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Article

Supplementation of goats with mesquite pod meal in deferred (*Urochloa mosambicenses)* grass pasture in the semiarid region

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Abstract:

Supplementation emerges as a simple strategy to improve animal productivity in systems that adopt deferred grass pasture as the basic diet. This study aimed to evaluate the effect of levels of supplementation of mesquite pod meal on intake, digestibility of nutrients, and body weight (BW) gain of goats in grazing deferred. Thirty-five (35) goat males (24.0 ± 2.9 kg BW) were distributed in a completely randomized design, with five treatments and seven replications. Treatments constituted a supplement control (0.05% BW of protein-mineral salt) and increasing levels at 0.5; 1.0; 1.5, and 2.0% BW of supplementation with mesquite pod meal. Dry matter intake and nutrients of the forage and total diet increased linearly (P<0.0001) as a function of the levels of the supplement. A quadratic effect was observed (P<0.0001) for the digestibility variables, except for ethereal extract and non-fiber carbohydrates, which presented an increasing linear effect (P<0.0001). Supplementation levels increased linearly on the performance variables (P<0.05). It is recommended the concentrate supplementation at 2.0% BW with mesquite pod meal at 30 % in its composition for promoting the reduction of the productive cycle of goats in deferred *Urochloa* grass pastures.

Keywords: Alternative supplementation, Animal production, Pasture management, *Prosopis juliflora*, Semiarid, Weight gain.

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Introduction

Goats breeding for meat production in the northeast region of Brazil is predominantly extensive and seasonal because the rainfall distribution is irregular and the adverse edaphoclimatic characteristics affect the forage production(1). The quantity and the quality of the food become obstacles to the productive chain, especially during the dry season. In this critical period, animals lose body weight, thus delaying the age at slaughter, causing losses to producers and to the economy in general.

These conditions justify the use of pasture management techniques such as deferral, which consists in selecting a pasture area of the property and excluding grazing, usually at the end of the rainy season(2), so that forage accumulation occurs to be grazed during the dry period, minimizing the negative effects of seasonal forage production on animal productivity(3). Nonetheless, changes in pasture structure occur during the deferment period and are also characterized by low nutritional value as a consequence of changes in environmental conditions and of the forage plant phenology itself, which tend to reduce the performance of ruminants(4).

Supplementation emerges as a simple strategy used for both an attempt to address the nutritional deficiencies of the pasture, by providing the balance of the animal’s diet, and also to reduce the risk caused by fluctuating pasture dry matter production(5,6). However, the effect of adding highly degradable carbohydrates to forage-based diets can be beneficial or undesirable, depending on the source used and, above all, the amount eaten by the animals(7). The constant search for alternative feeds to corn, which is the most used energy concentrate in animal production systems, is fundamental, especially in regions distant from those producing grain.

The use of mesquite pod meal (*Prosopis juliflora* (Sw.) D.C.) as a substitute for corn becomes an alternative due to its easy accessibility in semiarid regions and its use in diets for small ruminants has shown better productive indices compared to corn(8-13). However, the consumption of *P. juliflora* pods as the main source of food causes intoxication in animals(14-16). In this context, the objective of this study was to evaluate the effect levels of concentrate with mesquite pod meal on the performance of goats in deferred *Urochloa* grass pastures.

Material and methods

Ethical principles of experimentation

All the animal care and handling procedures were approved by the Ethics Committee on Animal Use f the State University of Southwest Bahia – UESB, with protocol number 23/2017.

Experimental area

The experiment was conducted at the Research Center for Sheep and Goat, located in the Iaçu municipality, State of Bahia, Brazil. The experimental period was from April 2018 to July 2018 with mean rainfall at 31.2 mm. The climate of the region is characterized as a tropical climate with a dry season(17).

