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Identification of factors affecting colostrum quality of dairy Lacaune ewes assessed with the Brix refractometer

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In this Research Communication we assessed factors affecting colostrum quality of dairy Lacaune ewes using the Brix-refractometer. Colostrum from 536 lambings from one commercial intensive dairy Lacaune farm were analysed for the following factors with potential influence in colostrum quality: (1) ewe parity ($n = 84$–132), (2) length of previous dry period (PDP) ($n = 23$–214), (3) age at first lambing (AFL) of primiparous ewes ($n = 9$–88), (4) lambing season ($n = 192$ or 344), and (5) year (2011–2013, $n = 142$–203). Parity significantly affected colostrum quality, with primiparous ewes showing the highest Brix refractometer values (22·6 ± 5·6%, $P < 0·0001$), though values were similar among multiparous ewes. PDP length also significantly affected colostrum quality: ewes with the shortest PDP showed the worst quality (16·8 ± 4·2%, $P < 0·0001$), with quality gradually rising with PDP length. Colostrum quality was significantly higher in 2011 (21·0 ± 5·2%) than in 2012 or 2013 ($P < 0·0001$); this likely reflects the several-fold greater proportion of animals with long PDP in 2011. In contrast, neither AFL nor lambing season significantly affected colostrum quality. These results suggest that parity and PDP length can substantially affect ovine colostrum quality of dairy ewes under intensive management conditions and they further show the usefulness of the Brix refractometer for providing a rough estimation of colostrum quality on-farm. However, further studies are needed to determine a validated cut-off Brix value for identifying good-quality colostra in ovine species.

Keywords: Dry period, parity, age, lambing, season, Brix percentage.

Passive immunity is essential to the ruminant newborn, and failure of passive transfer increases risk of morbidity and mortality. This highlights the importance of assessment of factors affecting colostrum quality. The colostrum quality is often evaluated in terms of immunoglobulin (Ig) concentrations (Gilbert et al. 1988) using one of several methods. Brix refractometry rapidly measures total solids content, which correlates with immunoglobulin G (IgG) concentration (Bartier et al. 2015) and requires small sample volumes. Therefore, it is probably the technique most suited for providing a rough estimation of ovine colostrum quality on-farm, and for assessing potential factors affecting colostrum quality.

Previous work has already identified several factors affecting quality colostrum: parturition-season, nutrition, age, parity and length of previous dry period (PDP; Gilbert et al. 1988; Banchero et al. 2009; Castro et al. 2011; Higaki et al. 2013; Tabatabaei et al. 2013). Whether other factors influence colostrum quality remains unclear. To address these questions, the present study identified factors affecting colostrum quality using Brix refractometry on an intensive farm of dairy Lacaune ewes.

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Material & methods

Colostrum samples were obtained from Lacaune ewes from one commercial dairy farm (Granja Cerromonte S.L., Spain) with 4100 ewes and 450 l of annual average production per ewe. Animal management on this farm has been described by Hernandez et al. (2011). Briefly, sheep are housed indoors without access to pasture. No suckling period is allowed: lambs are separated from mothers at delivery and fed with an automatic lamb feeder after colostrum administration with oesophageal feeder. From the day after lambing, ewes are milked twice a day until production drops below 0·5 l/d or until 30 d before the next lambing, when they are dried off.

First milking colostrum was obtained from 536 ewes within the first 6 h post-delivery by machine milking and stored at −20 °C until analysis. Thawed samples were measured in triplicate [intra-assay coefficient of variation (CV), 0·98%] using a digital Brix refractometer (Pocket Pal-1, Atago, Spain), and the mean value for each sample was used in statistical analyses. Average colostral temperature during analysis was 24·2 °C (range, 22·7–26·4 °C).

Data on age and reproductive life were extracted from the electronic farm management system, and colostrum samples were stratified according to potential risk factors of poor quality: parturition year, delivery season (considering seasonal lambing, deliveries between December and August and counter-seasonal lambing, deliveries between September and November, in the North Hemisphere), parity, PDP-length and age at first lambing (AFL).

