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in

Priolo A. (ed.), Biondi L. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.).
Advanced nutrition and feeding strategies to improve sheep and goat

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 74

2007
pages 395-398

Effect of propylene glycol addition to the diet of dairy ewes on metabolic profile, milk yield and quality

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SUMMARY – To study the effects of propylene glycol on metabolic profile and milk yield and quality during the 30 days prior to and 30 days after lambing, fifty one Valle del Belice dairy ewes were blocked by parity, body-condition score, previous milk production, and assigned randomly to three groups: Control, Propylene glycol (PG): Low PG: 80 g per ewe per day and High PG: 160 g per ewe per day. During the prepartum period, the addition of 160 g ewe/d of PG caused a decrease (P<0.05) of plasma non-esterified fatty acids, while during the postpartum period propylene glycol increased (P<0.01) plasma glucose. During the prepartum period, plasma total cholesterol and LDL decreased (P<0.01) in ewes of Low PG and High PG groups, while after lambing, plasma urea decreased (P<0.01) in Low PG group. In comparison to control ewes, propylene glycol increased milk yield in Low PG group (+16%) and in High PG group (+25%; P<0.01). The addition of propylene glycol was also associated to a decrease (P<0.01) of milk urea and improved milk clotting time (P<0.05) and curd firmness (P<0.01).

Keywords: ewe, pre-postpartum period, propylene glycol, metabolic profile, milk.

RESUME – *"Effet de l'addition de propylène glycol au régime de brebis laitières sur le profil métabolique, la production et la qualité du lait". Afin d'étudier les effets du propylène glycol sur le profil métabolique et la quantité et qualité du lait pendant les 30 jours avant et les 30 jours après la mise bas, 51 brebis laitières Valle del Belice ont été retenues d'après le numéro de mise bas, la note d'état corporel, la production laitière précédente, et distribuées au hasard dans trois groupes : Témoin, Propylène glycol (PG): Bas PG: 80 g par brebis et par jour et Haut PG: 160 g par brebis et par jour. Pendant la période prepartum, l'addition de 160 g de PG/brebis/j a entraîné une diminution (P<0,05) des acides gras non estérifiés plasmatiques, tandis que pendant la période postpartum le propylène glycol a entraîné une augmentation (P<0,01) du glucose plasmatique. Pendant la période prepartum, le cholestérol plasmatique total et les LDL ont baissé (P<0,01) chez les brebis des groupes à Bas PG et Haut PG, tandis qu'après la mise bas, l'urée plasmatique a baissé (P<0,01) chez le groupe Bas PG. En compaison aux brebis témoins, le propylène glycol a entraîné l'augmentation de la production de lait chez le groupe Bas PG (+16%) et le groupe Haut PG (+25%; P<0,01). L'addition de propylène glycol était également associée à une baisse (P<0,01) de l'urée du lait et améliorait le temps de coagulation du lait (P<0,05) et la fermeté du caillé (P<0,01).*

Mots-clés *: Brebis, période pre- et postpartum, propylène glycol, profil métabolique, lait.*

Introduction

The high productivity of Valle del Belice dairy ewe, coupled with under-nutrition and unbalanced feeding during the pre and postpartum period, leads to strong mobilisation of body reserves and results in weight losses of up to 20% and a higher mortality rate among lambs (Ford *et al*., 1990; Giaccone *et al*., 1996; Chiofalo, 2000).

During the pre and postpartum period it is important to control metabolic variations of ewes to undernutrition and consequences on milk production and, in such conditions, on the survival of lambs (Chilliard *et al*., 1998). In this context, ovine ketosis is a metabolic disorder appearing in pregnant ewes with 2 or more lambs (Aitken, 1996).

Nutritional strategies by using propylene glycol as an energetic source into the diet, could solve the problems of pregnant ewes during the last period of pregnancy and improve the performances of ewes in early lactation (Bertics *et al*., 1992).

