Research, Society and Development, v. 9, n. 8, e347985005, 2020
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i8.5005

Ingestão de feno picado de Tifton 85 teve efeito positivo sobre a digestibilidade da proteína e a produção e composição do leite de ovelhas Lacaune

Intake of Tifton 85 chopped hay have positive effects on protein digestibility, and milk production and composition of Lacaune sheep

Ingestión de heno picado de Tifton 85 tuvo un efecto positivo sobre la digestibilidad de las proteínas y la producción y composición de la leche de oveja Lacaune

Recebido: 27/05/2020 | Revisado: 19/06/2020 | Aceito: 24/06/2020 | Publicado: 07/07/2020

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Resumo

Este estudo comparou os efeitos do feno inteiro e picado na produção, composição, digestibilidade dos alimentos e fisiologia do leite de ovelhas Lacaune. Dezoito ovelhas foram distribuídas em dois grupos pelo número de partos (dois ou três), dias de lactação (60±3,7 dias) e produção de leite (1,04 L/ovelha/dia): 1) feno não-picado ou 2) feno picado (Tifton 85). Silagem de milho e concentrado também foram fornecidos. Ovelhas que consumiram feno picado apresentaram menor ($P \leq 0,01$) consumo de matéria seca e maior ($P=0,02$) digestibilidade da proteína bruta. Não foi verificado efeitos do tratamento ($P \geq 0,38$) para a digestibilidade da matéria seca ou das fibras detergente neutra e ácida. Ovelhas que ingeriram feno picado apresentaram maior ($P \leq 0,01$) produção de leite (d 7 e d 12), persistência da lactação e eficiência alimentar. Ovelhas que comem feno picado apresentaram maior ($P=0,03$) concentração de proteína no leite. No entanto, não houve efeito do tratamento × dia e do tratamento ($P \geq 0,16$) para concentrações de gordura, lactose, minerais, extrato seco desengordurado ou densidade do leite. Ovelhas que ingeriram feno picado tiveram menores ($P<0,01$) concentrações séricas de ureia e tendência de menores ($P=0,10$) concentrações séricas de glicose no dia 12. No entanto, não houve efeitos do tratamento × dia e do tratamento ($P \geq 0,16$) para concentrações séricas de proteína total, albumina, globulina, triglicerídeos ou colesterol no soro. Esses dados sugerem que o feno picado promove menor consumo de matéria seca, concentrações séricas de glicose e ureia, mas melhora a produção de leite, a persistência da lactação, a eficiência alimentar, assim como aumenta concentração de proteínas.

Palavras-chave: Eficiência produtiva; Metabolismo; Qualidade de leite; Tamanho de partícula.

Abstract

This study compared the effects of unchopped and chopped hay on milk production and composition, feed digestibility, and physiology of Lacaune sheep. Eighteen ewes were stratified by parity (two or three), days of lactation (60 ± 3.7 days), and milk production (1.04 L/ewe/day), and were randomly assigned to 1 of 2 treatments: 1) Unchopped or 2) Chopped Tifton 85 hay. Corn silage and concentrate were also provided. Chopped hay ewes gave lower (P≤0.01) dry matter intake and greater (P=0.02) crude protein digestibility. No effects of treatment were detected (P≥0.38) for the digestibility of dry matter, or of neutral and acid detergent fibers. Chopped hay ewes had greater (P≤0.01) milk production (d 7 and d 12), lactation persistence, and feed efficiency. Ewes eating chopped hay had greater (P=0.03) protein concentration in their milk. However, there were no effects of treatment × day and treatments (P≥0.16) for concentrations of fat, lactose, minerals, deffated dry extract, or density. Ewes eating chopped hay presented lower (P<0.01) serum concentrations of urea and tended to have lower (P=0.10) serum concentrations of glucose only on d 12. However, there were no effects of treatment × day and treatments (P≥0.16) for serum concentrations of total protein, albumin, globulin, triglycerides, or cholesterol. These data suggest that chopped hay promotes lower dry matter intake and serum concentrations of glucose and urea, but improves milk production, lactation persistence, feed efficiency, and protein concentration.

