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Effects of cooked molasses licking block supplementation pre- and post-partum on feed intake, suckling lamb performance, milk yield and milk quality in dairy sheep. Part 1

A. Cabiddu[A,C], *E. Trevisi*[B], *G. Molle*[A], *G. Lovotti*[B], *C. Manca*[A], *G. Epifani*[A] and *M. Dattena*[A]

[A]Agris, Dipartimento per la Ricerca nelle Produzioni Animali, loc. Bonassai, 07040 Olmedo, Italy.
[B]Istituto di Zootecnica, Facoltà di Scienze Agrarie, Alimentari e Ambientali, Università Cattolica del Sacro Cuore, via Emilia Parmense 84, 29122 Piacenza, Italy.
[C]Corresponding author. Email: acabiddu@agrisricerca.it

Abstract. This study tested the nutritional benefit of a supplement offered freely to dairy sheep over a period from 60 days before lambing to 60 days after lambing, at stall and grazing. Thirty Sarda dairy sheep on Day 90 of gestation, homogeneous for age, parity number, bodyweight (BW) and body condition score (BCS), were allocated to one of two groups: control (Ctr) or treated (Cry). Over 120 days, both groups received ryegrass hay and concentrate indoors. After weaning, the ewes also had access to pasture for 6 h/day. Throughout the experimental period, the Cry group had *ad libitum* access to a cooked molasses licking block. No significant differences were observed between the groups in forage, concentrate and total DM intake. During the experiment, the reduction in BCS in early lactation tended to be slower in the Cry than in Ctr group (P_{trend} < 0.09), whereas no significant effects were seen on BW. Lamb performance tended to be improved by Cry in terms of liveweight of litter size per sheep (9.65 vs 8.22 kg for Cry and Ctr, respectively; $P < 0.07$), whereas no significant effects were observed on milk yield and composition, except for a trend for increased fat content in the Cry versus Ctr group (6.15% vs 5.95%, respectively; $P < 0.08$). Cry ewes had higher blood cholesterol concentrations than did Ctr ewes (1.96 vs 1.63 mmol/L; $P < 0.01$). Because there were no differences between feed intake at stall and the estimated total DM intake at stall and during grazing between the two groups, the better performance of the Cry group could be explained by an increase of feed use efficiency at the digestive and/or metabolic level.

Additional keywords: grazing sheep, nutrition, supplement.

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Introduction

Dairy sheep farming systems in the Mediterranean basin are mainly characterised by extensive grazing, with a wide daily fluctuation in the nutritional value of the diet in terms of crude protein, fibre content and herbage digestibility, influenced by the harsh environment. These nutritional imbalances can impair animal performance and animal welfare status. The use of supplements to boost the digestibility and intake of grass, with an easy management system for farmers, could help improve animal performance and increase the efficiency of the dairy sheep farming systems in the Mediterranean basin. It has been reported that feed blocks can improve the digestion of low-quality forages (Ben Salem and Nefzaoui 2003), and consequently animal performance. Several authors have also reported that the use of block supplements can reduce labour expenditure, in particular in dairy grazing systems (cows and sheep), because this supplement is fed to the animals on a free access and/or self-help basis (Ben Salem and Nefzaoui 2003; Leupp *et al.* 2005). Steers consuming cooked molasses licking blocks exhibited increased neutral detergent fibre (NDF) intake and digestibility of low-quality hay compared with a control group (+22% and +11%, respectively; Greenwood *et al.* 2000). The free availability of a cooked molasses licking block to animals does not have negative effects at the level of the rumen (through excessive intake of the block supplement or acidosis) because licking the block results in an associated increase in saliva secretion, which has a buffering effect, regulating the effects of consumption. Moreover, the procedure through which the cooked molasses block is obtained induces the formation of sugar ester compounds, which reduce the fermentation rate of molasses sugars in the rumen.