We analysed 142 colostra from lambings in 2011, 191 colostra from 2012 and 203 from 2013. The quality of samples from seasonal lambings (December-August, $n = 344$) was compared with that of samples from counter-seasonal lambings (September-November, $n = 192$). Ewes were primi- or multiparous with this distribution: first lambing, $n = 117$; second lambing, 116; third lambing, 87; fourth lambing, 84; and fifth lambing and beyond, 132. Quality was compared among colostrum samples from ewes showing different PDP lengths: no PDP (primiparous ewes), 117; short (0–30 d), 23; adequate (31–60 d), 214; long (61–90 d), 134; and extremely long (>90 d), 48. Finally, quality was compared among colostrum samples from primiparous ewes with different AFLs: <13 months, 88; 13–15 months, 20; and >15 months, 9.

Statistical analysis

SPSS ® 22·0 (IBM, NY, USA) was used for statistical analysis, with a significance threshold of $P < 0·05$. Results are expressed as mean ± SD. Differences were assessed for significance using ANOVA, and potential relationships between parameters were explored using Pearson correlation analysis and non-parametric correlation tests (Spearman's rho). Potential influence of AFL on colostrum quality was evaluated in a separate analysis involving the 117 primiparous ewes.

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Results and discussion

Our results provide some of the first detailed insights into factors affecting ovine colostrum using Brix refractometry on-farm. Brix refractometer measurements of colostrum quality across all samples are shown in Fig. 1. Most samples (336 of 536, 62·7%) showed a solids percentage >18%. The remaining 200 samples (37·3%) showed a solids percentage <18%. With just a few drops of colostrum, measurements can be obtained rapidly and with excellent repeatability; in the present study, mean CV for repeated measures was 0·41%. Our results support the robustness of Brix refractometry, since colostrum quality showed an expected distribution across all samples, similar to that observed in sheep and cattle (Alves et al. 2015; Bartier et al. 2015). However Brix refractometry in ovine colostrum is not a fully qualified method since solid percentage has not been yet correlated to actual IgG concentrations in ovine colostrum as it has already been done in bovine colostrum (Bartier et al. 2015).

Parity significantly affected colostrum quality. Quality was highest in colostrum from primiparous ewes (22·6 ± 5·6%, $P < 0·0001$) and was lowest in colostrum from ewes with two lambings (18·8 ± 3·8%), rising gradually with three lambings (19·1 ± 4·8%), four (19·5 ± 5·9%) and finally five or more (19·7 ± 5·1%). This variation with number of lambings did not achieve statistical significance. Our results suggest that colostrum quality is highest at the first lambing, which contrasts with other studies reporting higher IgG concentration in sheep colostrum from multiparous than primiparous ewes (Chniter et al. 2016) or no variances (Alves et al. 2015). This discrepancy may reflect differences in breed, nutrition, method of analysis, and method of colostrum collection. In agreement with our results, Gilbert et al. (1988) measured higher IgG concentration in colostrum from primiparous ewes. Our observation that colostrum quality was lowest after the second lambing may reflect characteristics of the Lacaune animals in our study (Hernandez et al. 2012). The first lactation in these animals lasts the longest and is the most productive.

Among multiparous sheep, mean dry period length was 65·1 ± 41·5 d. PDP length significantly affected colostrum quality. Quality was significantly higher in ewes at first lambing (22·5 ± 5·6%) and in ewes with extremely long PDP (20·9 ± 6·3%) than in other ewes ($P < 0·0001$). Quality was significantly lower in ewes with the shortest PDP (16·8 ± 4·2%) than in other ewes ($P < 0·0001$). Quality was intermediate in ewes with adequate PDP (18·7 ± 4·1%) or long PDP (19·9 ± 5·4%). PDP length showed weak positive correlation with Brix values ($r = 0·235$, $P < 0·0001$). Our results are consistent with the idea

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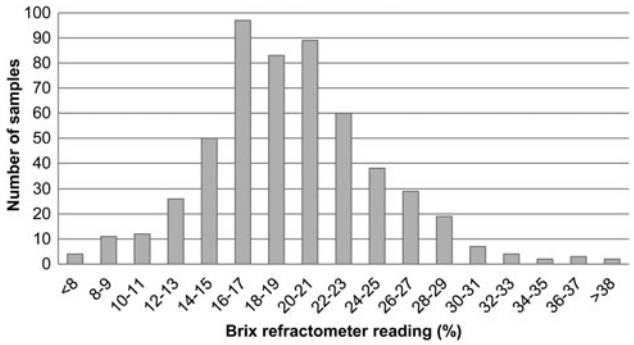

Fig. 1. Distribution of colostrum samples analysed with a Brix refractometer.

that colostrum quality increases with PDP length. This is consistent with reports that omitting the dry period leads to lower IgG concentration in colostrum from goats (Caja et al. 2006). One possible explanation is that selective transfer of IgG from the dam blood to colostrum begins in the udder a few weeks before parturition, and this transfer decreases if milk secretion is maintained (Guy et al. 1994).