Keywords: Metabolism; Milk quality; Particle size; Productive efficiency.

Resumen

Este estudio comparó los efectos del heno sin picar y picado en la producción de leche, composición, digestibilidad y fisiología de las ovejas Lacaune. Dieciocho ovejas fueron estratificadas por paridad (dos o tres), días de lactancia (60±3,7 días) y producción de leche (1,04 L/oveja/día), y fueron asignadas aleatoriamente a 1 de 2 tratamientos: 1) Sin picadura o 2) Tifton picado 85 heno. También se proporcionaron ensilaje de maíz y concentrado. Las ovejas de heno picadas dieron una menor ingesta de materia seca (P≤0.01) y una mayor digestibilidad de la proteína cruda (P=0.02). No se detectaron efectos del tratamiento (P≥0,38) para la digestibilidad de la materia seca o las fibras de detergente neutro y ácido. Las ovejas de heno picadas tuvieron mayor producción de leche (P≤0.01) (d 7 y d 12), persistencia de la lactancia y eficiencia alimenticia. Las ovejas que comían heno picado tenían una mayor concentración de proteína (P=0.03) en su leche. Sin embargo, no hubo efectos del tratamiento × día y los tratamientos (P≥0.16) para las concentraciones de grasa, lactosa, minerales, extracto seco desgrasado o densidad. Las ovejas que comían heno picado mostraron concentraciones de urea en suero más bajas (P<0.01) y tendían a tener concentraciones de glucosa en suero más bajas (P=0.10) solo en el día 12. Sin embargo, no hubo efectos del tratamiento × día y tratamientos (P≥0.16) para concentraciones séricas de proteínas totales, albúmina, globulina, triglicéridos o colesterol. Estos datos sugieren que el heno picado promueve una menor ingesta de materia seca y concentraciones séricas de glucosa y urea, pero mejora la producción de leche, la persistencia de la lactancia, la eficiencia alimenticia y la concentración de proteínas.

Palabras clave: Eficiencia productiva; Calidad de la leche; Metabolismo; Tamaño de partícula.

1. Introduction

The forage particle size influences dry matter intake and digestibility in castrated sheep (Tafaj et al., 2009), as well as dry matter intake in lambs (Norouzian and Valizadeh, 2014) and lactating sheep (Helander et al., 2014). Sheep pick up feed using their lips, resulting in greater feed selectivity than cattle are capable of (Van Soest, 1994). When sheep are confined, there may be uneven consumption, attributable to feed selectivity, possibly resulting in consumption of an unbalanced diet. Researchers verified that forage particle size has the potential to affect dry matter intake and performance of dairy cows but its effects are modulated by forage level, source, and preservation method (Nasrollahi et al., 2015). Nevertheless, the effect of fibrous feed particle size on the productive performance of dairy ewes is unknown.

In Brazil, corn silage is the primary roughage provided for cows and confined dairy sheep (Bernardes and Do Rêgo, 2014). Currently, the use of tropical grass hay is common (Silva et al., 2019) because tropical and subtropical climates are conducive to these crops (corn and grass). These feeds are given to dairy sheep because they are low-cost and are favored for large-scale use; despite this, a lack of scientific research on this subject is noticeable, especially with Tifton 85 hay.

In Brazil, forage species of the genus *Cynodon* are the most suitable for producing hay in view of their high production potential and nutritional value (Aguiar et al., 2006), although the nutritional value decreases with the advances in growth stage. This grass hay is an improved cultivar, with digestible dry matter yields (Burton, 2001). Lactating dairy cows were fed diets containing either Tifton 85 hay had the highest milk fat percentage (West et al., 1997).

Our hypothesis is that the process of chopping the hay will reduce the waste of that food, a frequent problem reported by producers. Therefore, the aim of this study was to compare the effects of unchopped and chopped hay (Tifton 85) on milk production and composition, as well as feed digestibility, and physiology of Lacaune sheep.