Results from experiments performed in the UK have shown that ewes consuming a supplement based on a cooked molasses licking block tended to gain weight faster during the pre-mating period, with a better body condition score (BCS) and better reproductive performance (Chaudhry *et al.* 2003). There is no information currently available from similar supplementation of grazing dairy sheep during the peripartum and early lactation period in the Mediterranean basin. It is well known that the final months of pregnancy are critical for health in dairy sheep (Caroprese *et al.* 2006). During this period, feeding management can influence both lamb vitality and early lamb growth, and have carry-over effects on subsequent lactation and mating performance. The last months of pregnancy in sheep in a Mediterranean environment usually coincide with a shortage of high-quality pasture, resulting in increased difficulty meeting the nutritional requirements of sheep as lambing approaches. Therefore, the aim of the present study was to evaluate the effect of a cooked molasses licking block on the performance of dairy sheep, from the last 2 months of pregnancy until 2 months after lambing.

Materials and methods

The study was performed at the Bonassai Research Station in north-western Sardinia (40°39′46″N, 8°21′46″E; 33 m a.s.l.), which has a Mediterranean climate and an average rainfall of 569 mm. The experiment started in September 2012 (60 days before lambing) and ended in February 2013 (60 days after lambing).

Animal and feeding management

Thirty Sarda dairy sheep on Day 90 of gestation (mean ± s.e.m. age 4.09 ± 2.02 years; parity number 3.82 ± 1.95; bodyweight (BW) 46.45 ± 8.62 kg; BCS 2.57 ± 0.48) were divided into two homogeneous groups, a control (Ctr) and a treated (Cry) group. Each experimental group was split into three replicates of five sheep each. Sheep were fed indoors from 60 days before lambing until weaning.

During the experimental period, sheep in both groups were fed a diet of ryegrass hay and concentrate offered in two meals, one in the morning (0800 hours) and one in the afternoon (1500 hours). The ingredients of the concentrate were (in g/kg DM): dehydrated alfalfa 280; wheat bran 275; sunflower meal 120; corn 106; calcium carbonate + premix + clay 62; molasses 50; barley 47; soybean meal 40; beans 20. In addition, the Cry group had free access to a cooked molasses licking block as an extra energy supplement. This supplement (Crystalyx Products Industrieweg, Münster, Germany) is manufactured using a unique patented cooking process and has the following composition (in g/kg DM): dehydrated molasses 700; palm oil 140; minerals 90; soybean 53; urea 17. During the patented production, part of the sugar contained in the molasses reacts with plant fat to form sugar ester compounds. These sugar esters are less fermentable than sugar contained in molasses and act as an emulsifier in the rumen. In addition, all animals had free access to fresh water every day. After weaning (30 days after lambing), sheep spent approximately 6 h per day grazing a plot of ryegrass, and were machine milked daily, at 0800 and 1500 hours. In stall, both groups of sheep received 600 g DM/sheep.day of hay and 500 g DM/sheep.day of concentrate (the daily amount of concentrate was provided in two doses, offered during each milking).

Pasture and pasture measurements

The pasture was a new sward of Italian ryegrass (*Lolium multiflorum* Lam., cv. Teanna) established in 2012 with 40 kg/ha of seed in a flat clay loam calcareous soil, pH 8.0, and low in P_2O_5 content. A randomised block design with three replicates was used. Each plot was 10 000 m^2 divided into 16 subplots. The stocking rate for all groups was 2.3 ewes/ha. The plots were grazed rotationally (7 days of occupation for each). Sward height was measured before and after grazing by a weighted-plate grassmeter (48 measurements/ha) and herbage mass was estimated by cutting at ground level and weighing twelve 0.5-m^2 quadrats/ha. Growth and regrowth of herbage were measured using the exclosure cage method (six 1 × 0.5 m^2 quadrats per subplot). The utilisation ratio of plots (gradient) was also measured by a weighted-plate grassmeter (48 measurements/ha) before and after the grazing session in every subplot. On two occasions, hand-picked samples of herbage (n = 3 per subplot) were taken during animal behaviour observation periods.

