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Does the cutting time of Tifton 85 grass change the nutritional composition of the hay produced?

Horário de corte do capim Tifton 85 altera a composição nutricional do feno produzido?

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This study aimed to evaluate the chemical-bromatological composition of fresh grass and hay from Tifton 85 cut at different times of the day, as well as the potential losses from haymaking. The experimental design was a randomized block, assessing three cutting times: 11:00 AM, 2:00 PM, and 5:00 PM. We determined the contents of dry matter, neutral detergent fiber, acid detergent fiber, crude protein, protein insoluble in neutral detergent, acid detergent lignin, and *in vitro* digestibility of the collected samples. We also estimated values for cellulose, hemicellulose, non-fibrous carbohydrates, total carbohydrates, and total digestible nutrients of both fresh forage and hay. Losses of each nutritional component due to haymaking were calculated from the fresh and dried material after 72 h. Cutting time influenced the nutritional composition of Tifton 85 grass; grass cut at 2:00 pm exhibited a superior nutritional profile with higher *in vitro* digestibility of dry matter (73.22%), total digestible nutrients (69.15%), non-fiber carbohydrates (20.37%), and lower levels of neutral detergent fiber (67.75%) and cellulose (31.92%). Differences in haymaking losses were observed only for non-fiber carbohydrates at 2:00 pm, with a loss of 60.41%. The cutting time of Tifton 85 alters the quality of fresh forage but does not significantly affect the composition of hays produced from grass cut at various times of the day.
Key words: cell wall, digestibility, nutritive value.

O objetivo foi avaliar a composição químico-bromatológica do capim fresco e do feno de Tifton 85 cortado em diferentes horários do dia, e as possíveis perdas oriundas do processo de fenação. O delineamento experimental utilizado foi em blocos casualizados, com avaliação dos horários de corte 11, 14 e 17 horas. Foram determinados os teores de matéria seca, fibra em detergente neutro e ácido, proteína bruta, proteína insolúvel em detergente neutro, lignina em detergente ácido e digestibilidade *in vitro* da matéria seca das amostras coletadas, e estimados os valores de celulose, hemicelulose, carboidratos não fibrosos e totais, e nutrientes digestíveis totais do capim fresco e do feno. As possíveis perdas de cada componente nutritivo decorrentes do processo de fenação foram calculadas a partir do material fresco e seco após 72 horas. O horário de corte afetou a composição nutricional do capim Tifton 85, sendo que o capim cortado às 14 horas apresentou melhor composição nutricional com maiores teores de digestibilidade *in vitro* da matéria seca (73,22%), nutrientes digestíveis totais (69,15%), carboidratos não fibrosos (20,37%), e menores teores de fibra em detergente neutro (67,75%) e de celulose (31,92%). Houve diferença entre as perdas do processo de fenação apenas para carboidratos não fibrosos no horário das 14 horas, com 60,41%. O horário de corte do capim Tifton 85 altera a qualidade da forragem fresca, sem impactar de maneira expressiva na composição dos fenos produzidos a partir do capim cortado em diferentes horários do dia.
Palavras-chave: parede celular, digestibilidade, valor nutritivo.

1. INTRODUCTION

Tifton 85 grass (*Cynodon* spp.) results from a cross between Bermuda grass (*Cynodon dactylon*) and star grass (*Cynodon nlemfuensis*). It is characterized by high economic and zootechnical potential due to its digestibility, palatability, and high crude protein concentration [1]. These characteristics enable the use of Tifton 85 for grazing or hay production, potentially reducing the need for protein supplementation in animals [2, 3].

As an alternative to forage conservation, haymaking is a technique that aims to maintain the nutritional quality of plants. Tifton 85 hay, known for its digestibility, palatability, and high crude protein concentration, also has significant commercial value, often fetching higher prices in regions with scarce forage availability for animal feed [1].