2. Materials and Methods

This study had an exploratory and quantitative nature (Pereira et al., 2018). To achieve our objectives, we used a completely randomized design, as detailed below.

2.1. Experiment location

The study was conducted at a commercial farm located in the municipality of Chapecó, Santa Catarina, Brazil. The farm is specialized in the production of sheep's milk, with approximately 300 lactating sheep.

2.2. Hay

The Tifton 85 hay used in this study was purchased from an agricultural company located in the municipality of Xaxim (Santa Catarina, Brazil). According to a trader, the hay was grown and processed on a rural property in the municipality of Xaxim.

2.3. Animals and experimental design

This study was approved by the Animal Experimentation Ethics Committee of Universidade do Estado de Santa Catarina, under protocol number 5076190617. All procedures involving animals are in accordance with Conselho Nacional de Experimentação Animal (CONCEA).

Prior to the beginning of the experiment, the animals were fed only concentrate and silage. During the experiment, silage was partially replaced by hay; therefore, the sheep received a diet of corn silage, Tifton 85 hay (*Cynodon* spp.) and concentrate (Table 1).

Eighteen ewes (67.1 ± 5.6 kg) were stratified by parity (two or three), days lactating (60 ± 3.7 days), and milk production (1.04 L/ewe/day), and were randomly assigned to one of two treatments: 1) Unchopped or 2) Chopped Tifton 85 hay. The experiment lasted 12 days, with the first 7 days for adaptation to the diet, as described by García-González et al. (2012) and Da Silva et al. (2017) in study with adult sheep.

The dairy sheep were housed separately per group in two 6 x 4 m pens with water available ad libitum. The animals used in this study were apparently healthy, as well as free of gastrointestinal parasites.

The feeders were individualized and measured 46 x 30 x 22 cm, with sheep being held using a chain that attached each sheep to the stall/feeder. The sheep were milked twice a day at 06:00 AM and 04:00 PM. Immediately afterwards, the animals received, as fed, 800 g of concentrate, 3200 g of corn silage, and 250 g of Tifton 85 hay (Table 1) per animal.

2.4. Feed intake, digestibility, and chemical composition

From day 8 to 12 of the experiment, feed intake was measured by weighing the offered feed and the leftovers. Leftovers were defined as the feed available inside the feeder as well as the hay spread on the floor of the stall. Of the total feed leftover collected, then homogenized; a 10% sampling was separated, and was subsequently maintained at –20 ºC until processing. In the laboratory, the offered feed and the leftovers were analyzed in terms of particle size distribution, using a particle separator, according to the methodology of Kononoff and Heinrichs (2003).

Table 1. Ingredients and composition of experimental diets provided to lactating ewes.

Diet ingredients	**As fed**	**Dry matter**
Corn silage (kg/day)	3.20	1.05
Concentrate[1] (kg/day)	0.80	0.72
Tifton 85 hay (kg/day)	0.25	0.22
Total (kg/day)	4.25	1.99

Chemical composition	**Corn silage**	**Concentrate**	**Unchopped hay**	**Chopped hay**
Dry matter (DM), g/kg	330	900	874	878
Ash, g/kg DM	42.2	69.6	32.0	33.0
Crude protein, g/kg DM	71.8	176.0	98.2	99.6
NDF g/kg DM	556	198	632	623
ADF, g/kg DM	217	93.5	288	275

[1]Ingredients present in 100 kg of concentrate: ground corn (67.13%), soybean meal (27.78%), calcitic limestone (0.93%), sodium bicarbonate (0.46%) and 3.7% core (Calcium Min 195–220 g, Phosphorus Min. 39 g, Sodium Min. 75 g, Sulfur Min. 18 g, Magnesium Min. 12 g, Cobalt Min. 45 mg, Iodine Min. 65 g, Manganese Min. 1300 mg, Selenium Min. 15 mg, Zinc Min. 3500 mg, Niacin Min. 500 mg, Vit. A Min. 316000 mg, Vit. D3 Min. 63000 IU, Vit. E Min. 650 IU, Fluorine max 390 mg in 1 kg of product).
[2]Neutral detergent fiber (NDF) and acid detergent fiber (ADF).
Source: Authors.

