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ANIMAL SCIENCE

Supplementation strategies for ewes during gestation and lactation

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Abstract: Concentrated supplementation of ewes is a strategy to increase productivity. The objective was to evaluate the effects of supplementation in the diet of ewes before, during and in the final third of pregnancy and lactation on, the performance and production and composition of colostrum and milk. Forty animals were distributed in a completely randomized design, into the following treatments: CONT = control treatment with mineral salt supplementation only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = suplementação a partir da confirmação da gestação (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES). Supplementation adoption changed (P < 0.05) the intake of organic matter, crude protein, neutral detergent fiber, the percentage of total digestible nutrients, and digestibility of dry matter, acid detergent fiber, non-fiber carbohydrates, and ether extract with their respective intake, in addition to colostrum and milk production and composition and animal performance. No difference (P > 0.05) was observed for organic matter, crude protein, and neutral detergent fiber digestibility and total digestible nutrient intake. Thus, supplementation in the final third of pregnancy may result in heavier lambs at weaning, reduction in slaughter time.

Key words: production colostrum, production milk, production sheep, sheep performance, ruminant nutrition.

INTRODUCTION

Adequate supplementation for pregnant ewes is a nutritional strategy that impacts the sheep production system, such as obtaining healthy lambs (Silva et al. 2019). Nutritional techniques, such as flushing, are strategies used to increase fertility. Flushing consists of the increase in nutritional intake, mainly with energy feeds, before mating, aiming to increase the ovulation rate (Valentim et al. 2016).

In a study carried out by Brondani et al. (2020) ewes that received food supplementation throughout the gestational period had higher body weight, differing from the other experimental treatments. This result indicates that the nutritional supply promoted by supplementation met the physiological needs of the animals, which did not need to overload the body for its physiological maintenance.

Birth weight is the biggest influence on the survival of lambs in the first days of life, and low birth weight is associated with increased mortality and reduced postnatal growth (Oldham et al. 2011). Geraseev et al. (2006) evaluated the performance of lambs born to ewes undergoing energy restriction at the end of gestation and found negative results for the birth weight of lambs (males and females) when their mothers were submitted to a diet that met only 60% of energy requirements. The significant reduction observed in the birth weight of male (30.5%) and female (17.8%) lambs revealed the importance of adopting an adequate nutritional level for pregnant ewes, especially during the final third of gestation.

Colostrum is the main feed source for lambs. It is essential for establishing passive immunity and, therefore, is one of the most important recommendations within the set of herd health measures to be applied to newborns (C.B. Silva et al. 2018, unpublished data). Colostrum essentiality comes from the fact that it has high concentrations of antibodies and immunoglobulins, which provide immunological protection until the animal's immune system becomes active (Hernández-Castellano et al. 2015).

Campos et al. (2019) evaluated colostrum and milk composition in the initial third of lactation of ewes kept on pasture receiving different types/levels of supplement and observed that the different types of supplementations did not change the colostrum composition of crossbred Santa Inês ewes but showed influence on milk composition.

Feeding is one of the most striking points among those that can influence milk production. Lactation is a phase of high nutritional requirement for the animal, demanding the supply of balanced diets to meet its requirements, as a diet with low levels of nutrients essential to life can lead to a decrease in productivity, with variations in the composition and quality of both colostrum and milk (Natel et al. 2013).

The sugarcane used as a forage resource for ruminants is one of the alternatives to minimize the inadequate nutrition of animals, especially in periods of drought. Sugarcane structural carbohydrates are a potential source of low-cost energy for feeding these animals. However, such potential is limited due to its low digestibility and degradation rate, with the consequent low voluntary intake (Wilkins et al. 1999).

Thus, this study aimed to evaluate the effects of supplementation in the diet of ewes before, during, and in the final third of gestation and lactation, on the animal performance and colostrum and milk production and composition.

MATERIALS AND METHODS

The experimental procedures were approved by the Committee for Ethics in Animal Experimentation (CEUA) of the Universidade Federal de Brasília under protocol number 10/2019. The experiment was conducted between January and November 2019 at Fazenda Água Limpa of the Universidade de Brasília (FAL/UnB).

Animals, feed and management

Forty pregnant crossbred Santa Inês x Dorper ewes plus two reserves were used. The ewes were distributed in a randomized design, according to age, weight, and body score, with four treatments and 10 replications. The ewes were maintained on a pasture with *Brachiaria brizantha* cv. Marandu, in an area of five hectares divided into seven paddocks, where the animals grazed together to remove the effect of pasture. Supplements formulated according to NRC (2007) were provided daily at 4 pm in an amount equivalent to 1% of body weight (BW), being adjusted every 15 days, when the ewes were weighed. The animals were confined in stalls, where they received supplementation according to the treatment. After consumption, they were kept in the same pen with water ad libitum, where they spent the night. The supplements were not isoproteic, but the metabolizable energy requirements were different due to the stage of gestation (Table I).

