

Soybean silage and sugarcane tops silage on lamb performance

Silagem de soja e silagem de ponta de cana no desempenho de cordeiros

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ABSTRACT

The objective of this study was to evaluate the performance of sheep fed with diets consisting of different proportions of soybean silage and sugarcane tip silage. Twenty four lambs from Morada Nova breed were used, with an average age of 75 days and average weight of 16.98±2.62kg. The following diets were evaluated: T1 = 20% sugarcane tops silage + 80% concentrate, T2 = 20% sugarcane tops silage + 30% soybean silage + 50% concentrate, T3 = 20% sugarcane tops silage + 60% soybean silage + 20% concentrate. The experimental design was a randomized complete block with eight repetitions and each animal was a repetition. It was evaluated the intake of dry matter, organic matter, ash, crude protein, ether extract, neutral detergent fiber, acid detergent fiber; weight gain, and feed conversion ratio and efficiency. The total weight gain, average daily gain, feed conversion ratio and efficiency were similar; with average values of 7.9kg animal⁻¹, 133.3g animal⁻¹ day⁻¹, 6.2 and 0.17, respectively. Diets based on sugarcane tops silage enriched with soybean silage + concentrate provide greater nutrient intake in relation to diet composed only of sugarcane tops silage + concentrate. Sugarcane tops silage supplemented with protein concentrate or enriched with soybean silage with lower inclusion of concentrate resulted in similar weight gains and feed conversion efficiency.

Key words: feed conversion, feed intake, *Glycine max*, *Saccharum officinarum*, weight gain.

RESUMO

Avaliou-se o desempenho de ovinos alimentados com dietas compostas por silagens de ponta de cana (*Saccharum officinarum*) e de soja (*Glycine max*). Utilizaram-se 24 cordeiros da raça Morada Nova, com idade média de 75 dias e peso vivo médio inicial de 16,98kg. Avaliaram-se as dietas: T1=20% silagem de ponta de cana + 80% de concentrado; T2=20% silagem de ponta de cana + 30% silagem de soja + 50% de concentrado;

T3=20% silagem de ponta de cana + 60% silagem de soja + 20% de concentrado. O delineamento foi em blocos casualizados, com oito repetições, sendo cada animal uma repetição. Avaliaram-se os consumos de matéria seca, matéria orgânica e matéria mineral; proteína bruta; extrato etéreo; fibra em detergente neutro e em detergente ácido; ganho de peso e conversão e eficiência alimentar. Os ganhos de peso total e diário, a conversão e a eficiência alimentar foram semelhantes, com valores médios de 7,9kg animal⁻¹; 133,3g animal⁻¹ dia⁻¹; 6,2 e 0,17; respectivamente. Dietas compostas por silagem de ponta de cana enriquecidas com silagem de soja + concentrado proporcionam maior consumo de nutrientes em relação às dietas compostas somente pela silagem de ponta de cana + concentrado. Silagem de ponta de cana suplementada com concentrado proteico ou com silagem de soja e menor participação de concentrado resulta em ganhos de peso, conversão e eficiência alimentar semelhantes.

Palavras-chave: consumo, conversão alimentar, ganho de peso, *Glycine max*, *Saccharum officinarum*.

INTRODUCTION

The use of crop residues in ruminant nutrition has increased in recent years and has proved to be a viable alternative for reducing the feeding costs of the herd (NUNES et al., 2010), also minimizing the deposition of these materials into the environment. Ruminants, when compared to other domestic species, have a great ability to convert by-products and residues in noble food (meat and milk) and do not compete directly with food and monogastric animals. Thus, the study of feeding strategies that

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optimizes animal productivity and, hence, provides environmental benefits are important to generate information that directs the herd food management under socio-economic-environmental basis.

In the context of agribusiness by-products, it is noted that, in the process of sugarcane harvesting, the tops are removed to increase industrial efficiency and to reduce transportation costs of raw materials. As this material is left on the ground, it becomes a factor of environmental congestion. It is, therefore, necessary to adopt technological strategies to reduce the amount of residues left on the ground. One alternative is the use of sugarcane tops in animal feed.