Experimental procedures, animals, and diets

The total pasture area was 4.4 ha composed exclusively of *Urochloa* grass (*Urochloa mosambicensis* (Hack) Daudy). The pasture was fenced for 110 d and used from April of the same year until July 2018 (92 d). The employed grazing method was continuous stocking with a variable stocking rate. The evaluated treatments were five supplements: protein-mineral salt and levels of concentrate containing mesquite pod meal. The structural variables of the deferred pasture were evaluated every 23 d during the whole usage period. Pasture height was measured with a graduated ruler in centimeters, with

100 readings performed per picket at the average curvature height of the leaves. Forage mass was estimated by cutting close to the forage soil (12 samples) with a square of 0.25 m^2 as described by McMeniman[18] and the pasture composition was measured (Table 1). Thirty-five uncastrated male goats of the Boer breed, at approximately 4-mo old, an initial body weight (BW) of 24.0 ± 2.9 kg were used, distributed in a completely randomized design with five treatments and, 7 replicates were adopted. The animals were kept in a *Urochloa* grass pasture under continuous stocking during the day (0007 to 1600 h) and housed in sheds in collective stalls during the night where they received: protein-mineral salt at fixed at 0.05% BW (control) and increasing levels at 0.5, 1.0, 1.5, and 2.0% BW of mesquite pod meal as an energy supplement.

Table 1: Pasture composition

Green leaf, g kg^{-1}	240.38
Green stem, g kg^{-1}	530.00
Senescent material, g kg^{-1}	670.44
Leaf/stem ratio	0.460
Availability of dry matter (DM), kg ha^{-1}	3.264
kg DM leaf ha^{-1}	795.76
kg DM stem ha^{-1}	1.729.92
kg DM senescent material ha^{-1}	737.99

The supplements were formulated to meet the protein requirements for maintenance and to provide an average daily gain of 150 g, according to the NRC[19]. Table 2 shows the chemical composition of the supplements and *Urochloa* grass. A 15-d adaptation period was used for the animals to acclimatize to the supplement and to the research facilities, followed by 92 d of the experiment divided into four subperiods of sample collection that lasted 5 d.

Table 2: Composition (g 100 g^{-1} of DM) of the supplements in ingredients and nutritive value of protein-mineral salt, *Urochloa* grass and concentrate containing mesquite pod meal

Ingredient	**Supplement**	
	Concentrate	**Protein-mineral**
Corn meal	45.0	33.6
Soybean meal	22.0	20.0
Mesquite pod meal	30.0	-
Urea	2.0	9.1
Mineral salt[a]	1.0	13.6
Ammonium sulfate	-	1.0
Sodium chloride	-	22.7
Total	100.0	100.0

Nutrient	Protein-mineral salt	*Urochloa* grass	Concentrate
Dry matter	88.6	91.3	86.1
Organic matter	72.2	89.1	98.8
Crude protein	41.2	13.7	20.3
Ether extract	1.5	1.9	2.6
Total carbohydrates	29.4	73.5	75.9
Non-fiber	44.3	13.1	45.4
NDF free of ash protein	13.2	60.4	36.2
Acid detergent fiber	7.6	43.0	28.2
Indigestible NDF	2.9	12.4	4.8
Lignin	1.4	7.6	13.7
Ash	27.8	10.9	1.2

[a] Quantity/kg of product: Calcium (max.)= 120 g; phosphorus= 87 g; copper= 590 mg; cobalto= 40 mg; iodine= 80 mg; manganese= 1,300 mg; molybdenum= 300 mg; fluorine (max)= 870 mg.
NDF= neutral detergente fiber.

Mature pods were obtained after harvesting in the ground, manually selected, discarding those attacked by insects, fungi, and of a small development. The pods were dried sun drying was used. And then, processed in a Wiley knife mill (A. H. Thomas, Philadelphia, PA, USA) using a 1-mm sieve, to obtain the pod meal.