The treatments consisted of CONT = control treatment with mineral salt supplementation

Table I. Centesimal and nutritional composition of concentrate, pasture (*Brachiaria brizantha* cv. Marandu), and sugarcane in the natural matter (%) supplied to ewes during gestation and lactation.

Item (%)	**Gestation**				**Lactation**	
	CONT	**SSREPRO**	**SSPREG**	**SEPREG**	**CONT**	**SSREPRO; SSPREG; SEPREG**
Soybean meal	–	56.37	56.37	36.04	–	45.59
Corn	–	40.24	40.24	61.53	–	50.61
Urea	–	–			–	0.50
Calcitic limestone	–	–	–	0.59	–	–
Vitamin mineral supplement[1]	+	3.39	3.39	1.84	–	3.30
Protein mineral supplement[2]	–	–	–	–	+	–

Nutrient	Gestation				Lactation	
	SSREPRO; SSPREG; SEPREG				CONT	SSREPRO; SSPREG; SEPREG
	Supplement	Pasture	Supplement	Pasture	Sugarcane	Supplement
DM (% NM)	96.61	93.05	92.75	94.79	95.81	89.72
CP (% DM)	29.98	9.55	23.14	4.70	2.86	25.55
NDF (% DM)	18.33	75.56	25.75	71.11	38.74	18.18
ADF (% DM)	4.98	35.25	5.61	38.84	23.25	4.85
EE (% DM)	2.74	4.60	2.65	2.85	2.10	3.66
MM (% DM)	7.33	8.96	5.61	6.22	2.96	13.21
CHOt (% DM)	59.91	80.54	68.58	86.20	92.35	57.56
NFC (% DM)	41.58	4.98	42.83	15.09	53.61	39.38
NDIN (% DM)	13.15	3.55	21.94	2.82	1.95	16.87
ADIN (% DM)	6.68	1.26	9.37	0.96	0.98	9.61
TDN (% DM)	58.42		68.43		69.11	

CONT = control treatment with mineral salt supplementation only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = supplementation after confirmation of pregnancy (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES). NM – natural matter; DM – dry matter; CP – crude protein; NDF – neutral detergent fiber; ADF – acid detergent fiber; EE – ether extract; MM – mineral matter; CHOt – total carbohydrates; NFC – non-fibrous carbohydrates; NDIN – neutral detergent insoluble nitrogen; ADIN – acid detergent insoluble nitrogen; TDN – total digestible nutrients.

(1) Composition of vitamin mineral premix: calcium (max.) 150 g, calcium (min.) 130 g, phosphorus (min.) 65 g, sodium (min.) 130 g, fluorine (max.) 650 mg, sulfur (min.) 12 g, magnesium (min.) 10 g, iron (min.) 1,000 mg, manganese (min.) 3000 mg, cobalt (min.) 80 mg, zinc (min.) 5,000 mg, iodine (min.) 60 mg, selenium (min.) 10 mg, vitamin A (min.) 50000 IU, vitamin E (min.) 312 IU.

(2) Protein mineral supplement: calcium 85 g, cobalt 20 mg, copper 400 mg, sulfur 6 g, fluorine 243 mg, phosphorus 18 g, iodine 50 mg, manganese 500 mg, crude protein 300 g, NPN (protein eq.) 255 g, selenium 10 mg, sodium 39 g, zinc 800 mg.

only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = suplementação a partir da confirmação da gestação (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES). The ewes were identified with paint on the back according to their treatment aiming to generate less stress. The animals were synchronized with the presence of a Dorper ram, causing the effect of male with release pheromones to stimulate estrus at the beginning of the breeding season. Oil and powder paint were used in the breast region of the sire to control which sheep were covered. Natural mating was used at the proportion of one male for every 50 females. Gestation was diagnosed about 55 days after mating using an Aloka 500 ultrasound device (Aloka Co. Ltd., Japan) coupled to a 5 MHz linear transducer positioned in the rectal region.

After giving birth, the ewes were housed in farrowing stalls equipped with buckets for water and troughs for roughage, concentrates, or protein salt, according to the treatments. The experimental diets were based on sugarcane and a concentrate mixture with soybean meal, corn, urea, mineral mixture, and protein mineral salt (Table I), balanced according to the NRC (2007) recommendations for lactating sheep. The experimental period lasted 60 days, with 10 days for adaptation to the facilities and diets. The supplied diets allowed 15% leftovers. Diets and leftovers were weighed daily and sampled weekly to obtain a composite sample from each experimental diet for further analysis. Leftovers were sampled at the proportion of 35% of the total daily amount supplied to each animal. All samples were properly packaged and stored in a freezer (–20°C) for further bromatological analyses.

Weight variation and body score condition

Performance was evaluated by weighing all dams at the beginning of the experimental period to obtain the initial live weight and every 15 days to obtain the average daily weight gain (ADG, g/animal/day), which was calculated by the difference in animal weight between weighings divided by the number of days between each weighing. The total weight gain (TG, kg/animal) was obtained by the sum of all weight gains up to the weaning day.