As the sugarcane tops are restricted to the harvesting period, it is crucial that strategies are adopted to conserve the material and to ensure the provision of food to animals for a prolonged period. In this sense, the silage is an effective storage technique and it is used in order to conserve the forage to be offered to cattle in times of food shortage or in feedlots. On the other hand, there is the need for supplemental protein of the sugarcane tops, because the content related to this variable is not sufficient to meet the animal requirement, and one option is the soybean silage.

This study was carried in order to evaluate the nutrients intake, the conversion and feed efficiency and performance of lambs fed with diets consisting of silage from sugarcane tops enriched with soybean silage.

MATERIAL AND METHODS

The experiment was carried out at Instituto de Zootecnia, Nova Odessa-SP, Brazil, in the months from June to August, 2010, for 75 days, being the 15 first days used to adapt the animals to the diets, facilities and management conditions. Twenty four Morada Nova lambs were used with an average age of 75 days and average live weight of 16.98 ± 2.62 kg. The animals were housed in individual pens with suspended floor with wooden slats, measuring 1.0m x 1.20m, located in a shed and provided with feeders, drinkers, and troughs for mineral mixture.

The following diets were evaluated: T1 = 20% sugarcane tops silage + 80% concentrate (ST₂₀C₈₀), T2 = 20% sugarcane tops silage + 30% soybean silage + 50% concentrate (ST₂₀SS₃₀C₅₀), T3 = 20% sugarcane tops silage + 60% of soybean silage + 20% concentrate (ST₂₀SS₆₀C₂₀). The experimental diets were balanced according to the protein level of soybean silage and sugarcane tops in order to meet the lambs protein demand (Table 1).

The silages and concentrate were weighed and manually mixed in the troughs in the correct proportion (dry matter basis) at the time of feeding, in two daily meals, at 8 am and 4 pm, and it was provided in sufficient quantity to allow remains between 10 and 15% of what was offered. The leftover from each animal were daily collected and weighed on the day after feeding, allowing the subsequent calculation of consumption and adjustment of the amount of diet to be provided.

Sugarcane tops came from an established sugarcane field, cultivar RB 855536, with a year of growth, and were collected manually from the soil after mechanical harvesting of sugarcane. The tops of sugarcane were fragmented by a stationary forage machine with an average size of particles of 1.0cm. The harvest and ensiling processes were held in June/2009 and the experimental silos consisted of 100-kg plastic containers with lids to ensure proper sealing. The forage was compressed in 15cm layers in order to remove most of the air and obtain as much as possible sugarcane tops in each silo. After filling up and compacting the forage, the silos were properly sealed to prevent air contact, and then, stored in a covered place at room temperature, free from moisture and solar radiation.

The soybean cultivar used was the M-7908 RR, which has determined growth habit, medium size, and 120-day life cycle. The sowing was in December/2009, using 80 kg seed/ha in 0.45m spacing between rows. The seeds were treated following the recommendations and dosages specified by the manufacturer. The correction and fertilization were performed according to soil analysis.

The soybean harvest was carried out by a harvester attached to a tractor. The forage was cut into particles with average size of 1cm. This practice was done when the plants reached R₆ stage in FEHR & CAVINESS (1977) scale. Like the sugarcane tops, the soybean was ensiled in plastic containers with an average capacity of 100kg of fresh matter.

The animals were individually weighed at the beginning of the experiment and, then, at every 14 days until the end of data collection period. The weighing was carried out around the same time before the diet delivery, at 8 am, aiming to monitor growth for the adjustment of diet and getting the average daily weight gain at the end of the experiment.

Daily samples of silage, diets offered, and leftovers were collected before the daily offering of diets, packed in plastic bags, labeled, and stored in a freezer for future bromatological determinations. At the end of the experiment, the samples were

Table 1 - Chemical composition (g kg⁻¹ of DM), *in vitro* digestibility of dry matter of diets, and chemical composition (g kg⁻¹ of DM) of the diet ingredients.