Evaluation of intake, digestibility, and live weight gain

The dry matter (DM) intake of forage and digestibility of nutrients was estimated from the fecal output, with the use of Enriched and Purified Isolated Lignin from Eucalyptus Grandis (LIPE®; Belo Horizonte, MG, Brazil) as an external marker(20), and indigestible acid detergent fiber (iADF) as an internal marker. The DM intake per supplement was estimated using titanium dioxide. The titanium dioxide (TiO_2) was analyzed according to the methodology described by Titgemeyer(21). Titanium dioxide was mixed with the supplement and supplied in the amount of 5 g per animal. LIPE® capsule oral administration for each animal happened for 7 consecutive days; the first 2 d were to stabilize the fecal excretion of the marker(20,22). Fecal samples were collected directly from the rectum twice a day (0800 and 1700 h), for 5 d, and stored in a cold chamber at -10 °C.

The concentration of iADF in supplement samples, consumed forage, and feces were obtained after incubation *in situ* for 264 h according to Casali *et al*(23). The voluntary intake of DM was estimated by the ratio between fecal excretion and indigestibility from the internal indicator iADF, as described above, using the equation proposed by Detmann(24):

$$DMI = \{[(FE \times MCF) - CIS] / CIFOR\} + DMIS$$

Where: DMI= dry matter intake (kg d^{-1}); FE= fecal excretion (kg d^{-1}); MCF= marker concentration in the animal feces (kg kg^{-1}); CIS= concentration of iADF in the supplement (kg d^{-1}); CIFOR = concentration of iADF in forage (kg kg^{-1}); and DMIS= intake of supplement DM (kg d^{-1}).

Supplement intake was measured by the quantity supplied divided by the number of animals in the treatment. The estimate of the quality of forage consumed was performed by analyzing the samples, using the technique for manual simulation of grazing[25], by visual observation of the animals.

The animals were weighed at the start, every 23 d, and at the end of the experiment. At the beginning of the experimental period, the animals were subjected to a 16-h solid fast and weighed to determine initial body weight (IBW). Total weight gain (TWG) was estimated as the difference between final body weight (FBW) and initial body weight (IBW): TWG= (FBW - IBW). Average daily gain (ADG) was calculated by dividing TWG by the total number of days in the experiment: ADG= TWG/days in the experiment. Finally, the feed conversion ratio was calculated as the ratio between dry matter intake (kg d^{-1}) and TWG (kg d^{-1}).

Sample processing and laboratory analyses

The contents of DM (method INCT-CA G - 003/ 1), ash (method INCT-CA M-001/1), crude protein (CP) (method INCT-CA N-001/1), ether extract (EE) (method INCT-CA G-004/1) were determined in the forage and supplement samples, according to the recommendations described by AOAC[26]. For the neutral detergent fiber (NDF) analyses, the samples were treated with thermostable alpha-amylase, without the use of sodium sulfite, and corrected for residual ash[27]. The correction of NDF for the nitrogen compounds and the estimate of the concentration of nitrogen-neutral detergent insoluble compounds (NDIN) and acid (ADIN) were performed according to Licitra[28].

Total carbohydrates (TC) were estimated according to Sniffen[29], non-fibrous carbohydrates were calculated according to the methodology proposed by Hall[30], using NDFap and total digestible nutrients (TDN) were calculated according to Weiss[31], but using NDF and NFC corrected for ash and proteins.

Statistical analysis

The statistical analysis of the data was achieved by the MIXED procedure of the SAS statistical computer program (SAS, 2006), considering a mixed model. The data were submitted for analysis of variance (ANOVA) and was realized the contrast between the control treatment with supplementation levels of concentrate. Also, the polynomial contrast and regression analysis were performed for supplementation levels (0.5, 1.0, 1.5, and 2.0% BW), adopting a 5 % to 10 % probability for type 1 error.

Results

The DM intake and of the nutrients of the total diet, forage (deferred *Urochlo*a grass), and supplements were greater (P<0.0001) for the animals who received the supplementation mesquite pod meal, independently of the levels, compared to animals fed only with protein-mineral salt, due to the higher supply of nutrients from concentrate (Tables 3, 4, and 5). The nutrient concentrations were proportionally unchanged as a function of DM intake, independent of supplementation levels since the concentrate supplement was the same.