To determine digestibility, feces were collected directly from the rectal ampulla, on the final 5 days of the experiment (days 8–12) at various times of day (8 h, 10 h, 12 h, 14 h, and 16 h). Fecal pooling was done per animal for chemical composition analyses according describe by Jaguezeski et al. (2018). To estimate the daily fecal excretion, indigestible neutral detergent fiber (iNDF) was calculated for the diets, orts, and fecal samples, using the in situ digestibility procedure described by Cochran et al. (1986), using quadruplicate samples of silage, concentrate and feces that were incubated in the bovine rumen for 288 h (Huhtanen et al., 1994). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations were determined and the results were used in the digestibility calculations.

Chemical analyses were performed on the feed, the leftovers, and feces. The samples were dried in a forced ventilation oven for 72 hours at 55 ºC and were then ground in a 1-mm Willey-mill and subjected to determination of the dry matter at 105 °C, crude protein (AOAC, 1990), and ash (AOAC, 2000), and neutral detergent fiber (NDF%) and acid detergent fiber (ADF%) according to Van Soest (1994).

2.5. Milk sampling and composition

Milk production was individually measured daily on days 1, 7 and 12 of the experiment, using a Milk Meter®. In sheep no were pre and post dipping done.

From the measuring cup, 40 mL of milk were collected in tubes containing bronopol and were refrigerated at 4 ºC (Jaguezeski et al., 2018) for analysis of centesimal composition and somatic cell counts (SCCs). From the same cup, we collected 2 mL of milk samples from each sheep in microtubes, to be frozen at –20 ºC for analysis of protein oxidation and total antioxidants. For fat, protein, lactose, defatted dry extract (DDE), and total dry extract (EST) analyses, we used methodologies defined by IDF Standard, using the infrared method. These processes were standardized and published by Jaguezeski et al. (2018).

From the feed intake and milk production of the sheep, the feed efficiency (FE) was calculated according to the formula described by Hall (2003): FE (%) = amount of milk produced (kg/day) divided by kg of dry matter consumed) x 100. Lactation persistence (LP) was calculated using the formula: LP (%) = [1- ((LPant - LPpost) x (30/IECL) / LPant)] x 100, where: LPant is previous milk production, LPpost is later milk production, and IECL is interval in days between dairy controls.

2.6. Blood collection and serum biochemical analyses

Blood samples were collected on days 1, 7, and 12 by jugular venipuncture using non-anticoagulant vacuum collection tubes; and the material was maintained in a thermal box until transport to the laboratory for analysis (Jaguezeski et al., 2018). The collected blood samples were centrifuged (3500 rpm, 10 min) and the supernatants were separated into microtubes (serum), stored at –20 °C until processing. Biochemical analyses were performed on Bioplus 2000 equipment, using commercial kits and following the proper methodology recommended for each exam: total protein, albumin, triglycerides, glucose, cholesterol, and urea. Globulin levels were calculated by subtraction (total protein – albumin) (Kaneco et al., 1997).

2.7. Statistical analysis

Each ewe was considered the experimental unit for all analyses. All dependent variables were tested for normality using Univariate procedure of SAS (SAS Inst. Inc., Cary, NC, USA; version 9.4) and all had normal distribution. Then, all data were analyzed using the

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MIXED procedure of SAS, with Satterthwaite approximation to determine the denominator degrees of freedom for the test of fixed effects. The particle size (sieve) of the hay, DM intake, digestibility variables, lactation persistence, and feed efficiency were tested for fixed effect of treatment using animal (treatment) as random effects. All other variables were analyzed as repeated measures and tested for fixed effects of treatment, day, and treatment × day, using animal (treatment) as random variables and animal (treatment) as subjects. All results obtained on d1 for each variable were included as covariates in each respective analysis, but were removed from the model when $P > 0.10$. The first order autoregressive covariance structure was selected for serum concentration of total protein, glucose, and urea. Compound symmetric covariance structure was selected for all other variables. The covariance structures were selected according to the lowest Akaike information criterion. Means were separated using PDIFF, and all results were reported as LSMEANS followed by SEM. Significance was defined when $P \leq 0.05$, and tendency when $P > 0.05$ and ≤ 0.10.