The aim of this work was to determine the effects of propylene glycol addition into the diet on metabolic profile, body condition score, milk yield and quality and milk coagulation properties in Valle del Belice dairy ewes.

Materials and methods

Fifty-one Valle del Belice ewes were blocked by parity (first, second, third or greater), body condition score (BCS) and previous milk production, and assigned randomly to three groups respectively: Control (n = 16 ewes); Low PG (n = 17 ewes) with 80 g per ewe per day of propylene glycol and High PG (n = 18) with 160 g per ewe per day of propylene glycol. Propylene glycol was added into the concentrate. The mean of BCS of ewes measured at the beginning of the experiment was 2.6 ± 0.3 (Russel, 1991). The trial lasted 60±5 days: starting 30 d (prepartum) before the expected lambing date determined by ultrasonography and for further 30 d post-lambing. During the 30 d of the prepartum period, ewes were fed with 0.400 kg/ewe/d of concentrate and 1.500 kg/ewe/d of vetch-oat hay. The diet was calculated to provide the nutritional requirements for dairy ewes (Bocquier *et al*., 1991). During the postpartum period, ewes were fed with 0.800 kg ewe/d of the same concentrate and 2.00 kg/ewe/d of the same hay. Ewes were scored for body condition by a trained technician 30 d and 15 d before lambing and 15 d and 30 d post lambing. Chemical composition of feeds is reported in Table 1. Individual blood samples were taken 30, 15, 7 and 3 days prior to lambing and 3, 7, 15 and 30 days during the postpartum period to determine plasma glucose, non esterified fatty acids (NEFA), β-hydroxibutyrate (BHBA), triglycerides, total cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), and urea by using a SIGMA kit (St Louis, MO, USA). Individual milk yield was measured weekly only at the morning milking and individual milk samples (50 ml) were collected to determine: fat, protein, lactose by Milko-Scan 4000, and milk pH, titrable acidity (SH/100 ml) and urea by CL10. Milk clotting time (r min), curd firmness (a_{30} mm) and firming rate (K_{20} min), were determined by Formagraph (Foss Electric), (ASPA, 1995). Data were analysed by the GLM procedure of SAS (1991).

Table 1. Chemical composition of hay and concentrate

	Vetch-oat hay	Concentrate
DM (%)	90.78	87.50
In DM %		
Crude protein	13.00	21.64
Neutral Detergent Fiber	51.57	17.9
Ether extract	1.55	3.15
Non-structural carbohydrates	24.77	46.81
Ash	9.11	10.05

Results and discussion

During the postpartum period, the addition of propylene glycol increased plasma glucose concentrations ($P<0.01$) in ewes (Table 2), indicating that propylene glycol has an efficacious glucogenic effect. During the prepartum period, plasma NEFA values were lower in ewes of High PG group ($P<0.05$). The results obtained for plasma NEFA in ewes of Control and Low PG groups, were probably due to an increase in the demand for foetal glucose. No significant differences between the three experimental groups were reported in plasma BHBA during the prepartum and postpartum periods. An increase of plasma NEFA and BHBA was detected in ewes of Control group during the last 7 days of pregnancy and could explain a possible metabolic disease such as pregnancy toxaemia (Aitken, 1996). The addition of propylene glycol added into the diet of ewes during the prepartum period could help to control plasma glucose, NEFA and BHBA values with positive effects on ewes metabolic conditions during the postpartum period. Propylene glycol had no effect on plasma triglycerides during prepartum and postpartum periods in all three groups. This result could be attributed to the utilisation of this metabolite in the uptake of the mammary gland (Ronchi *et al*., 1994). During the prepartum period, plasma total cholesterol was lower in PG groups ($P<0.01$), while no differences occurred after lambing in the three groups. The decrease ($P<0.01$) of plasma total cholesterol from pre to postpartum period in ewes of Control group could result from a temporary reduction of liver capacity. The addition of 80 g ewe/d of propylene glycol into the diet decreased plasma urea ($P<0.01$) and this finding could be attributed to a higher gluconeogenesis, as supported by Ronchi *et al*., 1994.