The body condition score was determined by palpations of the spine after the last rib, above the kidney region, according to the methodology described by Osório & Osório (2005). Values from 1 to 5 were assigned, with 1 corresponding to animals excessively thin and 5 to excessively fat animals. Intermediate values in variations of 0.25 were also considered.

Nutrient intake and digestibility

DM intake was determined by the difference the amount of DM provided and the DM of leftovers. Nutrient intake was calculated based on its relationship with DM and its levels in feed and leftovers.

Nutrient digestibility (ND) was obtained by the following formula: ND = (DM intake x % Nutrient) – (excreted DM x % Nutrient) x 100] / (DM intake x % Nutrient).

The content of total digestible nutrients (TDN) was calculated considering the intake and fecal excretion of nutrients, using the equation: TDN (%) = DCP + DEE x 2.25 + DNDF + DNFC, where CPD is the digestible crude protein, DEE is the digestible ether extract, DNDF is the digestible neutral detergent fiber, and DNFC is the digestible non-fiber carbohydrate (NRC 2001).

Colostrum production and composition

Colostrum production was measured after parturition at the colostrum stage (0 to 12 h postpartum) and determined by the indirect method of double weighing. The lambs were weighed individually in the case of a on a digital scale before breastfeeding and immediately taken to breastfeeding until satiety when they were weighed again. The difference between the weight of the lambs before and after suckling corresponds to the amount of colostrum produced by the ewe (Fernandes et al. 2009).

Colostrum collections were performed two times, with a pool of jets from both teats not exceeding the volume of 50–60 mL per collection in each female, using collection cups with lids with a maximum volume of 80 mL. The first collection occurred immediately after parturition and the second one 12 hours later. The flasks were identified and stored in a freezer at −20°C for later analysis of the concentration of fat, protein, lactose, total and defatted dry extract, somatic cell count, urea, and casein. The centesimal composition was measured using the mid-infrared absorption spectrometry technique – MID. Somatic cell count (SCC) was measured by flow cytometry and urea by infrared absorption spectrometry.

Milk production and composition

Milk production was measured every fifteen days after the colostrum stage and determined by the indirect method of double weighing. The lambs were weighed individually in the case of a on a digital scale before breastfeeding and immediately taken to breastfeeding until satiety when they were weighed again. The difference between the weight of the lambs before and after suckling corresponds to the amount of milk produced by the ewe (Fernandes et al. 2009).

The procedures were carried out during the following eight weeks, and the lambs were maintained separated from the ewes eight hours before the first weighing and the eight-hour interval between weighings until the 24 hours of the day were completed. The amount of milk in kg was obtained by the sum of the daily production. Likewise, individual samples of 100 mL of milk were collected in the morning every two weeks and placed in containers with bronopol (preservative) to determine the contents of fat, lactose, protein, and total and defatted solids. Milk chemical composition was determined in Bentley 2000 equipment (Bentley Instruments Inc.) by infrared spectroscopy. The total solids (TS) concentration was estimated by the Fleischmann formula, in which TS = 1.2 * % Fat + 2.665 [(100 * Density – 100) / Density].

Bromatological analysis

Samples of the supplied diet, leftovers, and feces were pre-dried in a forced-air ventilation oven at 55°C and ground in a Willey mill with a 1-mm diameter opening sieve to determine the dry matter (DM; AOAC 2005, method number 930.15), mineral matter (MM; AOAC - 2005, method number 942.05), crude protein (CP; AOAC 2005, method number 984.13), and ether extract contents (EE; AOAC 2005, method number 920.39). The fibrous fractions, i.e., neutral detergent fiber (NDF) and acid detergent fiber (ADF), were determined using the methodology proposed by Van Soest et al. (1991). Neutral detergent insoluble nitrogen (NDIN) and acid detergent insoluble nitrogen (ADIN) were determined following the recommendations by Licitra et al. (1996). The percentage of total carbohydrates (TC) was calculated by the equation proposed by Sniffen et al. (1992), while the non-fibrous carbohydrates (NFC) were determined using the equation recommended by Weiss (1993).

Statistical analysis

The data were subjected to analysis of variance, considering the diet and colostrum and milk production and composition as sources of variation. The comparison between the effects of the type of diet and gestation was carried out using Tukey's test at 0.05 probability by the PROC GLM statistical procedures from SAS (2004). The Kruskal-Wallis non-parametric test was used for the variable body condition score. A significant interaction between factors was subsequently sliced.

RESULTS

The absence of concentrate significantly ($P < 0.05$) reduced DM and OM intakes, with means of 1,131 and 1,112 g/day, respectively (Table II). However, it increased for variables expressed in $g/kg^{0.75}$ and %LW, with means of 46.05 and 3.45 $g/kg^{0.75}$ and 45.20 and 3.39% LW.

Unlike OM digestibility ($P > 0.05$), DM digestibility reduced ($P < 0.05$) for animals with no concentrate inclusion (Table II), reaching means of 66.86 and 70.43%, respectively.