	-----Diets-----			
	ST ₂₀ C ₈₀ ¹	ST ₂₀ SS ₃₀ C ₅₀ ²	ST ₂₀ SS ₆₀ C ₂₀ ³	
Dry matter (g kg ⁻¹ of DM)	551.1	496.0	394.5	
Organic matter (g kg ⁻¹ of DM)	961.3	961.3	935.4	
Crude protein (g kg ⁻¹ of DM)	169.3	200.0	191.7	
Ether extract (g kg ⁻¹ of DM)	21.5	38.7	52.7	
Ash (g kg ⁻¹ of DM)	38.7	52.3	64.6	
Neutral detergent fiber (g kg ⁻¹ of DM)	352.5	336.5	373.6	
Acid detergent fiber (g kg ⁻¹ of DM)	180.1	236.0	248.6	
<i>In vitro</i> DM digestibility (%)	78.5	76.3	66.0	
EM (Mcal kg ⁻¹)	2.9	3.0	2.9	
	-----Ingredients of the diets-----			
			-----Silage-----	
	Corn meal	Soybean meal	Sugarcane tops	Soybean
	(g kg ⁻¹ of DM)-----			
Dry matter	880.0	889.0	309.70	290.0
Organic matter	868.5	825.1	258.4	197.6
Crude protein	87.0	481.0	62.50	220.0
Ether extract	27.0	34.5	19.0	42.3
Ash	11.5	63.9	51.3	92.4
Neutral detergent fiber	126.1	122.5	730.8	424.4
Acid detergent fiber	48.1	101.3	458.0	376.0

¹ ST₂₀C₈₀ = 20% sugarcane tops silage + 80% concentrate.

² ST₂₀SS₃₀C₅₀ = 20% sugarcane tops silage + 30% soybean silage + 50% concentrate.

³ ST₂₀SS₆₀C₂₀ = 20% sugarcane tops silage + 60% soybean silage + 20% concentrate.

homogenized according to their type, dried at forced-air system at 55°C up to constant weight, and ground in a Willey mill with a 1-mm mesh sieve. The samples were analyzed for: dry matter (DM), organic matter (OM) (% OM=100-A), ash (A), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF) and dry matter *in vitro* digestibility (DMI_{VD}), according to the description made by SILVA & QUEIROZ (2002). It was evaluated the intake of DM, OM, CP, nitrogen in NDF (nNDF), nitrogen in ADF (nADF), EE, A, NDF, ADF, and neutral detergent fiber corrected for ash and protein (NDF_{ap}). For the calculation of metabolizable energy, equations suggested by NRC (2001) used were: ME(Mcal kg⁻¹) = 1.01 × DE (Mcal kg⁻¹) - 0.45; ED (Mcal kg⁻¹) = 0.04409 × TDN (%), where ME= metabolizable energy, TDN = total digestible nutrients, ED = digestible energy.

Nutrient intake for each animal was calculated as the difference between the amount of nutrient in the amount offered and its respective leftover. The calculation to determine the feed conversion (FC) was performed by the ratio between the average daily intake of DM (g animal⁻¹ day⁻¹) and

the average daily weight gain (g animal⁻¹ day⁻¹). The calculation to determine feed efficiency (FE) was performed by the relation between the average daily weight gain (g/animal.day) and the average daily intake of DM (g animal⁻¹ day⁻¹).

The average daily weight gain (ADWG) was obtained through the relation between total weight gain (TWG) and total experimental days, and TWG (kg) was obtained by the difference between the initial and the final weight of the animals.

The experimental design was a randomized complete block with eight repetitions, and the blocks determined according to the initial weight of animals. The data was subjected to analysis of variance (ANOVA) using SAS (2001) and the differences between means compared by Tukey test ($\alpha=0.05$).

RESULTS AND DISCUSSION

There were significant differences ($P<0.05$) for intake due to the presence of soybean silage in the diets (Table 2). This occurrence can be explained by the greater acceptability observed for the diets composed of soybean silage. It is noted

Table 2 - Average intakes of dry matter, organic matter, crude protein, nitrogen in the NDF and ADF, ether extract, ash, neutral detergent fiber, acid detergent fiber, neutral detergent fiber corrected for ash and protein and their standard errors (SE).