Animal measurements

Animal BW, BCS and blood metabolic profiles were recorded on Days –60, –30, –7, 30 and 60 from lambing date. Blood samples were taken from the jugular vein into lithium heparin tubes (from fasted animals, before the morning meal) and were immediately stored in iced water until centrifugation. Blood samples were centrifuged at 3500*g* for 15 min at 4°C and plasma samples were frozen (−20°C) in several fractions until analysis. Blood metabolites were determined by an automated biochemistry analyser (ILAB 6500; Instrumentation Laboratory, Lexington, MA, USA) in accordance with methods previously described by Bertoni *et al*. (2008) for the following parameters: glucose, non-esterified fatty acids (NEFA), β-OH-butyrate, total cholesterol, triglycerides, total protein, creatinine and urea. Lambs were weighed at birth and every week until weaning. Individual milk yield was measured fortnightly after weaning, at 30, 45 and 60 days after lambing. Milk samples were assayed for fat, protein (N*6.38), somatic cell count, and fatty acid composition (Fourier transform infrared analysis; Milkoscan FT+; Foss Electric, Hillerød, Denmark) and urea by differential pH-metry (CL-10 Micro; Eurochem, Ardea, Italy). Standard milk yield was calculated according to Bocquier *et al*. (1991).

Forage, concentrate and cooked molasses licking block intakes of each replicate within each group were measured daily as difference between offered and orts weights, whereas grazing behaviour was recorded by direct observation (6 h) on two occasions. Herbage intake was estimated during these sessions by multiplying the grazing time of each group by the intake rate measured in sheep exposed to micro-swards of the same forage species (Giovanetti *et al.* 2011). Forages, herbage and concentrates on offer and corresponding orts were sampled monthly and sequentially for 4 days for every replicate, to correspond with BW, BCS and blood sampling days. Subsequently, replicate samples were pooled and stored at −20°C until processing for further analysis. Forage samples were freeze-dried and then ground through a 1-mm screen before analysis.

The crude protein (CP) and ether extract (EE) content were determined according to the AOAC (1990). The NDF and acid detergent fibre (ADF) content was determined using an Ankom fibre analyser and the filter bag technique (Ankom Technology, Fairport, NY, USA). CP fractions (non-protein nitrogen (NPN), buffer soluble protein (BSP), acid detergent-insoluble nitrogen (ADIN; Licitra *et al.* 1996) and water soluble carbohydrates (WSC; Bailey 1958)) were also determined.

Statistical analyses

BW, BCS, blood parameters, lamb performance, milk yield and milk composition were analysed using the general linear model (GLM) repeated-measures procedure (SAS Institute Inc., Cary, NC, USA; release 8.0), with treatment, period of measurement and their interaction as fixed effects, and the animal within treatment groups as a random effect.

Results and discussion

Feedstuff composition and DM intake

The chemical composition of ryegrass hay (Table 1) showed a high concentration of NDF (644 g/kg DM) and a low concentration of CP (66 g/kg DM). The concentration of ADF in the concentrate and herbage was similar (196 and 189 g/kg DM, respectively), whereas the concentration of EE and WSC were, as expected, higher in the cooked molasses licking block (142 and 418 g/kg DM for EE and WSC, respectively) than in the other feedstuffs.

The intake of cooked molasses licking block was higher before lambing (on average 164 g/ewe.day in the last 60 days of pregnancy), in accordance with the higher ADF content of ryegrass hay. After the lambing period and in connection with the grazing of pasture, consumption of the supplement decreased (to, on average, 76 g per sheep per day in the first 60 days after lambing). Nevertheless, intake remained higher than expected (estimated as 50–70 g/day.sheep).

Total DM intake was similar between groups and ranged between 916 g of DM 60 days before lambing to 2500 g of DM 60 days after lambing. Overall, the Ctr group ingested more DM from hay (+10%; $P < 0.01$) than the Cry group, with a higher dietary NDF concentration in the total diet (55.87% vs 52.83% DM for the Ctr and Cry groups, respectively; $P < 0.01$). Previous results from cattle showed that animals supplemented with cooked molasses licking block increased daily forage intake (J. S. Drouillard, pers. comm.), probably because molasses content increases fibre digestibility (Greenwood *et al.* 2000; Firkins *et al.* 2008). In our experiment, Ctr ewes attempted to counteract a low level of energy intake by consuming more hay during the pre-lambing period, but they still ingested 16% less energy than the requirements for late pregnancy. Finally, as expected, the EE concentration of the diet tended to be higher in the Cry than Ctr group (29 vs 27 g/kg DM, respectively; $P < 0.06$).