Hay quality may be influenced by cutting and dehydration. Forage cutting for haying should be performed in the morning, just after the dew has evaporated, to allow for an extended period of sunlight during the initial dehydration phase [4]. However, the concentration of non-structural carbohydrates may vary in response to fluctuations in light intensity, temperature, relative humidity, and the intensity of atmospheric CO2 gas fixation, leading to increased cellular content accumulation [5-8]. This accumulation, particularly in C4 cycle plants, results from CO_2 fixation and assimilation exceeding the plant's requirements [9]. Consequently, fiber concentrations may decrease, which positively affects dry matter digestibility [7, 10]. Thus, we postulate the hypothesis that cutting conditions, sunlight exposure, and environmental factors directly influence the chemical composition and digestibility of hay. Within this framework, we presume that the timing of grass cutting for hay production, being a management practice intrinsically connected to the aforementioned factors, significantly contributes to determining the composition of the final product.

Considering the significance of the timing of forage cutting and its subsequent dehydration, this study aimed to assess Tifton 85 grass harvested at various times of the day and to examine the impact on chemical composition variables, total digestible nutrients, total carbohydrates, and fibrous components of both the fresh plant and the resulting hay. Additionally, the study evaluated potential losses incurred during the haying process.

2. MATERIAL AND METHODS

The experiment took place in a field on private property located in Arapongas (23°25’12’’ S, 51°25’31’’ W, altitude 816 m), Paraná state. The site’s average annual temperature ranges from 20.0–21.0 °C, with a Köppen climate classification of Cfa. Average annual precipitation varies between 1600 and 1800 mm, with January and December being the wettest and July and August being the driest months [11]. The soil in the experimental region is classified as Latossolo Vermelho Distroférrico + Latossolo Bruno Distrófico (Dystrofferic Red Oxisol + Dystrofic Brown Oxisol) according to the Brazilian Soil Classification System [12].

The experiment commenced on March 10, 2017, with the standardization of the experimental area, which was already planted with Tifton 85 grass. On that day, we also performed the initial top-dressing fertilization, applying 80 kg ha^{-1} of ammonium sulfate. The second fertilization followed on April 20, with the application of 25 kg ha^{-1} of urea. We conducted the cut for haying at the onset of winter, on June 23, 2017, and collected the resulting hay on June 26, 2017. The dry matter content of the material was assessed both during grass harvesting and hay collection.

The environmental conditions during the period from grass cutting to hay collection are described in Table 1. There was no rainfall in the area on these days.

Table 1. Climatic data for the haymaking period in June 2017.

Date	**Air temperature (°C)**		**Air relative humidity (%)**		**Tº dew point (°C)**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
June 23	23.7	14.2	93.7	59.8	16.1	13.0
June 24	23.8	14.8	89.0	61.3	16.4	12.7
June 25	23.9	14.3	89.7	58.0	16.0	12.3
June 26	23.5	12.4	90.1	59.6	15.3	10.6

* Data from the Datalloger TGD 400 device installed on the property.

The experimental design used was in randomized block, accounting for the terrain's contours due to slope variation. It evaluated three grass cutting times: 11 AM, 2 PM, and 5 PM, with each experiment being replicated seven times.

A total of 21 beds, each encompassing an area of 4 m^2, were demarcated and labeled according to their respective cutting times. Cutting times were scheduled such that the first (11:00 AM) coincided with the late morning, immediately after the dew had evaporated; the second (2:00 PM) was set at an intermediate point between the other two; and the third (5:00 PM) was timed to precede nightfall. Haymaking involved cutting grass at 105 days of regrowth, using a backpack cutter to achieve a uniform residual height of 5 cm above the ground, thereby ensuring greater consistency and utilization of the harvested material. The grass reached an average height of 40 cm at the time of cutting.

Grass sampling occurred at the time of cutting; the material cut from the entire bed was weighed, and approximately 700 g of grass was collected into paper bags. These bags were duly labeled according to the cutting time for subsequent analysis.