	ST ₂₀ C ₈₀ ¹	SE	ST ₂₀ SS ₃₀ C ₅₀ ²	SE	ST ₂₀ SS ₆₀ C ₂₀ ³	SE
	----- (g animal ⁻¹ day ⁻¹)-----					
Dry matter	647.6 b	38.45	854.6 a	34.89	871.7 a	34.89
Organic matter	621.8 b	36.23	810.0 a	32.88	815.4 a	32.87
Crude protein	110.33 b	7.49	170.93 a	6.79	167.10 a	6.79
Nitrogen in NDF (nNDF)	8.9 a	0.31	5.3 b	0.25	4.4 b	0.25
Nitrogen in ADF (nADF)	2.2 c	0.24	3.4 b	0.19	5.4 a	0.19
Ether extract	14.65 c	1.82	33.08 b	1.65	45.93 a	1.65
Ash	25.66 c	2.27	44.70 b	2.06	56.31 a	2.06
Neutral detergent fiber	228.5 b	13.74	287.6 a	12.47	325.7 a	12.47
Acid detergent fiber	118.4 b	9.28	201.7 a	8.42	216.7 a	8.42
Neutral detergent fiber corrected for ashes and protein	359.4 a	16.00	289.1 b	13.01	288.0 b	13.01

Means followed by different letters, in the row, differ by Tukey test ($P \leq 0.05$).

¹ ST₂₀C₈₀ = 20% sugarcane tops silage + 80% concentrate

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³ ST₂₀SS₆₀C₂₀ = 20% sugarcane tops silage + 60% soybean silage + 20% concentrate.

that consumption can be affected by dietary protein content. This fact was confirmed because the diet based only on sugarcane tops silage + concentrate (ST₂₀C₈₀) had the lowest protein content (169.3g kg⁻¹) (Table 1), as well as lower consumption (Table 2), compared to other diets. On the other hand, diets based on soybean silage (ST₂₀SS₃₀C₅₀ and ST₂₀SS₆₀C₂₀) had similar protein content, DM and OM intake (Tables 1 and 2, respectively). Thus, there was possible influence of protein content on DM and OM intake. ZUNDT et al. (2002) reviewing the influence of the level of crude protein on dry matter intake, mentioned that as the level of protein was increased from 8%-9% to 13%-14%, there were increases in food consumption. In this study, the energy content of the diets did not possibly influence differentiated consumption, since they were similar, between 2.9 and 3.0Mcal kg⁻¹ (Table 1).

The diets influenced the consumption of CP because, besides the highest DM intake, those containing soybean silage showed higher CP intake, which is certainly due to the higher protein content of soybean silage (220.0g kg⁻¹) in relation to sugarcane tops silage (63g kg⁻¹). According to NRC (2007), it is necessary a consumption of 167.0 g of CP animal⁻¹ day⁻¹ for lambs at 20kg of body weight with a daily gain of 250.0g animal⁻¹ day⁻¹. Diets composed by soybean silage complied with this requirement (170.9 and 167.1g animal⁻¹ day⁻¹ for ST₂₀SS₃₀C₅₀ and ST₂₀SS₆₀C₂₀, respectively). However, the diet composed only by the sugarcane tops silage + concentrate showed CP consumption much lower than mentioned, that is, only 110.3g animal⁻¹ day⁻¹, making a deficit of 57.0g

animal⁻¹ day⁻¹ compared to that suggested by NRC (2007). In this context, it is noteworthy that one of the most commonly attributed merits of legumes is the increase in crude protein content in the forage, exerting beneficial effects mainly on increasing the protein value of the component 'non-legume' mixtures of forages. At this point, it becomes necessary to refer to table 3 for the animals weight gain. It is observed that the weight gains were similar ($P > 0.05$) and, therefore, it is noteworthy that higher intakes of DM and CP observed for diets containing soybean silage is not reflected in significantly higher weight gain.

The consumption of nFDN decreased with the participation of soybean silage, 8.01%, 3.10%, and 2.60% in relation to consumption of CP respectively for ST₂₀C₈₀, ST₂₀SS₃₀C₅₀, and ST₂₀SS₆₀C₂₀. For the consumption of nFDA, the percentages were 2.0% for ST₂₀C₈₀ and ST₂₀SS₃₀C₅₀, and 3.2% for ST₂₀SS₆₀C₂₀, with respect to their CP intake. Of course, this fact is explained by the greater availability of nitrogen not connected to the fiber in soybean silage in relation to the tip of sugarcane silage.