There was an effect of treatments ($P < 0.05$) on CP intake in g/day, $g/kg^{0.75}$, and %LW related to the inclusion of the supplementation strategy due to the presence of an effect on DM intake (Table II) and the hetero-nitrogenous profile of the offered diets (Table I), with lower intake for the control group but higher digestibility coefficient (97. 54%).

Moreover, an effect ($P < 0.05$) of the addition of concentrate was observed on the CP digestibility coefficient (Table II), with a mean of 89.77%.

The absence of concentrate affected ($P < 0.05$) the daily NDF and ADF intake, which resulted in an increasing behavior for variables expressed in g/day, $g/kg^{0.75}$, and %LW.

NDF digestibility had no effect ($P > 0.05$) (Table II), with a mean of 40.47%, which is due to the sugarcane fiber and concentrate qualities.

The concentrate supplement decreases ($P < 0.05$) ADF digestibility (Table II), with a mean of 53.34%.

The absence of concentrate positively influenced ($P < 0.05$) non-fiber carbohydrates intake, expressed in g/day, $g/kg^{0.75}$, and %LW, with means of 649.44, 26.38, and 1.97, respectively.

Animals that received supplementation 20 days before the estrus synchronization (SE) protocol had a reduction ($P < 0.05$) in the non-fiber carbohydrates digestibility.

An effect ($P < 0.05$) was observed on EE intake without concentrate in the diet in g/day (Table II), with no difference ($P > 0.05$) for variables expressed in $g/kg^{0.75}$ and %LW.

Also, an effect ($P < 0.05$) of the inclusion of the supplementation strategy was observed in different stages of gestation and lactation on the EE digestibility coefficient (Table II), with a mean of 92.27%.

Total digestible nutrient intake (TDNI) showed no effect ($P > 0.05$) for the four treatments.

Supplementation affected ($P < 0.05$) the % TDN at the stage of lactation, with a mean of 67.43% between treatments, with a lower percentage for the control (59.97%).

Supplementation strategies showed an effect ($P < 0.05$) on colostrum production (Table III), in which animals supplemented from 20 days before the estrus synchronization (ES) protocol had higher production, with a mean of 0.274 kg at 0 h. However, a higher production was observed at 12 h for supplemented groups from the confirmation of pregnancy (60 days after ES) and the final third of gestation (90 days after ES), with means of 0.214 and 0.227 kg, respectively.

Animals that received concentrates at the different stages of gestation had higher fat contents in the colostrum ($P < 0.05$). However, dams supplemented from the confirmation of pregnancy (60 days after ES) had higher productions, with means of 12.61 and 14.66 g/100 g for 0 and 12 h, respectively.

Protein contents (Table III) reduced by 43.96% between 0 and 12 h ($P < 0.05$) but animals that received supplements 20 days before the estrus synchronization (ES) protocol had higher volumes, with means of 15.97 and 9.23 g/100 g, respectively.

Lactose levels (Table III) increased by 12.5% between periods ($P < 0.05$). At 0 h, ewes supplemented 60 days after ES had higher

Table II. Nutrient intake and digestibility in ewes fed sugarcane during lactation supplemented at different stages of gestation.

Variable	Treatment				
	CONT	SSREPRO	SSPREG	SEPREG	CV (%)
DMI (g/day)	1.131b	1.253a	1.329a	1.330a	12.06
(g/kg$^{0.75}$)	46.05a	33.57b	38.85ab	38.49ab	13.57
(%LW)	3.454a	2.517b	2.913ab	2.887ab	12.57
DMD (%)	66.86b	70.08ab	72.06a	71.63a	5.42
OMI (g/day)	1.112b	1.190ab	1.262a	1.266a	11.82
(g/kg$^{0.75}$)	45.20a	31.87b	36.88b	36.63b	13.18
(%LW)	3.390a	2.390b	2.766b	2.747b	13.18
OMD (%)	70.43	72.18	74.12	73.60	5.02
CPI (g/day)	39.81a	128.39b	124.86b	128.90b	9.98
(g/kg$^{0.75}$)	1.61b	3.44a	3.66a	3.73a	12.44
(%LW)	0.121b	0.258a	0.275a	0.280a	12.44
CPD (%)	97.54a	89.50b	89.26b	90.57b	6.75
NDFI (g/day)	402.16a	341.17b	357.29b	366.79b	14.84
(g/kg$^{0.75}$)	16.33a	9.11b	10.45b	10.58b	15.65
(%LW)	1.224a	0.683b	0.784b	0.793b	15.65
NDFD (%)	43.46	40.02	38.79	39.63	7.05
ADFI (g/day)	265.99a	184.24c	202.03bc	206.23b	14.83
(g/kg$^{0.75}$)	10.80a	4.93b	5.89b	5.98b	15.46
(%LW)	0.810a	0.370b	0.441b	0.448b	15.46
ADFD (%)	75.35a	48.98b	55.94b	55.10b	6.98
NFCI (g/day)	649.44a	573.99b	611.00ab	615.50 ab	8.22
(g/kg$^{0.75}$)	26.38a	15.30b	17.83b	17.83b	15.94
(%LW)	1.978a	1.147b	1.337b	1.337b	15.94
NFCD (%)	94.41a	91.54b	93.63a	93.89a	8.68
EEI (g/day)	25.17b	33.25a	35.26a	35.25a	13.30
(g/kg$^{0.75}$)	1.02	0.89	1.02	1.02	15.13
(%LW)	0.076	0.066	0.077	0.076	15.14
EED (%)	90.00b	92.39ba	94.46a	92.25ba	15.19
TDNI (kg)	0.903	0.855	0.940	0.946	15.57
TDN (%)	59.97a	67.99b	70.60b	71.17b	13.93