3. Results

3.1. Chopping and selection of hay

Differences were detected for particle size between treatments. Chopped hay had lower ($P = 0.02$) amounts in sieve 19 mm, but greater ($P \leq 0.01$) amounts in sieves 8 mm and 1.18 mm, compared to unchopped hay (Table 2). In the leftovers, chopped hay had lower ($P < 0.01$) amounts in sieve 19 mm but greater ($P \leq 0.04$) amounts in sieves 8 and 1.18 mm as well as in the bottom, compared to unchopped hay (Table 2).

3.2. Dry matter intake and digestibility

Ewes eating chopped hay had lower ($P \leq 0.01$) dry matter intake and greater ($P = 0.02$) crude protein digestibility, compared to ewes eating unchopped hay (Table 3). No effects of treatment were detected ($P \geq 0.38$) for DM, NDF, or ADF digestibility (Table 3).

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Table 2. Feed particle distribution and leftover according to particle separator screens.

Sieve	Treatments[1]		SEM	*P* – value[2]
	Unchopped hay	Chopped hay		
Offered				
19 mm	30.4[a]	12.0[b]	2.54	0.02
8 mm	4.84[b]	8.98[a]	0.58	<0.01
1.18 mm	30.8[b]	46.5[a]	1.77	<0.01
Bottom	34.0	32.5	1.70	0.70
Leftover				
19 mm	47.8[a]	11.7[b]	2.89	<0.01
8 mm	3.01[b]	7.69[a]	0.39	<0.01
1.18 mm	24.5[b]	39.8[a]	1.42	0.04
Bottom	20.9[b]	40.9[a]	1.98	0.03

[1]The treatments were unchopped and chopped hay of Tifton 85 for 12 days of study;
[2]$P \leq 0.05$ differs.
[a-b] Within a row, means without a common superscript differ ($P \leq 0.05$).
Source: Authors.

3.3. Milk production and composition

Ewes eating chopped hay had greater (P ≤ 0.01) milk production (d 7 and d 12), lactation persistence, and feed efficiency than did ewes eating unchopped hay (Table 4). Ewes eating chopped hay had greater (P = 0.03) milk concentrations of protein than did ewes eating unchopped hay (Table 4). However, no effects of treatment × day or treatments were detected (P ≥ 0.16) for milk concentrations of fat, lactose, minerals, deffated dry extract, or density (Table 4)

Table 3. Dry matter intake, and coefficients of apparent digestibility of sheep fed with unchopped and chopped hay (*Cynodon*).

Variables[1]	**Treatments**[2]		**SEM**	***P – value***[3]
	Unchopped hay	**Chopped hay**		
Dry matter intake (kg/day)	2.20[a]	2.06[b]	0.03	0.01
Coefficients of apparent digestibility, %				
Dry matter	61.61	62.89	1.00	0.38
Crude protein	57.88[b]	63.91[a]	1.60	0.02
NDF	56.48	56.51	1.71	0.98
ADF	13.24	15.27	1.71	0.42

[1]Neutral detergent fiber (NDF) and acid detergent fiber (ADF).
[2]The treatments were unchopped and chopped hay of Tifton 85 for 12 days of study.
[3]$P \leq 0.05$ differs. Note: [a-b] Within a row, means without a common superscript differ ($P \leq 0.05$).
Source: Authors.