After the grass was cut, the material in each bed was manually turned over daily to increase the surface area exposed to sunlight, enhancing the drying process. This turning occurred at 2 pm throughout the experiment. By the end of the third day, the cut grass reached the dry matter (DM) content typical for hay (85–90%). This assessment was conducted visually and manually. We observed characteristics such as the material's color, expecting a light green hue, and performed the torsion test. In this test, a bundle of forage was twisted to check for moisture and observed for its ability to slowly revert to its original position without breaking the material [13].

Hay was collected from the beds on June 26, 2017, at 1:20 PM (grass cut at 11:00 AM) and at 5:00 PM (grass cut at 2:00 PM and again at 5:00 PM). After weighing the hay from each bed, approximately 700 g samples were gathered and placed in paper bags labeled according to the grass cutting times for subsequent analysis. A portion of the sampled material was sent to the Bromatology Laboratory at Universidade Pitágoras UNOPAR Anhanguera – Arapongas campus for analysis. Another portion was dispatched to the Animal Nutrition Laboratory at the State University of Londrina to determine the fibrous fractions and the *in vitro* dry matter digestibility (IVDMD). All samples were ground in a Willey-type mill on a 1 mm sieve to determine dry matter (DM), mineral matter (MM) in muffle at 600 °C, crude protein (CP) using the Kjedhal method, and neutral detergent insoluble protein (NDICP), according to the methods described by Detmann et al. (2012) [14].

The sequential determination of neutral detergent fiber (NDF) and acid detergent fiber (ADF) was performed in an autoclave, followed by acid detergent lignin (ADL) by the acid hydrolysis method [14] utilizing 100 g/m² non-woven fabric bags. Sodium sulfite was employed in the NDF analysis. Hemicellulose (HEM) was estimated by subtracting ADF from NDF, and cellulose (CEL) was calculated by subtracting lignin content from ADF [15].

The determination of IVDMD for grass and hay, harvested at various cutting times, was conducted using the technique developed by Tilley and Terry (1963) [16] and described by Mizubuti et al. (2009) [17]. We placed the samples in 40 g/m² non-woven fabric bags and incubated them with ruminal inoculum at 39 ºC for 48 h in an artificial incubator (TE-421), with agitation at 80 rpm. The rumen fluid used as inoculum was sourced from a slaughterhouse, from cattle raised on pasture and then slaughtered.

The content of total carbohydrates (TC) and non-fiber carbohydrates (NFC) was estimated using equations proposed by Sniffen et al. (1992) [18]. The equations are as follows: $TC = 100 – (\%PB + \%EE + \%MM)$ and $NFC = 100 – (\%PB + \%EE + \%pNDF + \%MM)$, where EE represents ether extract and pNDF denotes NDF corrected for protein and ash. Total digestible nutrient (TDN) content was calculated based on the equation from Cappelle et al. (2001) [19], which is $TDN = 10.43 + (0.8019 \times DMD)$, with DMD representing dry matter digestibility.

To assess the percentage loss of a particular nutrient, the comparison involves quantifying the nutrient (by weight) at the moment of grass cutting (while it is still in a green state) and determining the quantity remaining following the completion of the haymaking process. The potential percentage losses of each nutritional component during the haying process were calculated using an adapted version of the equation described by Jobim et al. (2007) [20].

$$Losses\ (\%) = [(Ni - Nf)] * 100$$

Ni represents the product of the amount (weight) of nutrient at the time of cutting and the nutrient content in the forage at cutting, and Nf represents the product of the amount (weight) of nutrient after dehydration and the nutrient content at the end of dehydration. The nutrient cited content were obtained by the bromatological analysis.

The nutritional component data, NFC, TC, and TDN estimates, and loss values were subjected to analysis of variance using R software, version 3.5.1 [21]. Mean comparisons were conducted using the Tukey test at a 5% significance level.

3. RESULTS AND DISCUSSION

The time of day at which Tifton 85 grass was cut affected the IVDMD and NDF content, as well as the estimated values of CEL, TDN, and NFC (P < 0.05) (Table 2).