Table 3: Nutrient intakes of the diet of goats on grazing of deferred *Urochloa* grass with supplementation levels

Item	Supplementation					SE	*P* value		
	PMS	Concentrate level (% BW)					Contrast	L	Q
		0.5	1.0	1.5	2.0				
Total intake (g d^{-1})									
DM	353.	506.	936.	1196.	1738.	93.	<0.0001	<0.000	0.590
CP	52.9	80.0	151.	196.7	286.7	15.	<0.0001	<0.000	0.614
EE	6.6	10.6	20.1	26.0	37.8	2.1	<0.0001	<0.000	0.608
NFC	51.2	113.	235.	316.0	464.2	27.	<0.0001	<0.000	0.663
NDFa	206.	270.	480.	603.2	872.2	45.	<0.0001	<0.000	0.563
TND	80.0	260.	640.	890.0	1390.	80.	<0.0001	<0.000	0.516
Total intake (g kg^{-1} BW)									
DM	13.8	17.4	31.7	40.1	54.0	2.9	<0.0001	<0.000	0.958
NFCa	8.0	9.3	16.3	20.2	27.1	1.4	<0.0001	<0.000	0.983
Total intake (g kg^{-1} $BW^{0.75}$)									
CP	4.6	6.3	12.0	15.4	21.2	1.2	<0.0001	<0.000	0.954
NFC	4.5	9.0	18.6	24.7	34.3	2.0	<0.0001	<0.000	0.997

PMS= protein-mineral salt; SE= mean standard error; Contrast= PMS vs supplementation levels; L= linear effect; Q= quadratic effect; BW= body weight; DM= dry matter; CP= crude protein; EE= ether extract; NFC= non-fiber carbohydrates; NDFap= neutral detergent fiber corrected for ash and protein; TDN= total digestible nutrients; Significant * (P<0.0001); ** (P<0.001); *** (P<0.01); **** (P<0.05); ^{ns} (P>0.05); $^{a}\hat{Y}= 110.68^{ns} + 792.82X^{*}$; $^{b}\hat{Y}= 12.4414^{ns} + 133.69X^{*}$; $^{c}\hat{Y}= 1.8056^{ns} + 17.5525X^{*}$; $^{d}\hat{Y}= (0.5534^{ns} + 226.31X^{*}$; $^{e}\hat{Y}= 77.0549^{ns} + 387.13X^{*}$; $^{f}\hat{Y}= -0.099^{***} + 0.725X^{*}$; $^{g}\hat{Y}= 5.7387^{ns} + 24.3310X^{*}$; $^{g}\hat{Y}= 3.6930^{****} + 11.7801X^{*}$; $^{h}\hat{Y}= 12.1673^{ns} + 58.1458X^{*}$; $^{i}\hat{Y}= 15091^{ns} + 9.8537X^{*}$; $^{j}\hat{Y}= 0.7727^{ns} + 16.8385X^{*}$

Table 4: Nutrient intake of forage of goats on grazing of deferred *Urochloa* grass with supplementation levels

Item	Supplementation					SE	*P* value		
		Concentrate level (% BW)					Contrast	L	Q
	PMS	0.5	1.0	1.5	2.0				
Forage intake (g d^{-1})									
DM	338.2	361.0	586.3	704.0	1006.5	47.4	<0.0001	<0.0001[a]	0.5011
CP	46.5	49.7	80.6	96.8	138.4	6.5	<0.0001	<0.0001[b]	0.5011
EE	6.4	6.8	11.1	13.3	19.0	0.9	<0.0001	<0.0001[c]	0.5011
NFC	44.3	47.3	76.9	92.3	131.9	6.2	<0.0001	<0.0001[d]	0.5011
NDF_{ap}	204.2	218.0	354.0	425.0	607.7	28.6	<0.0001	<0.0001[e]	0.5011
Forage intake (g kg^{-1} BW)									
DM	13.2	12.5	19.9	23.6	31.3	1.5	<0.0001	<0.0001[f]	0.9504
NDF_{ap}	7.9	7.5	12.0	14.3	18.9	0.9	<0.0001	<0.0001[g]	0.9504
Forage intake (g kg^{-1} $BW^{0.75}$)									
CP	4.1	4.0	6.4	7.6	10.3	0.5	<0.0001	<0.0001[h]	0.8407
NFC	3.9	3.8	6.1	7.2	9.8	0.5	<0.0001	<0.0001[i]	0.8407