No difference in grazing time was observed between the Cry and Ctr groups (272 vs 283 min per 6 h observation period, respectively; $P > 0.1$), whereas ruminating time was increased by Cry treatments (38.66 vs 22.5 min per 6 h observation period; $P < 0.01$). These results agree with those of Molina-Alcaide *et al.* (2010), who showed that sheep supplemented with molasses had improved diet digestibility and diet efficiency due to a longer rumination activity. This positively influences the production of volatile fatty acids (VFA) thanks to improved buffering capacity. Licking activity may explain the observed association between the increase in rumination time and the administration of the cooked molasses licking block. Sheep that lick the supplement block have increased salivary production, which helps buffer rumen activity. These results are in agreement with those of Greenwood *et al.* (2000), who found a higher VFA content and higher ammonia concentrations in the Cry than in Ctr group as a result of improved ruminal microbial activity. Increased ruminal activity could also be the result of an improvement in rumen microbial efficiency, which may increase the protein available at the intestinal level for milk production (Leupp *et al.* 2005) and thereby improve feed efficiency.

The first session of estimation of the utilisation ratio of the paddock biomass showed that the position of the cooked molasses licking blocks did not significantly ($P > 0.09$) influence the utilisation ratio (overgrazing near the supplement block position). Nevertheless, in the second observation session the herbage height far from the supplement block position was approximately double that near the supplement block (10.88 vs 5.67 cm; $P < 0.02$). These results suggest that the supplement block should be moved during the grazing period in order to avoid pasture patchiness as a result of overgrazing near the block and undergrazing far from it. This also means that the placement of the supplement block can be used to influence where animals should graze, which is very relevant for management under extensive grazing conditions.

Animal performance

Over the experimental period, the Cry group showed numerically lower BW losses than the Ctr group (+2%; n.s.), in accordance with BCS values (2.54 vs 2.46 for the Cry and Ctr groups, respectively; $P < 0.09$). Furthermore, BCS loss was slower around the lambing period in the Cry group, suggesting a lower negative energy balance compared with the Ctr group. Chaudhry *et al.* (2003) reported similar results in meat sheep during the mating season for animals grazing ryegrass pasture with lower supplementation levels.

Although the litter weight of lambs at birth was higher (+16%) in the Cry than in Ctr group (5.34 vs 4.60 kg of BW; n.s.), no significant difference was detected between the treatments. Differences between the treatments grew until the weaning period. In the last control point (29 days after lambing), the effect of treatment was close to significance (14.59 vs 12.40 kg of live BW of lambs in the Cry and Ctr groups, respectively; $P < 0.07$; Fig. 1), and was consistent with the

Table 1. Chemical composition of feedstuff

Data are the mean ± s.e.m. CMB, cooked molasses block; DM, dry matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre; WSC, water-soluble carbohydrates; n.d., not determined

Parameter	Hay	Herbage	Concentrate	CMB
DM (g/kg)	850 ± 11	155 ± 2	880 ± 63	891 ± 6
Ash (g/kg DM)	78 ± 3	144 ± 3	128 ± 16	234 ± 7
CP (g/kg DM)	66 ± 18	180 ± 16	166 ± 3	90 ± 3
EE (g/kg DM)	21 ± 1	45 ± 1	29 ± 10	142 ± 0.2
Starch (g/kg DM)	n.d.	n.d.	205 ± 3	n.d.
NDF (g/kg DM)	644 ± 8	447 ± 3	367 ± 37	n.d.
ADF (g/kg DM)	377 ± 5	189 ± 2	196 ± 18	n.d.
WSC (g/kg DM)	n.d.	142.5 ± 2	n.d.	418 ± 6

daily gain in total litter size (323.44 vs 279.18 g/day; $P < 0.08$). The difference in litter size for dairy sheep was the main performance effect revealed by this experiment, and is consistent with previous results reported in meat sheep (Chaudhry *et al.* 2003) and beef (Greenwood *et al.* 2000).