Means followed by different letters on the row differ from each other by Tukey's test ($P < 0.05$). Average dry matter intake (DMI), organic matter intake (OMI), crude protein intake (CPI), neutral detergent fiber intake (NDFI), acid detergent fiber intake (ADFI), non-fibrous carbohydrates intake (NFCI), ether extract intake (EEI), and total digestible nutrient intake (TDNI) are expressed in g/day, g/kg$^{0.75}$, %BW, and kg and coefficients of dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD), neutral detergent fiber digestibility (NDFD), acid detergent fiber digestibility (ADFD), non-fiber carbohydrates digestibility (NFCD), ether extract digestibility (EED), total digestible nutrients (TDN), and coefficient of variation (CV) are expressed in %. CONT = control treatment with mineral salt supplementation only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = supplementation after confirmation of pregnancy (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES).

lactose contents (3.61 %) but with no significance (P > 0.05) at 12 h.

The concentration of total dry extracts decreased between 0 and 12 h (P < 0.05; Table III), except for animals supplemented after confirmation of gestation at 12 h. Defatted dry extracts decreased (P < 0.05) between times, with a higher content in the group supplemented 20 days before the ES protocol.

There were increases and decreases (P < 0.05) in casein and urea levels between groups (Table III). At 0 h, higher concentrations were observed for ewes that received the supplement 20 days before ES, with means of 10.62 g/100 g and 39.54 mg/dL, respectively. In contrast, the group supplemented 90 days after ES had lower values at 12 h, with means of 3.54 g/100 g and 15.77 mg/dL, respectively.

Somatic cell counts increased and decreased (P < 0.05), with higher counts for ewes that received the supplement before the ES protocol, with values of 217.6 and 279.09 SC/mL at 0 and 12 h (Table III).

There was an effect (P < 0.05) on milk production, but no statistical difference (P > 0.05) was observed at 15 days (Table IV), with a mean of 295.5 g/day. However, a higher (P < 0.05) peak of milk production was observed at 30 days, standing out the group that received supplementation started 20 days before the estrus synchronization (ES) protocol, with a mean of 484 g/day. A reduction in milk production (P < 0.05) was observed between treatments at 45 days but animals receiving concentrates (317.33 g/day) had higher production. A reduction and an increase (P < 0.05) in milk production was observed during the 60 days of production (Table IV), with animals without concentrate supplementation showing lower production, with a mean of 213 g/day.

Fat contents differed (P < 0.05) between treatments from 15 to 45 days, with an increasing effect, but without change at 60 days (Table IV).

Table III. Colostrum production and composition in supplemented ewes (n = 40) at different stages of gestation.

Variable	0 h				12 h					0 h	12 h
	CONT	SSREPRO	SSPREG	SEPREG	CONT	SSREPRO	SSPREG	SEPREG	CV (%)	EPM	EPM
Production (kg)	0.146b	0.274a	0.183b	0.200b	0.133b	0.147b	0.214a	0.227a	28.15	0.20 ± 0.04	0.22 ± 0.01
Composition											
Fat (g/100 g)	10.95b	11.22ab	12.61a	11.97ab	11.13b	12.05b	14.66a	10.69b	9.22	11.97 ± 0.39	10.69 ± 0.41
Protein (g/100 g)	12.56b	15.97a	8.17c	11.77b	6.61b	9.23a	6.39b	4.95c	10.23	11.77 ± 0.20	4.95 ± 0.29
Lactose (g/100 g)	2.94b	2.86b	3.61a	3.19b	3.10	3.55	3.63	3.42	8.59	3.19 ± 0.13	3.42 ± 0.11
TDE (g/100 g)	27.54b	31.15a	25.48c	27.93b	22.92b	25.68a	25.76a	20.17c	6.10	27.93 ± 0.43	20.17 ± 0.41
DDE (g/100 g)	16.59b	19.92a	12.87c	15.98b	11.79b	13.62a	11.10b	9.54c	7.43	15.98 ± 0.32	9.54 ± 0.30
Casein (g/100 g)	6.65b	10.62a	6.37b	6.59b	4.97b	5.54b	6.73a	3.54c	14.28	6.59 ± 0.20	3.54 ± 0.25
UN (mg/dL)	31.98b	39.54a	30.48b	30.99b	27.15b	22.11c	30.02a	15.75d	7.70	30.99 ± 0.74	15.75 ± 0.83
SCC (SC/mL)	57.6b	217.6a	69.38b	79.64b	77.68b	279.09a	48.73b	262.53a	19.37	262.53 ± 9.3	79.64± 9.53

Means followed by different letters on the row differ from each other by Tukey's test (P < 0.05). 0 hours (0 h), 12 hours (12 h). Total dry extract (TDE), defatted dry extract (DDE), urea nitrogen (UN), somatic cell count (SCC), coefficient of variation (CV) and mean standard error (EPM) are expressed in g/100 g, mg/dL, SC/mL, and %, respectively. CONT = control treatment with mineral salt supplementation only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = supplementation after confirmation of pregnancy (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES).