PMS= protein-mineral salt; SEM= mean standard error; Contrast= PMS *vs* supplementation levels; L= linear effect, Q= quadratic effect, BW= body weight; DM= dry matter; CP= crude protein; EE= ether extract; NFC= non-fiber carbohydrates; NDFap= neutral detergent fiber corrected for ash and protein; TDN= total digestible nutrients; Significant * (P <0. 0001); ** (P <0.001); *** (P <0.01); **** (P <0.05); ^{ns} (P >0.05); $^{a}\hat{Y}$= 152.70 *** + 414.60X *; $^{b}\hat{Y}$ = 21.0037*** + 57.0255X *; $^{c}\hat{Y}$ = 2.8887 *** + 7.8429X ****; ^{d}= 20.0181 *** + 54.3495X *; $^{e}\hat{Y}$ = 92.1912 *** + 250.30 X *; $^{f}\hat{Y}$ = 6.6600*** + 12.3386X *; $^{g}\hat{Y}$ = 4.0208*** + 7.4491 X *; $^{h}\hat{Y}$ = 2.0117*** + 4.0883 X *; $^{i}\hat{Y}$ = 1.9173 *** + 3.8965X *

Table 5: Nutrient intake of concentrate of goats on grazing deferred *Urochloa* grass pasture with supplementation levels

Item	Supplementationn					SE	*P* value		
	PMS	Concentrate level (% BW)					Contrast	L	Q
		0.5	1.0	1.5	2.0				
Concentrate intake (g d^{-1})									
DM	15.6	145.2	350.1	492.6	731.6	47.2	<0.0001	<0.0001[a]	0.7327
CP	6.4	29.4	71.0	99.8	148.3	9.4	<0.0001	<0.0001[b]	0.7327
EE	0.2	3.7	8.98	12.6	18.8	1.2	<0.0001	<0.0001[c]	0.7327
NFC	6.9	66.0	159.0	223.7	332.2	21.4	<0.0001	<0.0001[d]	0.7327
NDFap	2.1	52.5	126.6	178.1	0.73	17.2	<0.0001	<0.0001[e]	0.7327
Concentrate intake (g kg^{-1} BW)									
DM	0.6	5.0	11.8	16.5	22.7	1.5	<0.0001	<0.0001[f]	0.8462
NDFap	0.07	1.8	4.3	6.0	8.2	0.6	<0.0001	<0.0001[g]	0.8462
Concentrate intake (g kg^{-1} $BW^{0.75}$)									
CP	0.6	2.3	5.6	7.8	10.9	0.7	<0.0001	<0.0001[h]	0.9460
NFC	0.6	5.2	12.5	17.5	24.5	1.6	<0.0001	<0.0001[i]	0.9460

PMS= protein-mineral salt; SE= mean standard error; Contrast= contrasts between the SP and the levels of supplementation; L= linear effect, Q= quadratic effect; BW= body weight; DM= dry matter; CP= crude protein; EE= ether extract; NFC= non-fiber carbohydrates; NDFap= neutral detergent fiber corrected for ash and protein; $^{*}P$<0. 0001; $^{**}P$<0.001; $^{***}P$<0.01; $^{****}P$<0.05; ^{ns}P>0.05; $^{a}\hat{Y}$= - 43.8774 ^{ns} + 379.65 X *; $^{b}\hat{Y}$ = - 8.8931^{ns} + 76.9487X *; $^{c}\hat{Y}$ = - 1.1263^{ns} + 9.7457 X *; $^{d}\hat{Y}$ = - 19.9255 ^{ns} + 172.41X*; $^{e}\hat{Y}$ = - 15.8682 ^{ns} + 137.30X *; $^{f}\hat{Y}$ = -0.9681 ^{ns} +12.0713X*; $^{g}\hat{Y}$ = - 0.3501 ^{ns} + 4.3656X*; $^{h}\hat{Y}$ = - 0.5191 * + 5.7915 X; $^{i}\hat{Y}$ = - 1.1631^{ns} + 12.9761 X *