Table 2. Means and standard deviation of the chemical composition (% in dry matter) of Tifton 85 grass at different times of the day.

Variables (%)	**Grass cutting time**			**p-value**
	11 am	**2 pm**	**5 pm**	
DM	35.12±1.11	36.19±3.05	35.18±2.21	0.5074
MM	8.04±0.73	8.02±0.56	8.19±0.96	0.6774
IVDMD	69.95±2.46ab	73.22±4.77a	67.85±3.12b	0.0440
CP	9.40±0.63	9.28±0.96	9.50±1.46	0.9056
NDF	70.17±1.17a	67.75±2.05b	68.80±1.13ab	0.0367
ADF	38.52±1.71	37.05±3.02	37.38±2.32	0.4317
ADL	4.04±0.99	5.12±1.19	3.93±0.88	0.1065
HEM	31.64±2.62	30.70±2.07	31.41±2.94	0.7564
CEL	34.47±1.43a	31.92±2.34b	33.44±1.81ab	0.0339
TDN	66.29±1.98ab	69.15±3.83a	64.84±2.50b	0.0441
TC	80.85±0.70	81.42±1.00	80.91±0.88	0.4602
NFC	17.59±1.97b	20.37±0.65a	18.19±1.02b	0.0030

*Values followed by different letters, on the line, differ according to Tukey's test at 5%. DM: dry matter; MM: mineral matter; IVDMD: *in vitro* digestibility of dry matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; HEM: hemicellulose; CEL: cellulose; TDN: total digestible nutrients; TC: total carbohydrates; NFC: non-fiber carbohydrates.

The potential for increased insolation and elevated temperatures between 11 AM and 2 PM may have resulted in the collected grass having reduced water content. Diurnal fluctuations in forage moisture can arise from climatic and physiological factors, including the interplay between soil water uptake, transpiration, and translocation, variations in dew, and the plant's water needs for synthesizing or releasing photosynthetic products [7, 8].

The IVDMD was the highest in the grass at 2 PM (73.22%), whereas at 5 PM, the grass exhibited the lowest value for this variable (67.85%). At 11:00 AM, the grass's IVDMD was intermediate (69.65%) compared to the other evaluation times. The diurnal variation in grass IVDMD was likely due to increased accumulation of soluble carbohydrates in the afternoon, leading to a decrease in NDF content and, consequently, an enhancement in the quality relative to the cellular content of Tifton 85 grass. This pattern of carbohydrate accumulation was significant for the quality of tropical grasses, as evidenced by the superior digestibility observed in Marandu grass during the afternoon (71.8%) versus the morning (70.9%), regardless of canopy height or plant morphological fraction [7].

Regarding the fibrous fraction of the grass, a reduction was observed throughout the day. The NDF content in the plant was the lowest at 2 PM (67.75%), with the highest value observed at 11 AM (70.17%). The NDF content at 5 PM was intermediate (68.80%) compared to the other two evaluation times. The decrease in NDF concentration at 2 PM, the hottest time of the day, can be attributed to a dilution effect caused by an increased accumulation of non-fiber carbohydrates in the forage, resulting from the plant's higher photosynthetic rate.

The estimated cellulose content of Tifton 85 grass at 2 PM (31.92%) was lower compared to the values at other times, with the highest content observed at 11 AM (34.47%). By 5 PM, the cellulose estimate was intermediate relative to the earlier measurements. The NDF fraction comprises cellulose, hemicellulose, and lignin, with cellulose proportions ranging from 20–40% [22]. The observed fluctuations in grass cellulose content appeared to follow the dilution/accumulation pattern of NDF content, an effect likely explained by the diurnal dynamics of cellular content accumulation.