No significant treatment effects were found for twin or single lambs (weight or daily gain). The total liveweight of twin lambs in the Cry and Ctr groups was 10.37 and 8.71 kg, respectively; the liveweight for single lambs in these two groups was 8.09 and 7.80 kg, respectively. The reason for the lack of significant effects is probably due to the higher variability of lamb liveweight in the Cry compared with Ctr group (the s.e.m. is 30% higher in the Cry than Ctr group; data not shown).

The ewes in the Cry group showed a slight increase in BCS ($P < 0.09$) compared with ewes in the Ctr group (indicating a probably better nutritional status). This is probably related to a better energy balance in the Cry group, as suggested by the higher plasma glucose concentration in this group (3.58 vs 3.49 mmol/L; n.s.). However, plasma NEFA concentrations did not differ between treatment groups (0.476 vs 0.475 mmol/L in the Cry and Ctr groups, respectively; $P > 0.9$), suggesting that the slight increase in milk production in the Cry group cannot be attributed to the mobilisation of body reserves.

Regarding the other variables measured to evaluate the ewes' metabolic profile, supplementation had no effect on creatinine, total protein or urea. Conversely other blood markers of energy status showed a significant treatment effect. Specifically, concentrations of cholesterol (1.96 vs 1.63 mmol/L; $P < 0.01$) and triglycerides (0.28 vs 0.23 mmol/L; $P < 0.01$) were higher in the Cry versus Ctr group, whereas the effect of Cry supplementation on β-OH-butyrate did not reach statistical significance (0.50 vs 0.46 mmol/L in the Cry and Ctr groups, respectively; $P < 0.11$), as shown in Fig. 2. As reported previously in dairy cows (Bionaz *et al.* 2007; Bertoni and Trevisi 2013) and goats (D'angelo *et al.* 2005), the high concentration of plasma cholesterol during peripartum and the quick increase during early lactation represents a good index of liver functionality. The β-OH-butyrate concentration did not show high values or important variations around partum in the ewes, which suggests a low ketogenesis risk in both groups. Compared with the Ctr group, the Cry group had slightly higher concentrations of plasma β-OH-butyrate at 30 and 60 days of lactation, which is consistent with the higher rumen activity in these ewes and confirms the supposed higher synthesis of rumen VFA. In fact, the absorption of butyrate from the rumen epithelia could explain most of the β-OH-butyrate content in

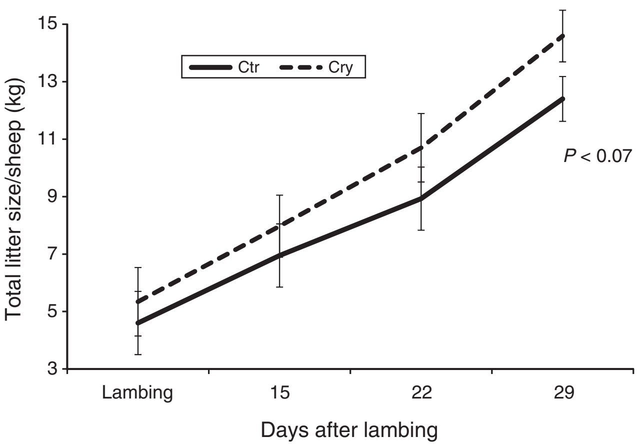

Fig. 1. Performance of total litter size (weight (in kg) of lambs per sheep) in ewes fed a diet with (Cry) or without (Ctr) an energy supplement offered as feed blocks. Data are the mean ± s.e.m.

