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Note

Effect of dietary palygorskite on performance of lactating ewes

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ABSTRACT

Twenty eight lactating Chios ewes were used in an experiment to determine effects of dietary activated micronized palygorskite (Pal; Sanfed® Ultra, Geohellas SA, Athens, Greece) supplementation on productivity and milk composition. In the experiment, which started on day 43 postpartum, ewes were allocated after equal distribution relative to milk yield and lactation number (i.e., 2 or 3), into 4 treatment groups being Pal0, Pal2.5, Pal5.0 and Pal7.5 of 7 ewes each and accommodated in individual pens. For a period of 60 days (i.e., days 43–102 postpartum), ewes were fed one of four isonitrogenous (crude protein 175 g/kg, dry matter (DM) basis) and isoenergetic (net energy for lactation (NEl) 7.69 MJ/kg DM) concentrates (1.35 kg DM/ewe/day) and alfalfa hay (1.02 kg DM/ewe/day). The concentrate for treatment Pal0 (Control) had no Pal, while that for treatments Pal2.5, Pal5.0 and Pal7.5 contained 2.5, 5.0 and 7.5 g/kg of Pal (as mixed basis), respectively. All ewes remained healthy until the end of the experiment without visually altered behavior. In the 60 day experimental period, milk fat, crude protein and NEl contents were highest with the Pal5.0 treatment ($P < 0.01$, $P = 0.01$ and $P < 0.01$, respectively). In contrast, milk lactose content was lowest ($P < 0.01$) with the Pal2.5 treatment. With increased Pal feeding, milk fat and NEl yields were highest with the Pal5.0 treatment ($P < 0.01$ and $P = 0.03$, respectively), but milk yield and yields of other components, as well as milk somatic cell counts and colony forming units were not affected. Dietary Pal supplementation, at levels up to 5.0 g/kg, in isonitrogenous and iso-NEl diets fed to lactating ewes increased milk fat and NEl yields and improved milk quality, increasing fat, crude protein and NEl contents, while, at higher level (7.5 g/kg), dietary Pal supplementation did not affect milk yield and composition, with optimal Pal feeding levels identified between 3.4 and 4.0 g/kg of concentrate.

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1. Introduction

Palygorskite (Pal) belongs to phyllosilicates and is among the world's most important and useful industrial clay minerals, due to its unique structure that provides high absorption and adsorption capacity (Brigatti et al., 2013; Harvey and Lagaly, 2013). Recently, dietary Pal supplementation has been tested on animal performance; specifically on performance of weaned piglets (Zhang et al., 2013; Tang et al., 2014), growing pigs (Schell et al., 1993), sows (Papadopoulos et al., 2016), broiler chickens (Pappas et al., 2010; Chen et al., 2016a, 2016b; Cheng et al., 2016), laying pullets (Chalvatzi et al., 2016), laying hens (Chalvatzi et al., 2014; Qiao et al., 2015), and lactating cows (Bampidis et al., 2014). However, no studies are available on effects of dietary Pal supplementation in lactating ewes. The objective was to evaluate Pal supplementation in diets of lactating Chios ewes, relative to their performance and chemical composition of milk.

2. Materials and methods

2.1. Palygorskite

Pal was used in an experiment with lactating Chios ewes, at the Research Institute of Animal Science, Hellenic Agricultural Organization – Demeter (Giannitsa, Greece; 40°44′N, 22°27′E). The Pal used in the experiment was activated micronized palygorskite (Pal; Sanfed® Ultra) obtained from Geohellas S.A. (Athens, Greece) and mined from deposits located in the Ventzia basin (Grevena, Greece). Pal (Sanfed® Ultra) was mechanically and thermally processed and thus differed from untreated Pal (Theophilou, 2014), since it received: 1) mechanical activation through extrusion to enhance its inherent hydrophilic behavior, 2) thermal activation that improved oleophilic behavior (i.e., binding of toxins and bacterial toxigens) of the Pal surfaces, and 3) dynamization to reduce the size of the product to under 1 μm through a dynamic milling technique. Pal (Sanfed® Ultra) was obtained as a red-gray powder (AFG-60 mesh), and was a minimum 750 g/kg Pal and 250 g/kg bentonite-saponite. The main chemical components of the