The participation of soybean silage in the diets affected the consumption of ether extract ($P < 0.05$), which increased from 14.65g animal⁻¹ day⁻¹ (ST₂₀C₈₀) to 45.93g animal⁻¹ day⁻¹ (ST₂₀SS₆₀C₂₀). This was expected due to the high content of EE in diets containing soybean silage, 38.7g kg⁻¹ and 52.7g kg⁻¹, respectively, for diets containing 30% and 60% soybean silage in relation to diet composed only by the sugarcane tops silage + concentrate (21.5g kg⁻¹ of EE). LIMA et al. (2009) observed EE intake of 32.3g animal⁻¹ day⁻¹, when working with *Santa Ines* lambs

Table 3 - Mean values of total weight gain (WG), average daily gain (ADG), conversion and feed efficiency of *Morada Nova* lambs fed with diets consisting of sugarcane tops silage and soybean silage and their standard errors (SE).

Variables	ST ₂₀ C ₈₀ ¹	SE	ST ₂₀ SS ₃₀ C ₅₀ ²	SE	ST ₂₀ SS ₆₀ C ₂₀ ³	SE	Average
WG (kg)	7.28	0.88	8.45	0.80	7.86	0.80	7.9
ADG (g animal ⁻¹ day ⁻¹)	123.47	14.98	143.22	13.59	133.26	13.59	133.3
Feed conversion	5.40	0.42	6.17	0.38	6.93	0.38	6.2
Feed efficiency	0.19	0.01	0.17	0.01	0.15	0.01	0.17

¹ ST₂₀C₈₀ = 20% sugarcane tops silage + 80% concentrate.

² ST₂₀SS₃₀C₅₀ = 20% sugarcane tops silage + 30% soybean silage + 50% concentrate.

³ ST₂₀SS₆₀C₂₀ = 20% sugarcane tops silage + 60% soybean silage + 20% concentrate.

fed with diets containing 60% soybean silage + 40% corn silage.

Despite the higher content of EE in diets composed of soybean silage in relation to diet consisting of sugarcane tops silage, it was not observed adverse effects in animals. Logically, the highest level of EE in diets composed of soybean silage is due to the high content of this variable in soybean silage (72.0g kg⁻¹) compared to sugarcane tops silage (19.0g kg⁻¹). Another factor that may be associated with lower consumption of EE in ST₂₀C₈₀ is the lowest DM intake, compared to other diets. However, the main factor that explains higher consumption of EE in diets composed of soybean silage is the high content of EE from the soybean plant.

With respect to the consumption of ash, the highest intakes were observed for diets containing soybean silage. This fact was expected due to the high ash content in soybean silage in relation to the sugarcane tops silage, 92.0g kg⁻¹ and 51.0g kg⁻¹, respectively.

There were significant differences among diets (P<0.05) for the consumption of fibrous constituents. The diet composed solely by sugarcane tops silage + concentrate (ST₂₀C₈₀) had the lowest value in relation to the diets composed of soybean silage, except for neutral detergent fiber corrected for ashes and protein. This fact occurred due to the high contribution of the concentrate (80%) in that diet. Considering that in other diets the participation of roughage increased due to the increasing participation of soybean silage and reduced level of concentrate, it is natural that the consumption of NDF and ADF were higher in such diets. As CARDOSO et al. (2006), the increased level of fiber in the diet of feedlot lambs causes a reduction in average daily gain and decreased feed conversion and efficiency, increasing thus the number of days to reach slaughter weight. It should be noted that, despite the participation of silage soybean in diets with higher levels and intake of NDF (Tables 1 and 2, respectively), this did not

influence weight gain, feed conversion and efficiency (Table 3).

The lowest intake of NDF and ADF detected in diets composed solely by sugarcane tops silage besides lower DM intake (Table 2), it can also be explained by the ingredients selection by animals during the ingestion, because the diet composed of sugarcane tops silage had higher levels of NDF (352.5g kg⁻¹) compared to the diet composed of 30% soybean silage (336.5g kg⁻¹) (Table 1). Although the diet was finely ground and well mixed, sheep have the ability to select different components. Another factor that may have contributed to the increase in NDF intake of diets containing soybean silage is the fact that it have higher moisture content (Table 1) in relation to diet composed only the tip of sugarcane silage + concentrate, which contributes to reduced by selecting animals. In turn, lower consumption of ADF was consistent with the lowest level of this variable in sugarcane tops silage (180.1g kg⁻¹) compared to other diets (236.0g kg⁻¹ and 248.0g kg⁻¹, respectively, for ST₂₀SS₃₀C₅₀ and ST₂₀SS₆₀C₂₀). CARDOSO et al. (2006) observed that DM intake by lambs fed with diets containing different levels of NDF (250.0, 313.7, and 430.0g kg⁻¹) decreased linearly with increasing NDF content in the diet.