Table 2. Plasma metabolites ($mmol^{-1}$) in ewes during the pre and the postpartum periods

	Period	Dietary treatment					
		Control		Low PG		High PG	
		Mean	S.E.	Mean	S.E.	Mean	S.E.
Glucose	Prepartum	2.19	0.08	2.43	0.09	2.31	0.09
	Postpartum	3.04^{A}	0.07	3.33^{B}	0.09	3.40^{B}	0.08
NEFA	Prepartum	0.81^{a}	0.06	0.75^{a}	0.06	0.71^{b}	0.07
	Postpartum	0.67	0.06	0.59	0.07	0.64	0.06
BHBA	Prepartum	0.46	0.03	0.44	0.03	0.37	0.03
	Postpartum	0.38	0.02	0.39	0.03	0.35	0.03
Triglycerides	Prepartum	0.27	0.01	0.25	0.01	0.25	0.01
	Postpartum	0.16	0.01	0.16	0.01	0.18	0.01
Cholesterol	Prepartum	1.51^{A}	0.04	1.36^{B}	0.04	1.34^{B}	0.04
	Postpartum	1.28	0.04	1.32	0.04	1.30	0.04
LDL	Prepartum	0.65^{A}	0.02	0.55^{B}	0.02	0.58^{B}	0.02
	Postpartum	0.47	0.02	0.45	0.02	0.44	0.02
HDL	Prepartum	0.75	0.03	0.69	0.03	0.72	0.03
	Postpartum	0.74	0.02	0.81	0.03	0.77	0.03
Urea	Prepartum	5.89	0.24	5.42	0.25	5.12	0.26
	Postpartum	5.97^{A}	0.23	5.07^{B}	0.25	5.35^{AB}	0.24

The addition of 160 g per ewe per day of propylene glycol yielded a 25.5% increase of milk yield ($P<0.01$), while the increase of milk yield was only around 16% by using 80 g/ewe/d in comparison with the Control group (Table 3). Milk fat, protein and lactose were not influenced by the addition of propylene glycol. Milk urea decreased ($P<0.05$) in ewes fed with propylene glycol (Table 4). A decrease of milk clotting time ($P<0.05$) and an increase of curd firmness ($P<0.01$) was obtained in PG groups, indicating an improvement of coagulation properties of ovine milk.

Table 3. Use of propylene glycol: Milk yield and composition

Parameters	Dietary treatment					
	Control		Low PG		High PG	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Milk yield (g/d)	686^{A}	56.34	796^{AB}	52.83	861^{B}	52.50
Fat (%)	5.69	0.33	5.38	0.31	5.73	0.30
Protein (%)	5.15	0.15	4.96	0.14	5.02	0.14
Lactose (%)	4.61	0.08	4.61	0.08	4.75	0.08

Conclusions

The use of propylene glycol added into the diet of ewes from 30 days before parturition until 30 days after lambing was associated with positive effects on metabolic parameters that could explain the increase of milk yield and the improvement of its coagulation properties.

Table 4. Use of Propylene glycol: Milk coagulation properties

	Control		Low PG		High PG	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
pH	6.67	0.02	6.68	0.02	6.66	0.02
Titrable acidity (SH/100 ml)	8.71	0.22	8.50	0.20	9.22	0.20
Urea (mg/l)	32.59^{a}	0.73	27.58^{b}	0.71	29.50^{C}	0.70
Clotting time r (min)	23.57^{A}	0.48	21.04^{B}	0.48	21.26^{B}	0.44
Curd firmness a_{30} (mm)	25.30^{A}	1.43	32.87^{B}	1.13	32.80^{B}	1.05
Firming rate K_{20} (min)	2.15	0.12	2.34	0.12	2.55	0.11

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