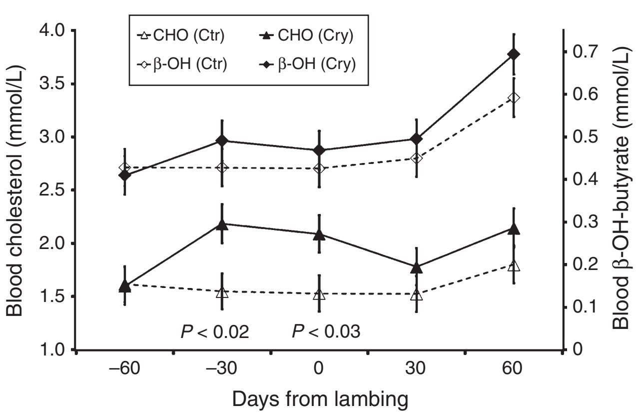

Fig. 2. Blood plasma concentrations of metabolic parameters in ewes fed a diet with (Cry) or without (Ctr) an energy supplement offered as feed blocks. Data are the least square mean ± s.e.m. CHO, cholesterol; β-OH, butyrate.

Table 2. Milk yield and composition 30, 45 and 60 days after lambing of ewes fed a diet with (Cry) or without (Ctr) an energy supplement offered as feed blocks

TR, treatment; OBS, milk sampling period; TR × OBS, interaction between treatment and sampling period; MY, milk yield; SMY, standard milk yield, calculated as MY × [(0.0071 × fat) + (0.00427 × protein) + 0.224]; UFA, unsaturated fatty acid. **$P = 0.01$

Parameter	Ctr			Cry			s.e.m.	Significance		
	30	45	60	30	45	60		TR	OBS	TR × OBS
MY (mL)	1752	1708	1561	1902	1724	1652	88	n.s.	n.s.	n.s.
SMY (mL)	1443	1488	1385	1612	1517	1473	75	n.s.	n.s.	n.s.
Fat (%)[A]	5.68	6.02	6.17	5.96	6.19	6.28	0.12	0.08	**	n.s.
Protein (%)[A]	4.68	5.18	5.28	4.64	5.12	5.19	0.12	n.s.	**	n.s.
Lactose (%)[A]	4.92	4.99	4.99	4.91	5.02	5.00	0.04	n.s.	n.s.	n.s.
Casein (%)[A]	3.64	4.09	4.17	3.59	4.04	4.01	0.10	n.s.	**	n.s.
UFA (%)[A]	1.49	1.56	1.60	1.67	1.66	1.71	0.05	**	n.s.	n.s.

[A]Note, percentage values show the milk content of a given compound in g per 100 mL milk.

plasma (Weigand *et al.* 1972) in animals in good health and with a positive energy balance.

Overall milk yield was not increased significantly in the Cry compared with Ctr group (1759 vs 1674 mL, respectively; $P > 0.3$), nor was standard milk yield (1534 vs 1439 mL, respectively; $P > 0.31$). However, fat content was significantly greater in the Cry than in Ctr group (6.14 vs 5.95%, respectively; $P < 0.08$; Table 2). No treatment effect was detected on milk protein, casein, lactose or somatic cell count ($P > 0.1$; data not shown). The unsaturated fat content of the milk was greater in the Cry than Ctr group (1.68% vs 1.55% of milk, respectively; $P < 0.05$).

Conclusions

The supplementation of the diet with cooked molasses licking blocks during peripartum benefitted dairy sheep in terms of BCS, lamb performance and milk fat content. No clear effect was detected on milk yield, although 30 days after lambing the treated group produced 8% more milk than the control group. Because feed intake at stall and estimated feed intake during grazing did not differ between the two groups, the slight increase in milk yield in the Cry group could be explained by increased feed efficiency at the digestive and/or metabolic level. In fact, blood profiles confirmed that the sheep exposed to blocks containing cooked molasses had a better nutritional status. The use of this licking supplement should be evaluated not only in relation to animal performance, but also in terms of its implications for feed efficiency, work, labour (easy management of supplement) and animal health. Future research is needed to better explain how this supplement stimulates rumen activity and feedstuff digestibility and, consequently, how it improves feed efficiency.

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