It is worth noting that although the content of NDF and ADF of diets influenced their consumption, they have no influence on DM intake (Table 2), because this was higher in diets with higher concentrations and consumption of NDF and ADF (ST₂₀SS₃₀C₅₀ and ST₂₀SS₆₀C₂₀). In this context, it was emphasized that the effect of filling up the rumen of animals fed on leguminous plants is lower due to the weakness of the particle (VAGHORN et al., 1989) and to the short retention time (HOFFMAN et al., 1998) compared to grass plants.

The consumption of NDFap was the reverse of NDF intake, that is, higher consumption (P<0.05) was observed for ST₂₀C₈₀, and all diets presented intake greater than 12.0g kg⁻¹ of BW as suggested

by MERTENS (1994), once the consumption from which food intake is controlled by the physical effect. Therefore, this may have occurred because the diet with the highest consumption of NDFap (18.0g kg⁻¹) and lower consumption of nutrients (Table 2).

There was no significant effect ($P>0.05$) of diets on TWG, ADG, conversion and feed efficiency (Table 3). Considering the higher consumption of DM and CP (Table 2) for animals fed diets composed by soybean silage, was expected to gain more weight; however, this did not happen and it shows that all diets were satisfactory for animals from *Morada Nova* breed, which is not genetically improved for weight gain. Possibly, for this reason, weight gains provided by the diets were below the gain suggested by NRC (2007), 250g animal⁻¹ day⁻¹.

As for conversion and feed efficiency, whose average values were 6.2kg of DM kg⁻¹ of weight and 0.2kg of gain kg⁻¹ of DM, respectively (Table 3), both diets, therefore, are considered similar. For Santa Ines lambs fed with diets containing 17% crude protein, MONTEIRO et al. (1998) reported feed conversion of 3.8kg of DM kg⁻¹ of weight. SIQUEIRA et al. (2001) using feed containing 60% concentrate and 0.9% soy oil observed feed conversion ratio of 4.9kg of DM kg⁻¹ of weight, while FURUSHO-GARCIA et al. (2004) using feed containing 80% concentrate without fat supplementation obtained feed conversion of 4.2kg of DM kg⁻¹ of body weight. It is noted that the surveys were carried out with lambs belonging to *Santa Inês* breed. In this context, it is noteworthy that in this study a greater amount of dry matter required in relation to *Santa Inês* breed, for every kg of weight gain, was expected. *Morada Nova* breed used in this study is not genetically improved for this purpose and, therefore, it is natural to require greater dry matter intake for animal performance. Moreover, the average feed conversion obtained in this study was better than the one mentioned by CIRÍACO (1983), whose average was 13.6, while working with male and female *Morada Nova* sheep, aged between five and six months, fed with butterfly pea grass hay and elephant grass hay. It was also better than the one found by OLIVEIRA et al. (1986), 10.3; who worked with *Morada Nova* sheep, fed with *Chromolaena maximilianii* hay and concentrate.

Thus, it is noted that the diets used in this study allowed the animals to express their genetic capacity for weight gain, which may not occur with the most demanding races. The soybean silage showed to be an interesting alternative, which may be used in conditions of high cost of the protein concentrate, or use of crops not suitable for grain harvest.

CONCLUSION

Diets based on sugarcane tops silage enriched with soybean silage + concentrate provide greater nutrient intake in relation to diet composed only of sugarcane tops silage + concentrate. Sugarcane tops silage supplemented with protein concentrate or enriched with soybean silage with lower inclusion of concentrate resulted in similar weight gains and feed conversion efficiency. The use of soybean silage to enrich the protein content of diets consisting of sugarcane tops silage should be based on the cost of protein production in the property through ensiling soybean plant.

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Soybean silage and sugarcane tops silage on lamb performance

Silagem de soja e silagem de ponta de cana no desempenho de cordeiros

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