The dry matter digestibility and of the other nutrients were greater (*P*<0.0001) for supplementation levels compared to protein-mineral salt. There was a quadratic effect for the digestibility of most nutrients, except for EE and NFC which showed a linear increase (Table 6). Maximum points were calculated for digestibilities of DM, OM, CP, and NDF near the upper limit of supplementation (2.0% BW), with the same response for the variation of TDN content. Therefore, it was not possible to estimate the maximum point because the range of the supplementation levels studied was restricted to a range of the quadratic fit in which the rate of increase in digestibility coefficient was not proportional to the supplement increment, that is, it was in points previous to curve inflection.

Table 6: Nutrient digestibility (g 100 g^{-1} of DM) of goats on grazing deferred *Urochloa* grass pasture with supplementation levels

Item	Supplementation					SE	*P* value		
	PMS	Concentrate level (% BW)					Contrast	L	Q
		0.5	1.0	1.5	2.0				
DM	21.8	45.6	66.2	73.2	80.0	3.8	<0.0001	<0.0001	0.0011[a]
OM	21.9	48.1	68.3	74.7	81.0	3.8	<0.0001	<0.0001	0.0008[b]
NDFap	23.7	43.2	63.0	69.7	77.5	3.5	<0.0001	<0.0001	0.0081[c]
EE	40.4	43.9	60.3	68.1	76.4	2.7	<0.0001	<0.0001[d]	0.2183
CP	31.1	48.8	68.1	75.8	79.4	3.3	<0.0001	<0.0001	0.0002[e]
NFC	10.7	57.5	82.4	86.3	90.4	5.3	<0.0001	<0.0001[f]	0.0056
TDN	21.6	47.1	67.0	73.6	79.9	3.8	<0.0001	<0.0001	0.0008[g]

PMS= protein-mineral salt; SEM= mean standard error; Contrast= PMS *vs* supplementation levels; L= linear effect; Q= quadratic effect; BW= body weight; DM= dry matter; CP= crude protein; EE= ether extract; NFC= non-fiber carbohydrates; NDFap= neutral detergent fiber corrected for ash and protein; TDN= total digestible nutrients; Significant **(*P*<0. 0001); ** (*P*<0.001); *** (*P*<0.01); ****(*P*<0.05); ^{ns} (*P*>0.05); [a]$\hat{Y}= 20.099^{*} + 58.357 X^{*} - 14.294 X^{2\,**}$; [b]$\hat{Y}= 23.499^{*} + 56.554 X^{*} - 13.993 X^{2\,**}$; [c]$\hat{Y}=19.817^{**} + 52.997 X^{*} - 12.166 X^{2\,***}$; [d]$\hat{Y}= 39.7744^{*}$ +/ $18.596 X^{*}$; [e]$\hat{Y}= 23.452^{*} + 58.868 X^{*} - 15.490 X^{2\,**}$; [f]$\hat{Y}= 72.547^{*} + 8.996 X^{*}$; [g]$\hat{Y}= 22.343^{*} + 56.718 X^{*} - 14.070 X^{2\,**}$

The supplementation levels with the energy source containing mesquite pod meal provided greater final body weight (FBW), average daily gain (ADG), and total weight gain (TWG) when compared to the protein-mineral salt supplementation (Table 7). There was a linear effect for supplementation levels on the performance variables (*P*<0.05). Supplementation levels promoted a linear increase (*P*<0.0001) in feed conversion and the level at 0.5% BW was efficient considering 92 d of pasture supplementation to reach 35 kg for slaughter weight.