We found similar colostrum quality between ewes with adequate PDP length (30–60 d) and those with long PDP (61–90 d). This is consistent with similar quality of cattle colostrum with PDPs of 30–40 d or the traditional 60 d (Cermakova et al. 2014; Shoshani et al. 2014; Mayasari et al. 2015). Similar results have been observed in goats (Caja et al. 2006). Our data suggests even higher IgG concentration can be achieved in colostrum if PDP is prolonged beyond 90 d, but this is not advisable for production. Taken together, our results support the conclusion of Hernandez et al. (2012) that a 30 d prepartum is the most appropriate drying period for milk production in Lacaune ewes reared under intensive conditions.

Mean AFL was 12·7 ± 1·7 months. Colostrum quality was similar among primiparous ewes with an AFL < 13 months (22·8 ± 5·8%), 13–15 months (21·9 ± 4·7%) or >15 months (22·2 ± 6·2%; $P = 0·77$). No significant correlation was observed between AFL and Brix-values. These results suggest that AFL does not influence colostrum quality and run counter to the idea that older ewes are likely to have experienced more immune challenges that increase IgG content in colostrum, as demonstrated for cows (Bartier et al. 2015). In part, our negative result may reflect the narrow range of AFL (11·5–19 months) among our ewes. It may also reflect the intensive management conditions, which may reduce animal exposure to new immune challenges. Finally, this result suggests that our previous proposal of 13–15 months as optimal AFL for reproductive and productive performance of the Lacaune breed under intensive management conditions (Hernandez et al. 2011) is reasonable.

Similarly, season did not affect colostrum quality: colostrum quality was 20·11 ± 5·0% in the seasonal lambing and 19·7 ± 5·7% in th; counter-seasonal lambing ($P = 0·47$). This is despite the fact that season has been shown to influence over- and under-nutrition as well as body condition (Gilbert et al. 1988; al-Sabbagh et al. 1995). Variations in energy intake during late pregnancy influence colostral IgG content (Castro et al. 2011). Our negative result probably reflects the intensive management that likely provides balanced nutrition throughout the year, independent of seasonal variations in food availability.

However, year of study affected colostrum quality: quality was significantly higher in 2011 (21·0 ± 5·2%) than in 2012 (19·8 ± 5·7%) or 2013 (19·5 ± 4·7%; $P < 0·0001$). Our observation of higher quality in 2011 may be due to the higher percentage of animals with very long PDP that year. In any event, we did not measure body condition score in the present study, so future work should examine whether this parameter may be associated with colostrum quality.

High-quality colostrum means sufficiently high IgG concentration, since newborns would be unable to absorb sufficient volumes of colostrum with low IgG concentrations. Unfortunately, our data do not allow us to determine appropriate Brix refractometer cut-off(s) to classify colostrum as adequate, and we are unaware of any such standards for sheep. On the basis of available evidence, we suggest threshold values of <18% (discard) and 21–22% (retain). With a cut-off of 22%, 164 of 536 of our samples (30·6%) would be classified as high-quality; with a cut-off of 20%, 253 of 536 (47·2%) would be so classified; with a cut-off of 18%, 336 of 536 (62·7%) would be so classified. Studies are needed to determine whether colostrum meeting our proposed cut-offs would provide the minimum of 30 g of IgG during the first 24 h of life needed for successful passive immune transfer in lambs (Alves et al. 2015). The proportions of samples in our study meeting these cut-offs for high quality colostrum are smaller than the corresponding proportions reported for cattle (Bartier et al. 2015). This may reflect loss of colostrum quality during the time from lambing to colostrum sampling: IgG concentration in sheep colostrum can drop by over 30% between 1 and 6 h post-delivery (Chniter et al. 2016). Consistent with this possibility, mortality and morbidity of lambs bred artificially since birth were low throughout the study period.