The absence of concentrate did not change this parameter when compared to the group that received it from 20 days before the estrus synchronization (ES) protocol. Sheep milk is different from that of other mammals due to its high protein levels and especially fat, a characteristic that provides high yields in the dairy industry.

Protein levels (Table IV) differed (P < 0.05) between days of lactation, with variations in the groups supplemented with concentrate and increasing effect for those with no supplementation.

An alteration in lactose contents (P < 0.05) was observed during the 60 days of lactation, indicating that the concentrate exclusion leads to a decrease in the lactose levels (Table IV), but without a statistical difference (P > 0.05) at 15 days, with a mean of 5.14%.

Total dry extract contents differed (P < 0.05) between treatments (Table IV) up to 45 days of lactation but this parameter was maintained when the concentrate was not used compared to the group that received it from 20 days before the estrus synchronization (ES) protocol, showing increasing effect, with its peak at 45 days and mean levels of 17%. However, no difference (P > 0.05) was observed from 46 to 60 days, with a mean of 15.75%.

Defatted dry extract levels differed only between the 15 days of lactation, with lower values for animals without concentrate, reaching a mean of 9.9% (P < 0.05; Table IV).

A reduction (P < 0.05) was observed in the initial and final live weight, the total weight gain, daily weight gain, and body condition score of animals (Table V) with supplementation strategies but with less effect in the supplemented groups from 20 days before the estrus synchronization protocol and in the final third of gestation, with means of 54.15, 49.04, −5.11, −85.11, and 2.5 expressed in kg, g/animal/day, and BCS, respectively.

DISCUSSION

The lowest DMI (1,131 g/day) for the control is lower than that indicated by NRC (2007), which is 1,700 g/day for lactating ewes. Rangel et al. (2015) observed that the digestion rate of sugarcane fiber is very slow in the rumen, causing it to remain in this compartment,

Table IV. Milk production and composition in supplemented ewes (n = 40) at different stages of gestation and lactation.

Variable	15 days				30 days				45 days				60 days					days			
	CONT SSREPRO SSPREG SEPREG				CONT SSREPRO SSPREG SEPREG				CONT SSREPRO SSPREG SEPREG				CONT SSREPRO SSPREG SEPREG				CV (%)	EPM 15	EPM 30	EPM 45	EPM 60
Production (g)	279	329	303	271	310b	484a	353b	364b	216b	310a	328a	314a	213b	345a	263ab	295ab	19.05	279 ±0.1	320±01	300±02	279±02
Composition %																					
Fat	4.87ab	5.39a	4.10ab	3.55b	5.00ab	5.83ab	6.10a	4.48b	6.62a	5.05ab	5.52ab	4.23b	4.23	5.44	4.43	4.45	25.38	5.3±0.40	5.8±0.3	5.2±0.3	5.4±0.3
Protein	3.93b	4.84a	4.72a	4.97a	4.27	4.53	4.47	4.51	5.20a	4.76ab	4.36b	4.73ab	5.21	4.86	4.98	4.71	9.73	4.2±0.14	4.5±0.1	4.4±0.1	4.5±0.1
Lactose	4.95	5.21	5.23	5.17	4.73ab	5.07a	5.05a	4.60b	4.12b	5.00a	4.90a	4.70a	4.32b	5.06a	4.96a	4.94a	5.97	4.9±0.09	5.2±0.1	5.2±0.0	5.3±0.1
TDE	14.8ab	16.5a	15.1ab	14.6b	15.0ab	16.5a	16.7b	14.5b	17.0a	15.9ab	15.8ab	14.6b	16.0	16.4	15.4	15.2	8.65	16±0.32	16±0.4	15.±0.3	15±0.4
DDE	9.9b	11.1a	11.0a	11.1a	10.0	10.6	10.6	10.1	10.4	10.8	10.3	10.6	10.6	11.0	11.0	10.8	5.10	10±0.17	10.6±0	10±0.2	10±0.1

Means followed by different letters on the row differ from each other by Tukey's test (P < 0.05). Total dry extract (TDE), defatted dry extract (DDE), coefficient of variation (CV) and mean standard error (EPM) are expressed in %. CONT = control treatment with mineral salt supplementation only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = supplementation after confirmation of pregnancy (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES).

which limits dry matter intake by activating the physical factors that regulate voluntary intake. Thus, this inferiority in dry matter intake and, consequently, OM (Table II), is mainly related to the NDF content, its slow degradation, and the low sugarcane passage rate through the rumen, which activated this lower intake effect.