The estimated TDN content for the grass at 2 PM was 69.15%, exceeding the value recorded at 5 PM (64.84%). At 11 AM, the TDN content was intermediate, at 66.29%. The TDN estimate for Tifton 85 grass was derived from IVDMD values, allowing for the correlation of the satisfactory energy values with the plant's favorable digestibility.

When estimating the NFC content, Tifton 85 grass exhibited a value of 20.37% at 2 PM, which was higher than the averages recorded at 11 AM (17.59%) and 5 PM (18.19%). This suggests a greater accumulation of rapidly degrading carbohydrates, including starch, sugars, and pectin. Similarly, both tropical forages like Tifton 85 and temperate ones such as Timoteo grass (*Phleum pratense* L.), when harvested at 3 PM, demonstrate a pattern of increased NFC content due to an extended period of photosynthesis [5]. It is also noteworthy that the present study observed a reduced NFC content towards the late afternoon, coinciding with less favorable photosynthetic conditions and a potential increase in carbohydrate consumption through respiration, reflecting the balance between production and consumption in fresh forage.

The chemical composition of Tifton 85 grass varies throughout the day, likely due to diurnal fluctuations in the accumulation of photosynthetic products and water loss through transpiration. These processes result in an increased concentration of dry matter during daylight hours and may also cause the dilution of accumulated proteins and fibers as the day advances [23]. The other parameters assessed in relation to the grass, such as CP and ADF content, which serve as indicators of grass quality, did not vary throughout the day ($P > 0.05$), exhibiting average contents of 9.39% and 37.65%, respectively. 65%, respectively.

The time of day at which Tifton 85 grass was harvested for hay affected ($P < 0.05$) the DM and NFC contents of the preserved forage (Table 3). Hay prepared from Tifton 85 grass cut at 11 AM had a higher DM content (91.65%) compared to that cut at 2 PM (89.63%). Conversely, hay from grass cut at the end of the afternoon (17 h) had an intermediate DM content (90.91%).

Table 3. Means and standard deviation of the chemical composition (% in dry matter) of Tifton 85 grass hay cut at different times of the day.

Variables (%)	Grass cutting time			p-value
	11 am	2 pm	5 pm	
DM	91.65±1.41a	89.63±1.09b	90.91±1.61ab	0.0367
MM	7.90±0.71	8.11±0.57	8.06±0.77	0.6353
IVDMD	63.42±2.19	63.59±2.85	64.92±3.23	0.5485
CP	10.27±0.66	10.58±0.97	9.98±1.61	0.4924
NDF	72.95±2.60	74.29±3.07	71.38±0.92	0.0842
ADF	38.27±3.15	39.35±5.10	36.98±3.19	0.5555
NDICP	6.18±0.57	6.98±1.02	6.39±0.91	0.1837
ADL	4.15±1.02	4.52±1.06	4.02±1.24	0.7022
CEL	34.12±2.50	34.82±4.57	32.96±2.12	0.5912
HEM	34.67±4.05	34.94±3.96	34.40±3.18	0.9598
TDN	61.29±1.76	61.42±2.28	62.49±2.59	0.5470
TC	80.42±0.56	79.91±0.98	80.53±1.46	0.5509
NFC	13.65±2.18ab	12.60±2.36b	15.53±1.56a	0.0486

*Values followed by different letters, on the line, differ according to Tukey's test at 5%. DM: dry matter; MM: mineral matter; IVDMD: *in vitro* digestibility of dry matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; NDICP: neutral detergent insoluble protein; ADL: acid detergent lignin; HEM: hemicellulose; CEL: cellulose; TDN: total digestible nutrients; TC: total carbohydrates; NFC: non-fiber carbohydrates.

The DM content may vary with insolation and the duration of plant exposure to solar radiation, particularly immediately post-cutting. In view of this, the first phase of the dehydration process is accelerated, in which the stomata are still open [13], which may explain the lower moisture content in hay made from grass cut at 11 AM in the present study. Additionally, morphological and structural characteristics of Tifton 85 grass, including its high leaf-to-stem ratio [24, 25], further facilitate rapid dehydration.