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Pal supplement were: SiO_2 560 g/kg, MgO 150.5 g/kg, Fe_2O_3 106 g/kg, Al_2O_3 49.7 g/kg, CaO 3.3 g/kg, K_2O 3 g/kg, Na_2O 0.6 g/kg, and loss on ignition (water content) was 109.5 g/kg. Moreover, Pal (Sanfed® Ultra) physicochemical properties were: apparent bulk density 0.4 g/cm^3, specific surface area 148 m^2/g, water absorption capacity (Westinghouse method) 150%, oil absorption capacity (Westinghouse method) 130%, and pH (5% dispersion) 8.0 (Geohellas S.A., 2016).

2.2. Experiment: Lactating ewes

Twenty eight lactating and clinically healthy Chios ewes were used to determine effects of dietary activated micronized palygorskite (Pal) supplementation on their productivity and milk composition. All animals used in the experiment were cared for according to applicable recommendations of the U.S. National Research Council (2010). Milk yield of ewes was recorded at the beginning of the experiment (1344 ± 436 g/day). The body weight (BW) of Chios ewes has been reported to be 60 kg (Ploumi et al., 1998). Ewes were allocated at weaning, on day 43 postpartum, after equal distribution relative to milk yield and lactation number (i.e., 2 or 3), into 4 treatment groups (Pal0, Pal2.5, Pal5.0 and Pal7.5) of 7 ewes each and accommodated in individual pens. All 28 pens were essentially identical, with the same direction and surface area (2 m^2/ewe), and all were equipped with similar troughs for feeding concentrates, hay, and water. For a period of 60 days (i.e., days 43–102 postpartum), ewes were offered one of four isonitrogenous and isoenergetic (net energy for lactation (NEl)) concentrates (Tables 1 and 2) and alfalfa hay. The concentrate (Table 1) for treatment Pal0 (Control) had no Pal, while that for treatments Pal2.5, Pal5.0 and Pal7.5 contained 2.5, 5.0 and 7.5 g/kg of Pal (as mixed basis), respectively. Diets were formulated to meet nutrient requirements of sheep for lactation (National Research Council, 2007) and were designed to be identical except for the presence or absence of Pal.

Table 1
Concentrate composition of lactating ewes rations.

	Treatment[a]			
	Pal0	Pal2.5	Pal5.0	Pal7.5
Ingredient composition (g/kg, as mixed)				
Corn grain, ground	400	400	400	400
Barley grain, ground	260	257.5	255	252.5
Soybean meal (440 g/kg CP)	130	130	130	130
Sunflower meal (280 g/kg CP)	70	70	70	70
Wheat bran	100	100	100	100
Activated micronized palygorskite (Pal)	0	2.5	5.0	7.5
Limestone	15	15	15	15
Monocalcium phosphate	6	6	6	6
Salt	4	4	4	4
Vitamin-trace mineral premix[b]	15	15	15	15
Chemical composition[c] (g/kg dry matter-DM)				
Dry matter (as fed)	882	882	881	881
Crude protein (CP)	175	175	175	174
Crude fat	32	32	32	32
Neutral detergent fiber(om)	185	185	184	184
Acid detergent fiber(om)	82	82	82	82
Ash	34	34	33	33
Calcium	12.6	12.6	12.6	12.6
Phosphorus	7.5	7.5	7.5	7.5
Sodium	2.5	2.5	2.5	2.5
Net energy for lactation (NEl, MJ/kg DM)	7.72	7.70	7.68	7.67

[a] Pal0 = control treatment, Pal2.5 = treatment with 2.5 g/kg palygorskite, Pal5.0 = treatment with 5.0 g/kg palygorskite, Pal7.5 = treatment with 7.5 g/kg palygorskite.
[b] Premix contained 230 g/kg Ca and 60 g/kg P and supplied/kg of concentrate: 12,000 IU vitamin A; 15 mg vitamin B_1; 2250 IU vitamin D_3; 49.5 mg vitamin E; 12 mg choline; 0.75 mg Co; 1.95 mg I; 90 mg Mn; 0.45 mg Se; 210 mg Zn.
[c] Concentrates were analyzed for dry matter, crude protein, crude fat, acid detergent fiber and ash according to Association of Official Analytical Chemists (1990), and for neutral detergent fiber according to Van Soest et al. (1991). All other values were calculated from National Research Council (2007) values.