Freitas et al. (2008) evaluated nutrient intake and performance of sheep fed diets based on fresh or hydrolyzed sugarcane and found a mean dry matter intake of 3.9% LW. Mendes (2006, unpublished data) worked with similar diets, which had 50% of fresh sugarcane, and also observed dry matter intake values of 3.9% LW. These values are close to those found in the present study (3.45% LW).

The positive effect nce of non-fiber carbohydrates intake is due It reflects the higher DM intake in g/kg$^{0.75}$ and %LW (Table II) and the increase in this fraction in the sugarcane-only diet (Table I).

We can infer that sugarcane increased the non-fiber carbohydrates (NFC) content in the diets (Table I). In fact, NFC are rapidly fermented and, therefore, provide higher energy input for microbial growth, which results in higher carbohydrate digestibility (Cardoso et al. 2006).

The effect on EE consumption and digestibility is due to the absence of similarity in the EE contents of the diets (Table I) and changes in CEE (Table II).

Considering the difference in DMI for the different supplementation strategies at the different stages of gestation and lactation, this behavior for NDFI and ADFI is due to an increase in the concentration of fiber content, as only sugarcane was used in the diet (Table I).

The average TDN intake (0.911 kg) found in this research is within the range recommended by NRC (1985), that is, 0.750 and 1 kg. However, Murta et al. (2011) observed a lower average, with a value of TDNI of 569.2 g/day when evaluating the effects of the addition of 0, 0.75, 1.5, and 2.25% of calcium oxide in the sugarcane bagasse (based on natural matter) on the performance, nutrient intake, and apparent digestibility of diets for crossbred Santa Inês sheep and native breeds. The authors justified the results according to the quality of roughage (bagasse) and dry matter intake, which possibly influenced TDN intake.

The lower ($P < 0.05$) digestibility in % TDN (Table II) for the control treatment is due to the lower synchronization between energy and

Table V. Live weight gain and body condition score from postpartum to weaning of ewes using supplementation strategies.

Item	Treatment					
	CONT	SSREPRO	SSPREG	SEPREG	CV (%)	P
ILW (kg)	45.02b	55.88a	55.24a	52.42ab	15.59	0.019
FLW (kg)	33.34b	50.98a	46.34a	47.10a	16.05	0.001
TLWG (kg/animal)	- 11.68b	- 4.90a	- 8.90b	- 5.32a	28.09	0.001
ADG (g/animal/day)	- 194.53b	- 81.60a	- 148.33b	- 88.63a	28.38	0.001
Final BCS	1.22b	2.50a	2.42a	2.55a	22.57	0.001

Means followed by different letters on the row differ from each other by Tukey's test (P < 0.05). Initial live weight (ILW), final live weight (FLW), total live weight gain (TLWG), and average daily gain (ADG) are expressed in kg, g/animal/day, and kg/animal, while body condition score (BCS) and coefficient of variation (CV) are expressed in %. CONT = control treatment with mineral salt supplementation only, SSREPRO = supplementation started 20 days before the estrus synchronization (ES) protocol, SSPREG = supplementation after confirmation of pregnancy (60 days after ES), and SEPREG = supplementation in the third end of pregnancy (90 days after ES).

protein sources, used simultaneously by ruminal microorganisms for their growth, consequently increasing nutrient digestibility. Alves et al. (2015) also reported this behavior in a study with sheep fed low digestibility roughage.

Hashemi et al. (2008) researched changes in colostrum production and composition in Karakul ewes fed at different nutritional levels and found a reduction in production. The authors stated that different supplementation levels, especially energy, tend to affect the amount of colostrum. Thus, the lowest amount of colostrum observed for animals without concentrate from 0 to 12 h is due to a lack of energy, resulting from the unavailability of corn as a source of starch for energy intake (Table I).

Campos et al. (2019) evaluated the colostrum composition of ewes maintained on pasture receiving different types/levels of supplementation (0.4 or 0.8% body weight), but no changes were observed in composition contents, with a fat content of 10.05% on day 0. It is a level close to that found in this study, with a mean of 12.22%.

Alves et al. (2015) observed a more pronounced reduction in protein levels when analyzing the chemical composition and IgG concentration of colostrum from Santa Inês ewes and the transfer of passive immunity to lambs with a decrease in levels (62.52%) within the first 36 hours after birth. According to Godden (2008), colostrum has a high content of nutrients and IgG and there is a progressive drop in these levels over the next 6 h after the first milking.

According to Lima et al. (2016), a higher concentrate level in the diet increases propionic acid levels in the rumen, resulting in higher energy availability in the form of glucose, a precursor of lactose. This particularity of energy metabolism in ruminants may explain the higher lactose levels observed in the colostrum of ewes that received concentrate after confirmation of pregnancy at 0 h.

According to Campos et al. (2019), the variables TDE and DDE result from the sum of milk constituents. Therefore, lower percentages verified for these variables in colostrum are due to a reduction in protein and fat levels (Table III). Alves et al. (2015) observed a reduction of total solids by 36.58% between 0, 12, 24, and 36 h postpartum.