It is essential to note that despite variations in DM content among produced hays, the moisture content stayed within the 10–20% range required to maintain hay quality [26]. These values are crucial for preserving the integrity of the stored feed, preventing DM losses and fungal growth [3].

The cutting times of Tifton 85 grass for haying influenced the NFC content of the hay and the losses of this component due to the dehydration process (Table 4). During the forage drying process, losses in content of nutrients may occur, where negative results indicate losses during the forage drying process, while positive values indicate a greater concentration of nutrients after this process.

Table 4. Percentage losses of nutritional components resulting from the haying process of Tifton 85 grass cut at different times of the day.

Variables (%)	Grass cutting time			p-value
	11 am	2 pm	5 pm	
DM	-5.26±5.32	-3.09±9.35	-1.69±15.38	0.84
MM	-3.47±5.98	-4.16±8.90	0.14±18.47	0.80
IVDMD	4.21±8.20	11.96±15.75	3.57±21.91	0.60
CP	-13.25±6.30	-14.89±10.43	-5.85±19.53	0.44
NDF	-8.75±6.54	-11.53±9.30	-5.07±16.03	0.59
ADF	-3.96±11.49	-7.79±13.64	-0.44±15.43	0.64
NDICP	6.86±15.91	-7.01±16.11	-5.83±21.45	0.34
ADL	-4.99±26.87	15.06±40.55	0.83±25.50	0.52
HEM	-12.73±11.27	-13.93±13.59	-9.31±20.04	0.83
CEL	-3.56±12.45	-10.09±13.82	-0.29±14.72	0.45
TDN	2.57±7.33	9.39±14.31	2.66±20.71	0.66
TC	-4.71±5.60	-1.26±9.53	-1.30±14.65	0.80
NFC	26.36±34.95ab	60.41±26.93a	15.36±16.23b	0.02*

*Values followed by different letters, on the line, differ according to Tukey's test at 5%. DM: dry matter; MM: mineral matter; IVDMD: *in vitro* digestibility of dry matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; NDICP: neutral detergent insoluble protein; ADL: acid detergent lignin; HEM: hemicellulose; CEL: cellulose; TDN: total digestible nutrients; TC: total carbohydrates; NFC: non-fiber carbohydrates.

The NFC content indicated that hay from grass cut at 5 PM had a greater accumulation (15.53%) compared to that cut at 2 PM (12.60%). Hay from grass cut at 11 AM exhibited an intermediate value (13.65%) relative to the other two evaluated times (Table 3).

The results presented in Table 4 suggest that NFC consumption occurs throughout the day, predominantly in forage harvested at 2 PM. This is attributed to dehydration and ongoing cellular respiration immediately following the cutting of the forage. The observed consumption is evidenced by a loss of cellular content carbohydrates, as indicated by the NFC, which was 60.41% in this study. The increased NFC content in hay resulting from forage cut at 5 PM could be attributed to a reduced loss (15.36%) of these compounds following sunset during the haymaking process.

It is crucial to link the DM results of hay produced at various grass cutting times with its cellular content, as indicated by the NFC content. This association suggests that shortening the first stage of dehydration could result in reduced losses of soluble carbohydrates due to respiration [27].

Considering the subtle variations discerned in the hay quality resulting from diverse grass cutting times, it can be inferred that this information bears practical significance in the decisionmaking process for rural producers. The study's findings suggest that the imperative of cutting grass in the morning immediately after dew drying is not obligatory. Instead, the determination of the most appropriate cutting time should consider the available infrastructure on the property, encompassing labor availability and optimizing logistics for the distribution of hay production.

Regarding the other variables of the biochemical composition of Tifton 85 grass hay, as well as in fresh grass, levels considered satisfactory for CP, IVDMD, and NDF in tropical forages were found, with averages of 10.28%, 63.98%, and 72.87%, respectively. The concentration of crude protein is a critical aspect when evaluating the nutritive value of forage plants. Concentrations below 7% negatively affect DM intake due to a deficiency of degradable protein in the rumen, which causes problems in bacterial growth and ruminal fermentation [22].