Table 2
Dry matter (DM) intake of lactating Chios ewes during the experiment (days 43 to 102 postpartum).

	Treatment[a,b]				SEM	Significance level[c]	
	Pal0	Pal2.5	Pal5.0	Pal7.5		Linear	Quadratic
DM intake (kg/day)							
Concentrate (Table 1)	1.36	1.38	1.31	1.33	0.029	0.57	0.99
Alfalfa hay	1.01	1.02	1.01	1.05	0.015	0.42	0.71
Total	2.37	2.40	2.32	2.38	0.037	0.88	0.90

[a] Pal0 = control treatment, Pal2.5 = treatment with 2.5 g/kg palygorskite, Pal5.0 = treatment with 5.0 g/kg palygorskite, Pal7.5 = treatment with 7.5 g/kg palygorskite.
[b] Number of ewes/treatment = 7.
[c] Numbers are probability values.

Feed intake was measured daily for each ewe. Ewes had free access to water and were machine milked twice daily at 07:00 and 18:00 h with a 2 × 24 DeLaval (Thessaloniki, Greece) milking machine. During the experimental period, the health status and behavior of all ewes was monitored on daily basis. Milk yield was recorded at twelve day intervals (i.e., on days 43, 54, 66, 78, 90 and 102 postpartum) from consecutive morning and afternoon milkings. Milking was conducted at a vacuum level of 42 kPa, pulsation rate of 90/min and pulsation ratio of 60/40. During 6 morning and afternoon milkings (i.e., on days 43, 54, 66, 78, 90 and 102 postpartum), milk samples were collected from each ewe, after cleaning and disinfecting the teats. The morning and afternoon milk samples of each ewe, taken in proportion to the different yield, were finally pooled and kept refrigerated (+4 °C) until chemical analysis.

2.3. Analyses

2.3.1. Feed chemical analyses

The alfalfa hay and concentrates were analyzed for dry matter (DM) by drying at 102 °C for 16 h in a forced air oven, and for crude protein (CP), crude fat, acid detergent fiber (ADFom) and ash according to methods 976.06, 920.39, 973.18 and 942.05, respectively, of the Association of Official Analytical Chemists (1990). Neutral detergent fiber (NDFom) was determined according to Van Soest et al. (1991), without use of sodium sulfite or *a*-amylase, and NDFom and ADFom were expressed without residual ash.

2.3.2. Milk chemical analyses

Milk samples were analyzed for fat, CP, lactose and solid-not-fat (SNF) with IR spectroscopy (Milkoscan 4000; FOSS, Hillerød, Denmark) according to method 972.16 of the Association of Official Analytical Chemists (1990). Ash was calculated as SNF minus protein and lactose. Milk samples were also analyzed for somatic cell counts (SCC) using a Fossomatic 400 cell counter (FOSS, Hillerød, Denmark), and for colony forming units (CFU) using a BactoScan FC (FOSS, Hillerød, Denmark).

2.3.3. Calculations and statistical analysis

NEl content of milk was calculated using eq. 2–15 of National Research Council (2001). Performance and milk composition of ewes were analyzed by one-way analysis of variance procedures, and significant differences among treatment means were tested using linear and quadratic contrasts (Steel and Torrie, 1980). To identify the optimum Pal inclusion level in ewes' concentrates, relative to milk yield, milk fat, crude protein and NEl contents, and milk NEl yield response, curvilinear regression analysis was performed and appropriate equations were obtained best fitted to the parameters response. For all tests, a probability level of <0.05 was accepted as significant. Statistical analysis used the Statistical Package for the Social Sciences (2008).

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