According to Urbano et al. (2017), colostrum has a large amount of protein, especially in the postpartum period. Thus, the highest casein and urea concentrations in the first hours are directly correlated to the protein levels and metabolism of the animal at 0 h.

According to Souza et al. (2009), the prepartum leads to an increase in the mammary gland volume, which can lead to the rupture of vessels and an increase in SCC, but this number decreases in healthy cows as the amount of colostrum decreases in the milk. Thus, the higher SCC at 0 and 12 h for ewes supplemented from 20 days before the estrus synchronization (ES) protocol and 12 h for the group supplemented in the final third of gestation (90 days after ES) is due to the higher colostrum production, which can lead to rupture of vessels and an increase in SCC.

The behavior observed in milk production was inverse to the concentration of fiber in the diet. Thus, the increase in NDF levels in the diet had a negative effect on milk production. Possibly, the energy content of the diet, associated with DM and OM intake, which seems to have been restricted by the reticulo-rumen, limited the production of animals that ingested diets containing high fiber levels. The amount of milk produced by ewes is influenced by diet (Zeppenfeld et al. 2005).

Natel et al. (2013) studied the effect of including neutral detergent fiber (NDF) on dry matter intake, feed efficiency, milk production, and milk composition of Bergamasca ewes and found that feed efficiency, expressed in kg milk/kg DMI, also showed a negative linear effect, with an increase of NDF levels in the diet. It may be related to the higher energy intake in diets with higher amounts of starch-rich concentrate, allowing higher yields with lower intakes compared to animals receiving high-fiber diets.

The difference in protein levels between lactation days is related to the lack of similarity in CP content in the diet (Table I), reflecting intake and digestibility (Table II). According to the literature, the values observed for protein (4.68%) in this experiment (Table IV) are consistent with previously published values for Bergamacia sheep, with 4.71% protein in milk, receiving a diet with 56% NDF (Queiroz et al. 2014).

In this study, fat levels averaged 4.95%, which is higher than those reported by Fernandes et al. (2013) (4.05%). However, it remained close to the levels found in the literature for sheep milk (5.5–7.0%). It may be related to the fact that small ruminants can accumulate 75% of the fat in the alveolar portion of the mammary gland, which is only extracted more efficiently with the administration of oxytocin (Ribeiro et al. 2007), but it was not used in this study and hence could explain the lower fat content in the analyzed milk.

Bianchi et al. (2018) reported that the main precursor of glucose in animals, resulting in lactose in milk, is propionic acid, produced mainly by the fermentation of non-fibrous carbohydrates in the rumen. Thus, the inclusion of concentrate affects propionate production, interfering with the synthesis of glucose by the liver and, subsequently, lactose by the mammary gland. As observed in this study, the inclusion of concentrate in the diet increases the intake of ground corn (starch), promoting an increase in the production of propionic acid, a precursor of glucose, and, consequently, higher lactose contents in the milk. The results found in this study for this constituent (4.87%) are similar to those presented by Blagitz et al. (2013), who found 4.51% for lactose.

The total dry extract content (fat, protein, lactose, and minerals) in the milk presented significant differences between groups, mainly in the fat content, which was higher at 45 days for those with no supplements. Thus, the production of the total solids changed between groups and a possible reason is the effects of their composition during the lactation period.

The DDE content observed in this study (10.6%) is close to that found by Campos et al. (2019) for ewes supplemented on pasture with 0.4 to 0.8% LW, with a decreasing linear effect for DDE between 7 and 28 days of lactation, with a mean of 11.38%. However, it is within the range found by Ribeiro et al. (2007) and Ochoa-Cordero et al. (2002), who observed values between 10.33 and 12.68% for this variable, with a negative correlation between milk production and the amount of proteins and total solids, characterized by the dilution effect. Therefore, the results found for these constituents are consistent with milk production towards the peak of lactation, which occurs around 30 days postpartum (Table IV).

According to Mertens (1994), 60 to 90% of the differences in animal performance occur as a result of intake, and 10 to 40% as a result of digestibility. Usually, the highest weight gain in feedlots can be obtained as a result of higher nutrient and dry matter intake (Barroso et al. 2006). The inclusion of concentrate changed dry matter intake and digestibility (Table II), reducing the daily and total weight gains (Table V), which justifies the difference in the animal's final live weight and BCS.

Therefore, the likely impact that the adopted feeding strategies will have on performance, immune response, and production and quality of colostrum and milk must be considered when the objective is productivity. According to Geraseev et al. (2006), studies in this area are important, as pre-and postnatal growth is the main product of beef sheep production.

CONCLUSIONS

Supplementation strategies during the stages of gestation and lactation influenced nutrient intake and digestibility, as well as the performance and production and composition of colostrum and milk of the animals. However, supplementation can result in the production of heavier lambs at weaning when fed to dams in the final third of gestation, thus leading to a reduction in the time until their slaughter.

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