Table 7: Performance of goats on grazing deferred *Urochloa* grass pasture with supplementation levels for 92 days

Item	Supplementation					SE	*P* value		
	PMS	Concentrate level (% BW)					Contrast	L	Q
		0.5	1.0	1.5	2.0				
IBW	23.3	24.1	24.2	23.7	24.4	0.5	0.4669	0.9372	0.7711
FBW	28.9	34.6	34.6	37.6	40.3	0.8	<0.0001	0.0004[a]	0.3039
BW	26.1	29.4	29.4	30.7	32.4	0.6	0.0001	0.0280[2b]	0.4471
$BW^{0.75}$	11.5	12.6	12.6	13.0	13.6	0.2	0.0002	0.02810[c]	0.4437
TWG	5.7	10.5	10.4	13.9	15.9	0.7	<0.0001	0.0003[d]	0.3311
ADG	0.06	0.12	0.12	0.16	0.18	0.01	0.0001	0.0003[e]	0.3312
FC	22.7	4.4	8.1	8.0	10.0	3.4	0.3877	<	0.1987

PMS= protein-mineral salt; SE= mean standard error; Contrast= PMS *vs* supplementation levels; L= linear effect; Q= quadratic effect; BW= body weight; IBW= initial body weight (kg); FBW= final body weight (kg); TWG= total weight gain (kg); ADG= average daily gain; FC= feed conversion (kg DMI/ kg BW); Significant *(P<0.0001); ** (P<0.001); ***(P<0.01); ****(P< .05); ^{ns} (P>0.05); $^{a}\hat{Y}$= 31.560 * + 4.263X *; $^{b}\hat{Y}$= 27.812* + 2.132 X ****; $^{c}\hat{Y}$= 12.112 * + 0.681X $^{****;}$ $^{d}\hat{Y}$= 3.016 * + 4.273X $^{*;}$ $^{e}\hat{Y}$= 0.574 ^{ns} + 0.047 X *; $^{f}\hat{Y}$= 0.666 *** + 1.234 X*

Discussion

The concentrate supplement provided an improvement of nutrient supply to the ruminal microbiome, leading to greater digestion of the fiber, which consequently promoted an increase in total and forage DM intake characterizing the additive effect (Tables 3, 4, and 6). Moore[(32)] stated that if supplement intake does not influence forage intake, the substitution coefficient is zero and, when positive, it means that forage intake was increased by supplementation. This fact can be explained by the relationship between the total digestible nutrients and the crude protein (TDN/CP) of the forage, which were 0.4, 1.8, 3.3, 4.0, and 4.7 for respective supplementation levels.

However, the increase in DM intake of forage supplemented with concentrate 0.5% BW was 6 % higher than protein-mineral salt supplementation. Still, when corrected for BW, the DM intake of forage was 5 % lower. It indicates that the supplementation at 0.5% BW was insufficient to avoid the ingestion's empty physical effect. Due to the increase in DM intake, the nutrient intake of CP, NDFap, and NFC also increased (Table 4).

For concentrate supplementation levels, there was an increase in forage intake of 12.3 g kg^{-1} BW for each concentrate percentual unit. As the supply of concentrate was controlled, it can be evidenced that the 0.5% BW supplied would not be indicated to increase the forage intake, despite the improvement of fiber and other nutritional components' digestibilities (Table 6). The forage proportions were 95.59, 71.31, 62.61, 58.83, and 57.91 % in the respective diets with protein-mineral salt and concentrate levels.

In the deferred pasture, there is usually a decrease in CP and fiber digestibilities, because of the maturation process. In this study, the CP content of the *Urochloa* grass was 13.7 % and 85.8 % was in the NDF fraction, presenting a lower rumen degradation rate, especially when the microbial growth was affected by the lower content of soluble nutrients. The forage contributed to decreasing proportion of CP according to the supplementation levels, whose respective values were 13.1; 9.8; 8.6; 8.1, and 7.9 %. Likewise, the proportional values of NDF from forage also decreased: 57.7; 43.1; 37.8; 35.5, and 35.0 %, respectively.