Dry matter digestibility, when approaching 65%, may indicate high nutritional value, as it suggests a suitable provision of digestible energy [22]. High-quality fresh forage, coupled with proper conservation processes, can yield hay with substantial nutritional value, as demonstrated in this study. Hays of superior quality, characterized by elevated crude protein levels and high digestibility, can serve as a means to partially reduce concentrated protein supplementation [3].

4. CONCLUSION

Variation in the quality of Tifton 85 grass occurs throughout the day, primarily concerning cellular content. While hay made from grass cut at 5 PM exhibited minor alterations in NFC content, the timing of grass cutting did not affect the hay’s chemical composition. Consequently, producers may base haymaking decisions on their logistics and production infrastructure, especially concerning the most advantageous time available for grass cutting.

5. REFERENCES

1. Araújo ED, Borges AC, Dias NM, Ribeiro DM. Effects of gibberellic acid on Tifton 85 bermudagrass (*Cynodon* spp.) in constructed wetland systems. PLoS ONE 2018 Oct;13(10):1-26. doi: 10.1371/journal.pone.0206378
2. Pasqualotto M, Neres MA, Guimarães VF, Klein J, Inagaki AM, Ducati C. Gas exchanges and dehydration in different intensities of conditioning in Tifton 85 bermudagrass: nutritional value during hay storage. Asian-Australas J Anim Sci. 2015 Jun;28(6):807-15. doi: 10.5713/ajas.14.0826
3. Sunahara SMM, Neres MA, Sarto JRW, Nath CD, Scheidt KC, Kuhn OJ. Nutritional value of Tifton 85 bermudagrass at two cutting heights and different times of storage. Semina: Ciênc Agrár. 2017 Jul;38(4):2129-40. doi: 10.5433/1679-0359.2017v38n4p2129
4. Jobim CC, Lombardi L, Gonçalves GD, Cecato U, Santos GT, Canto MW. Desidratação de cultivares de *Cynodon spp*. durante o processo de fenação. Acta Sci, Anim Sci. 2001, 23(4):795-9. doi: 10.4025/actascianimsci.v23i0.2612
5. Bertrand A, Tremblay GF, Pelletier S, Bélanger G. Yield, and nutritive value of Timothy as affected by temperature, photoperiod and time of harvest. Grass Forage Sci. 2008, Dec:63(4), 421-32. doi: 10.1111/j.1365-2494.2008.00649.x
6. Brito AF, Tremblay GF, Bertrand A, Castonguay Y, Bélanger G, Michaud R, et al. Performance and nitrogen use efficiency in mid-lactation dairy cows fid timothy cut in the afternoon or morning. J Dairy Sci. 2016, Jul;99(7):5445-60. doi: 10.3168/jds.2015-10597
7. de Oliveira FCL, Sanchez JMD, Vendramini JMB, Lima CG, Luz PHC, Rocha CO, et al. Diurnal vertical and seasonal changes in non-structural carbohydrates in Marandu palisade grass. J Agric Sci. 2018 Apr;156(3):457-64. doi: 10.1017/S0021859618000394
8. Taiz L, Zeiger E, Møller I, Murph A. Plant physiology and development. 6. ed. Sunderland (US): Sinauer Associates, Inc.; 2014.
9. Lechtenberg VL, Holt DA, Youngberg HW. Diurnal variation in nonstructural carbohydrates of sorghum sudanense (stapf) as influenced by environment. Agron J. 1973 Jul;65(4):579-83. doi: 10.2134/agronj1973.00021962006500040016x
10. Pelletier S, Tremblay GF, Bertrand A, Bélager G, Castonguay Y, Michaud R. Drying procedures affect nonstructural carbohydrates and other nutritive value attributes in forage samples. Anim Feed Sci Technol. 2010 May;157(3):139-50. doi: 10.1016/j.anifeedsci.2010.02.010
11. Nitsche PR, Caramori PH, Ricce WS, Pinto LFD. Atlas climático do Estado do Paraná. Londrina (PR): IAPAR; 2019.

