González-Redondo, and F. P. Caravaca. 2009. Influence of kid rearing system on milk yield, kid growth and cost of Florida goats. Small Rumin. Res. 81:105–111.

Díaz, J. R., M. Alejandro, C. Peris, and N. Fernández. 2013. Use of ultrasound scanning to estimate wall thickness in Murciano-Granadina goats. Livest. Sci. 155:114–122. https://doi.org/10.1016/j.livsci.2013.04.007.

Díaz, J. R., G. Romero, R. Muelas, M. Alejandro, and C. Peris. 2012. Effect of intramammary infection on milk electrical conductivity in Murciano-Granadina goats. J. Dairy Sci. 95:718–726. https://doi.org/10.3168/jds.2011-4698.

Díaz, J. R., G. Romero, R. Muelas, E. Sendra, J. C. F. Pantoja, and C. Paredes. 2011. Analysis of the influence of variation factors on electrical conductivity of milk Murciano-Granadina goats. J. Dairy Sci. 94:3885–3894. https://doi.org/10.3168/jds.2011-4187.

Domingo, E. 2017. Condiciones de funcionamiento de la máquina para el ordeño de cabras Murciano-Granadina. Bachelor degree final paper. Universitat Politècnica de València, València, Spain.

Fernández, N., A. Martínez, J. V. Martí, M. Rodríguez, and C. Peris. 2015. Milkability and milking efficiency improvement in Murciano-Granadina breed goats. Small Rumin. Res. 126:68–72. https://doi.org/10.106/j.smallrumes.2015.03.001.

Gil, Z. 1988. Milk temperature fluctuations during milking in cows with subclinical mastitis. Livest. Prod. Sci. 20:223–231. https://doi.org/10.1016/0301-6226(88)90074-7.

Hamann, J., G. A. Mein, and B. Nipp. 1996. Recommended method for measuring changes in thickness of the bovine teat with spring-loaded calipers. J. Dairy Res. 63:309–313.

Hamzaoui, S., A. A. Salama, E. Albanell, X. Such, and G. Caja. 2013. Physiological responses and lactational performances of late-lactation dairy goats under heat stress conditions. J. Dairy Sci. 96:6355–6365. https://doi.org/10.3168/jds.2013-6665.

Isaksson, A., and O. Lind. 1992. Teat reactions in cows associated with machine milking. Zentralbl Veterinarmed A 39:282–288.

ISO. (International Organization for Standardization). 2006. ISO 13366-2/IDF 148-2: Milk—Enumeration of Somatic Cells, Part 2: Guidance on the Operation of Fluoro-opto-electronic Counter. International Organization for Standardization, Geneva, Switzerland.

Labussière, J. 1984. Etude des aptitudes laitières et de la facilite de traite de quelques races de brebis du "Basin Mediterraneen". Pages 730–790 in Proc. 3rd International Symposium on Milking of the Small Ruminants, Valladolid, Spain. Comité Español III Symposium Internacional de Ordeño Mecánico de Pequeños Rumiantes, Valladolid, Spain.

Le Du, J., and B. Benmederbel. 1984. Aptitude des chèvres de race Saanen à la traite mécanique. Relations avec les caractéristiques physiques du trayon. Ann. Zootech. 33:375–384.

Marnet, P. G., P. Billon, G. Da Ponte, J. Martin, and E. Manfredi. 2001. Aptitude à la traite mécanique chez la chevre: Variabilité génétique et bases physiologiques du débit du lait. Pages 321–327 in Rencontres Recherche Ruminants, Paris, France. ITOVIC, Paris, France.

Mein, G. A., R. A. Sherlock, and R. W. Claycomb. 2004. Making sense of in-line sensing for milk conductivity. Pages 252–253 in Automatic Milking. A. Meijering, H. Hogeveen, and C. J. A. M. de Konig, ed. Wageningen Academic Publishers, Wageningen, the Netherlands.

Neijenhuis, F., G. A. Mein, J. S. Britt, D. J. Reinemann, J. E. Hillerton, R. Farnsworth, J. R. Baines, T. Hemling, I. Ohnstad, N. Cook, W. F. Morgan, and L. Timms. 2001. Evaluation of bovine teat condition in commercial dairy herds: 4. Relationship between teat end callosity or hyperkeratosis and mastitis. Pages 362–366 in Proc. AABP-NMC II International Symposium on Mastitis and Milk Quality, St. Louis, MO. National Mastitis Council Proceedings Library.

Norberg, E., and I. R. Korsgaard. 2004. Electrical conductivity of milk as an indicator trait for mastitis. Pages 254–255 in Automatic Milking. A. Meijering, H. Hogeveen, and C. J. A. M. de Konig, ed. Wageningen Academic Publishers, Wageningen, the Netherlands.

Peris, S., G. Caja, X. Such, R. Casals, A. Ferret, and C. Torre. 1997. Influence of kid rearing systems on milk composition and yield of Murciano-Granadina dairy goats. J. Dairy Sci. 80:3249–3255.

Requena, R., S. Balasch, C. Peris, M. Rodríguez, and N. Fernández. 2010. Dose response of lactating dairy ewes during suckling and milking to bovine somatotropin. J. Anim. Sci. 88:3136–3144.

Ruiz, I. 2008. Valoración morfológica en ganado caprino lechero. Cabra Murciano-Granadina, ed. Comunidad Autónoma de la Región de Murcia, Murcia, Spain.

SAS Institute. 2011. SAS User's Guide: Statistics. Version 9.2. SAS Institute Inc., Cary, NC.

Sauvant, D., S. Giger-Reverdin, and F. Meschy. 2007. Alimentation des caprins. Pages 137–148 in Alimentation des Bovines, Ovins et Caprins. Ed. Quae, Versailles, France.

Such, X. 1990. Factores condicionantes de la aptitud al ordeño mecánico de ovejas de raza Manchega: Influencia de la simplificación de rutina y las características de la máquina de ordeño. MS Thesis. Universitat Autonoma de Barcelona, Barcelona, Spain.

Zecconi, A., J. Hamann, V. Bronzo, and G. Ruffo. 1992. Machine induced teat tissue reactions and infection risk in a dairy herd from contagious mastitis. J. Dairy Res. 59:265–271.

ORCIDS

N. Fernández https://orcid.org/0000-0001-7150-2903
C. Peris https://orcid.org/0000-0003-3529-1269