Conclusion

Our results confirm parity and PDP length as factors affecting colostrum quality under intensive management conditions. On the other hand, colostrum quality may not be affected by lambing season or AFL. Moreover, the usefulness of the Brix refractometer for providing a rough estimation of colostrum quality on-farm was shown. However, further studies are needed to determine a validated cut-off Brix value for identifying good-quality colostra in ovine species.

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References

al-Sabbagh TA, Swanson LV & Thompson JM 1995 The effect of ewe body condition at lambing on colostral immunoglobulin G concentration and lamb performance. *Journal of Animal Science* **73** 2860–2864

Alves AC, Alves NG, Ascari IJ, Junqueira FB, Coutinho AS, Lima RR, Pérez JRO, De Paula SO, Furusho-Garcia IF & Abreu LR 2015 Colostrum composition of Santa Inês sheep and passive transfer of immunity to lambs. *Journal of Dairy Science* **98** 3706–3716

Banchero GE, Quintans G, Lindsay DR & Milton JTB 2009 A pre-partum lift in ewe nutrition from a high-energy lick or maize or by grazing Lotus uliginosus pasture, increases colostrum production and lamb survival. *Animal* **3** 1183–1188

Bartier L, Windeyer MC & Doepel L 2015 Evaluation of on-farm tools for colostrum quality measurement. *Journal of Dairy Science* **98** 1878–1884

Caja G, Salama AAK & Such X 2006 Omitting the dry-off period negatively affects colostrum and milk yield in dairy goats. *Journal of Dairy Science* **89** 4220–4228

Castro N, Capote J, Bruckmaier RM & Argüello A 2011 Management effects on colostrogenesis in small ruminants: a review. *Journal of Applied Animal Research* **39** 85–93

Cermakova J, Kudrna V, Simeckova M, Vyborna A, Dolezal P & Illek J 2014 Comparison of shortened and conventional dry period management strategies. *Journal of Dairy Science* **97** 5623–5636

Chniter M, Salhi I, Harrabi H, Khorchani T, Lainé A-L, Nowak R & Hammadi M 2016 Physiological changes in the peri-partum period and colostral IgG transfer in prolific D'man sheep: effects of parity and litter size. *Tropical Animal Health and Production* **48** 387–394

Gilbert RP, Gaskins CT, Hillers JK & Parker CF 1988 Genetic and environmental factors affecting immunoglobulin G 1 concentrations in ewe colostrum and lamb serum. *Journal of Animal Science* **66** 855–863

Guy MA, McFadden TB, Cockrell DC & Besser TE 1994 Regulation of colostrum formation in beef and dairy cows. *Journal of Dairy Science* **77** 3002–3007

Hernandez F, Elvira L, Gonzalez-Martin J-V, Gonzalez-Bulnes A & Astiz S 2011 Influence of age at first lambing on reproductive and productive performance of Lacaune dairy sheep under an intensive management system. *Journal of Dairy Research* **78** 160–167

Hernandez F, Elvira L, Gonzalez-Martin J-V & Astiz S 2012 Influence of dry period length on reproductive performance and productivity of Lacaune dairy sheep under an intensive management system. *Journal of Dairy Research* **79** 352–360

Higaki S, Nagano M, Katagiri S & Takahashi Y 2013 Effects of parity and litter size on the energy contents and immunoglobulin G concentrations of awassi ewe colostrum. *Turkish Journal of Veterinary Animal Science* **37** 109–112

Mayasari N, de Vries RG, Nieuwland MGB, Remmelink GJ, Parmentier HK, Kemp B & van Knegsel TM 2015 Effect of maternal dry period length on colostrum immunoglobulin content and natural and specific antibody titers in calves. *Journal of Dairy Science* **98** 3969–3979

Shoshani E, Rozen S & Doekes JJ 2014 Effect of a short dry period on milk yield and content, colostrum quality, fertility, and metabolic status of Holstein cows. *Journal of Dairy Science* **97** 2909–2922

Tabatabaei S, Nikbakht G, Vatankhah M, Sharifi H & Alidadi N 2013 Variation in colostral immunoglobulin G concentration in fat tailed sheep and evaluation of methods for estimation of colostral immunoglobulin content. *Acta Veterinaria Brno* **82** 271–275