12. Santos HG, Jacomine PKT, Anjos LHC, Oliveira VA, Lumbreras JF, Coelho MR, et al. Sistema brasileiro de classificação de solos. 3. ed. Brasília (DF): Embrapa; 2013.
13. Evangelista AR, Lima JA. Conservação de alimentos para bovinos. Inf Agropec. 2013;34(277):43-52.
14. Detmann E, Souza MA, Valadares Filho SC, Queiroz AC, Berchielli TT, Saliba EOS, et al. Métodos para análise de alimentos-INCT. Visconde do Rio Branco (MG): Suprema Gráfica; 2012.
15. Van Soest PJ. Use of detergents in the analysis of fibrous feeds. II. A rapid method for determination of fiber and lignin. J AOAC Int. 1963 Oct;46(5):829-35. doi: 10.1093/jaoac/46.5.829
16. Tilley JMA, Terry RA. A two-stage technique for *in vitro* digestion of forages crops. Grass Forage Sci. 1963 Jun;18(2):104-11. doi: 10.1111/j.1365-2494.1963.tb00335.x
17. Mizubuti IY, Pinto AP, Pereira ES, Ramos BMO. Métodos laboratoriais de avaliação de alimentos para animais. Londrina (PR): EDUEL; 2009.
18. Sniffen CJ, O'Connor JD, Van Soest PJ, Russel JB. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. J Anim Sci. 1992 Nov;70(11):3562-77. doi: 10.2527/1992.70113562x
19. Cappelle ER, Valadares Filho SC, Silva JFC, Cecon PR. Estimativas do valor energético a partir de características químicas e bromatológicas dos alimentos. R Bras Zootec. 2001 Dec;30(6):1837-53. doi: 10.1590/S1516-35982001000700022
20. Jobim CC, Nussio LG, Reis RA, Schmidt P. Avanços metodológicos na avaliação da qualidade da forragem conservada. Rev Bras de Zootec. 2007 Jul;36(suppl):101-19. doi: 10.1590/S1516-35982007001000013
21. R Core Team. R: A language and environment for statistical computing. Vienna (AT): R Foundation for Statistical Computing. Disponível em: https://www.R-project.org/
22. Van Soest PJ. Nutritional ecology of the ruminant. New York (US): Cornell University Press; 1994.
23. Gregorini P. Diurnal grazing pattern: its physiological basis and strategic management. Anim Prod Sci. 2012 Apr;52(7):416-30. doi: 10.1071/AN11250
24. Sanches AC, Gomes, EP, Rickli ME, Friske EE. Produtividade, composição botânica e valor nutricional do Tifton 85 nas diferentes estações do ano sob irrigação. Irriga. 2016 Feb;1(1):221-32.
25. Taffarel LE, Mesquita EE, Castagnara DD, Oliveira PSR, Oliveira NTE, Galbeiro S, et al. Produção de matéria seca e valor nutritivo do feno de Tifton 85 adubado com nitrogênio e colhido com 35 dias. Rev Bras Saúde Prod Anim. 2014 Sep;15(3):544-60.
26. Neres MA, Castagnara DD, Mesquita EE, Zambom MA, Souza LC, Oliveira PSR, et al. Production of alfalfa hay under different drying methods. Rev Bras de Zootec. 2010 Aug;39(8):1676-83. doi: 10.1590/S1516-35982010000800008
27. Morin C, Tremblay GF, Bélanger G, Bertrand A, Castonguay Y, Drapeau R, et al. Nonstructural carbohydrate concentration during field wilting of PM- and AM-cut alfalfa. Agron J. 2012 May;104(3):649-60. doi: 10.2134/agronj2011.0365