3.4. Biochemical parameters

Ewes eating chopped hay had lower (P < 0.01) serum concentrations of urea and tended to have lower (P = 0.10) serum concentrations of glucose only on d 12, compared to ewes eating unchopped hay (Table 5). However, no effects of treatment × day or treatments were detected (P ≥ 0.16) for serum concentrations of total protein, albumin, globulin, triglycerides, or cholesterol (Table 5).

4. Discussion

Sheep, in general, seek feeds with higher energy concentrations and reject fibrous feeds. This is especially so for sheep with the highest energy demands, such as lactating sheep (Helander et al., 2014). In the present study, sheep selected the fraction of the feed with small particles, and avoided the remaining large particles. When the hay was chopped, the selection capacity was reduced, considerably reducing the proportion of leftover feed particles retained in the 19-mm sieve, and increasing in the lower and (notably) in the bottom. The particles trapped in the first sieve consisted essentially of hay and large silage particles. In addition, chopped hay reduces waste, that is, less hay on the floor of the pen (Figure 1).

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Table 4. Milk production and composition of ewe fed with unchopped and chopped hay (*Cynodon*).

Items	Treatments[1] Unchopped hay	Chopped hay	SEM	*P* – value[2] Treat	Treat × day
Production (L)				<0.01	<0.01
d 1	1.16	1.18	0.02		
d 7	1.11[b]	1.23[a]	0.02		
d 12	1.02[b]	1.30[a]	0.02		
Lactation persistence (%)					
d 1 to 7	81.41[b]	117.89[a]	2.05	<0.01	-
d 1 to 12	47.97[b]	143.62[a]	1.03	<0.01	-
Feed efficiency (%)					
d 7	80.20[b]	83.22[a]	0.38	<0.01	-
d 12	73.62[b]	87.88[a]	0.45	<0.01	-
Fat (g/100 g)	6.59	6.37	0.14	0.35	0.33
Protein (g/100 g)	4.00[b]	4.10[a]	0.02	0.03	0.48
Lactose (g/100 g)	5.98	5.99	0.06	0.87	0.94
Minerals (g/100 g)	0.61	0.60	0.01	0.16	0.28
Defatted dry extract (g/100 g)	11.00	11.03	0.10	0.91	0.92
Density	1.03	1.03	0.01	0.48	0.80

[1]The treatments were unchopped and chopped hay of Tifton 85 for 12 days of study;
[2]$P \leq 0.05$ differs. Note: [a-b] Within a row, means without a common superscript differ ($P \leq 0.05$).
Source: Authors.

It is assumed that the main regulating factors of feed consumption were not physical but rather chemical mechanisms. According to the literature, NDF intake (Allen, 2000) and feed particle size (Helander et al., 2014) may interfere with dry matter intake, as verified in the present study. Researchers found that sheep receiving 700 g of non-fibrous carbohydrate-rich concentrate had greater ruminal propionate production as an indicator of satiety (Roche et al., 2008). Cannas et al. (2013) observed limitation of consumption of lactating sheep by chemical mechanisms, with the inclusion of 1000 g of a concentrate with lower concentrations of non-fiber carbohydrates (NFC) than the one used in the present study. Relevant effects of treatments on rumen pH are unlikely, because it is expected that, with lower consumption of NDF, there would be a reduction in rumen pH, resulting in lower NDF digestibility (Dijkstra et al., 2012) and decreased milk fat content (Pulina et al. 2016). Nevertheless, these effects were not significantly observed in the present study. The magnitude of changes in consumption were insufficient to alter these parameters. On the other hand, protein digestibility is not substantially related to ruminal pH, but rather to intrinsic degradability of feed and passage rate (Sauvant and Nozière, 2016). This phenomenon may have stimulated biochemical pathways with consequent direct or indirect effects on milk production. According to the literature, with chopped hay, there is an increase in NDF consumption, which has an inverse relationship with the passage rate (Mertens and Ely, 1979). As a result, we believe that the feed retained for longer periods in the rumen increased the apparent protein digestibility. Probably the increase in protein digestibility is related to higher milk production and increased protein concentrations in milk.