The concentrate supplementation levels provided an increase in CP, NFC, and TDN intakes, being that the CP concentration in the total DM ingested was similar when comparing the supplementation with protein-mineral salt and levels of concentrate (Table 3). In addition, it was observed that, regardless of the use of protein-mineral salt or concentrate levels, goat's kids did not change the composition of the forage consumed, with an average of 13.7 % CP, 13.1 % NFC, and 60.4 % NDFap, characterizing non-selectivity during grazing (Table 4).

The greater supply of concentrate containing mesquite pod meal at 30 %, improved the rumen fermentation and digestibility of nutrients. The maximum points for digestibility were estimated for DM, OM, NDF, and CP in the range of 1.9 % to more than 2.0% BW in supplementation, with the same changing, for the TDN concentration. The quadratic fit was possible because the digestibility did not change proportionally to the increase in supplementation, probably due to the increase in the rumen passage rate. The linear increase in the digestibility of EE and NFC is consistent with the fact that there was an increase in the intake of these nutritional components, due to the levels of supplementation and, thus, the increment of intestinal utilization.

It can be inferred that the rumen passage rate affected the CP and NDF digestibilities because the highest proportion of CP from forage belongs to the fibrous fraction. The greater passage rate can reduce the extent of ruminal degradation of the fibrous fraction of the diet when the DMI rises. Considering that this fraction of the diet is not effectively digested in the small intestine.

To increase the intake of forage, it is necessary to manipulate the diet through two mechanisms, increasing the ruminal digestion rate and/or accelerating the rate of passage of indigestible components[33,34]. In this study, it was observed that the supplementation with concentrate provided an increase in forage intake, as a consequence of both increased ruminal digestion rates, since the NDF digestibility increased. The supplementation with concentrate has an associative effect with the pasture, that is, it entails changes in digestibility (Table 6) and/or in forage intake (Table 3), which may have additive and substitutive effects. An additive effect was observed because there was an increase in TDN intake as a consequence of a greater intake of concentrate, without a decrease in forage intake (Table 3).

The major intake of mesquite pod meal occurred at 2% supplementation showing an average of 219.5 g d^{-1}, which is equivalent to 126.2 g kg^{-1} of total DM consumed. Studies have reported that the use of mesquite pod meals in diets should not exceed 200 g kg^{-1} of DM consumed in goats, both for BW gain and for better lactating performance. Therefore, in this study, the toxic effect of mesquite pod meal did not occur, since the level of 2.0% BW of the concentrate supplement showed a greater ADG (Table 7).

There was a linear effect of supplementation levels on the performance variables (P<0.05) because the concentrate supplementation levels increased the total DM intake and improved the digestibility, reflecting a greater ADG.

The supplementation with protein-mineral salt resulted in reduced ADG as a response to the restriction of its intake and the advanced stage of maturation of the *Urochloa* grass, which presented high contents of NDF indigestible and CP bound to the fibrous fraction (Table 1). However, animals kept in grazing under semiarid conditions usually present a loss of BW during the critical period of forage production. Thus, the use of simple technology, such as supplementation with protein-mineral salt, softens the effects of low availability and quality of biomass. Additionally, the supplementation levels with concentrate provided higher ADG when compared to protein-mineral salt supplementation, and the levels of 1.5% and 2.0% BW provided 155 and 176 g in the ADG, respectively.
The DM intake has an influence on performance, as it determines the number of nutrients ingested, which are necessary to meet the requirements of maintenance and animal production. The feed conversion at 0.5% BW of mesquite pod meal supplementation did indicate the best productive response than the other levels since the goat kids reached the ideal slaughter weight (35 kg) at 92 d of supplementation.

Conclusions and implications

The use of deferred pasture enables a high forage supply in the dry season of the year, even if it is of low quality; and when combined with minimum supplementation levels (0.5% BW), it is possible to increase the rate of average daily gain contributing to the reduction of the productive cycle. The mesquite pod meal supplementation at 2.0% BW provides a higher average daily gain and slaughter body weight at 92 d under grazing, enabling greater gain per pasture area.

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