Table 5. Serum biochemistry of sheep fed with unchopped and chopped hay (*Cynodon*).

Items	**Treatments[1]**		**SEM**	***P* – value[2]**	
	Unchopped hay	**Chopped hay**		**Treat**	**Treat × day**
Total protein (g/dL)	8.78	8.60	0.43	0.77	0.33
Albumin (g/dL)	2.62	2.73	0.10	0.48	0.39
Globulin (g/dL)	6.22	5.80	0.43	0.52	0.46
Glucose (mg/dL)	113.30[x]	97.70[y]	6.36	0.10	0.29
Triglycerides (mg/dL)	50.94	50.47	3.83	0.93	0.16
Cholesterol (mg/dL)	57.59	55.41	2.80	0.59	0.88
Urea (mg/dL)				0.05	<0.01
d 1	36.19	37.70	3.07		
d 7	50.97	51.59	3.07		
d 12	90.08[a]	71.25[b]	3.07		

[1]The treatments were unchopped and chopped hay of Tifton 85 for 12 days of study;
[2]$P \leq 0.05$ differs and $P \leq 0.10$ tends to differ.
[a-b] Within a row, means without a common superscript differ ($P \leq 0.05$).
[x-y] Within a row, means without a common superscript tended to differ ($0.05 > P \leq 0.10$).
Source: Authors.

Figure 1. Chopped hay favored consumption and decreased wastage (Fig. 1A), different from what occurred when unchopped hay was offered (Fig. 1B). The illustrations correspond to the 7th day of the experiment (end of the adaptation period), with small amount of chopped hay (Fig. A) and large amount of whole hay on the pen floor (Fig. B). It is important to note that the accumulated hay in image B corresponds to the sum of the period of adaptation (Days 1 to 7).

Fonte: Autores.

Milk yield, persistence of lactation, and feed efficiency were greater for ewes that consumed chopped hay. We believe that this positive effect on milk production is related to the greater feed efficiency in these ewes. Nevertheless, we cannot rule out that the increase in dairy production was related to the greater protein digestibility rates, because protein would increase the nitrogen available for microbial protein synthesis (Sauvant and Nozière, 2016) and, consequently, the amount of amino acids available for milk synthesis (Ahmed et al., 2016). According to researchers, higher NFC consumption of whole hay-fed ewes raises serum insulin concentrations (Cannas et al., 2013) and, as in sheep, mammary gland tissue is poorly insulin-sensitive; glucose levels resulting from gluconeogenesis may increase. Glucose may have been used by skeletal muscle (Davis and Colier, 1985), another explanation for the better sheep milk production that we observed. Other studies have shown an inverse relationship between dietary NFC concentration and milk yield in sheep (Cannas et al., 2013;

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Bovera et al., 2004; Zenou and Miron, 2005). Lower glucose and urea levels in ewes eating chopped hay may indicate that the nutritional requirements were met by the feed; this differs from what would be the case with sheep that consumed unchopped hay, because higher levels of urea would indicate increased protein catabolism, an alternative used by the animal to meet the demands needed to produce milk and carry out physiological functions. We believe that the absence of changes in most of the metabolic variables is directly related to hay being part of only 11% of the diet (dry matter) consumed by sheep.

5. Final Considerations

Chopped hay in sheep feed reduces their ability to select feed and increases consumption. Chopped hay promotes lower dry matter intake and increases serum concentrations of glucose and urea, while improving milk production, lactation persistence, feed efficiency, and concentrations of milk protein.

Acknowledgements

This study enjoyed the technical cooperation of Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES). We also thank the “Fundo de Apoio à Manutenção e ao Desenvolvimento da Educação Superior – FUMDES (UNIEDU)”, for granting scholarship for this study. We also thank Cabanha Chapecó for making the animals available.

Conflict of Interest

The authors declare that they have no conflict of interest.

Financial Support and Acknowledgments

We thank CAPES, CNPq and FAPESC for their technical and financial support.

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