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Paiaguás grass hay harvested at different times of the day and at two moisture levels

Feno de capim Paiaguás ceifado em diferentes horários do dia com dois teores de umidade

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Abstract: The objective of this research work was to assess the effect that cutting time and moisture content at baling have on losses in production process and nutritional quality when it comes to the storage of Paiaguás grass hay. The assessed treatments were hay harvested at 10:00, 13:00 and 16:00, and baled at two moisture levels, 15% and 20%. The lowest dry matter losses were recorded when cutting happened at 10:00, and with baling at 15% moisture. Non-fibrous carbohydrate content increased for the cut made in the afternoon, and reduced during the storage period, with an influence for cutting time and baling moisture. There was an increase in fibrous fraction content in all assessed treatments with storage time, especially for the material that was baled at a 20% moisture. During storage, dry matter digestibility reduced mainly in hay stored at a 20% moisture, harvested at 10:00 and 13:00. The best time to cut forage for haymaking is in the afternoon, between 13:00 and 16:00.

Keywords: *Urochloa brizantha*; haymaking; storage time; nutritional value

Resumo: O objetivo do trabalho foi avaliar o efeito do horário de corte e do teor de umidade no enfardamento sobre as perdas no processo de produção e a qualidade nutricional na armazenagem do feno do capim Paiaguás. Os tratamentos avaliados foram, feno ceifado nos horários 10; 13 e 16 h e enfardado em dois teores de umidade, 15 e 20%. As menores perdas de matéria seca foram obtidas no corte às 10 horas e enfardamento com 15% de umidade. Os teores de carboidratos não fibrosos aumentaram para o corte realizado no período da tarde e reduziram durante o período de armazenamento, com influência para horário de corte e umidade de enfardamento. Houve aumento no teor da fração fibrosa em todos os tratamentos avaliados com o tempo de armazenamento, principalmente para o material que foi enfardamento com 20% de umidade. Durante a armazenagem a digestibilidade da matéria seca reduziu principalmente nos fenos armazenados com 20% de umidade ceifados às 10 e 13 h. O melhor horário de corte da forragem para fenação é no período da tarde entre 13 e 16 h.

Palavras-chave: *Urochloa brizantha*; fenação; tempo de armazenamento; valor nutricional

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1. Introduction

The *Urochloa* genus is among the most prominent forage crops in Brazilian livestock farming, taking up around 85% of the cultivated pasture area [1]. In Brazilian conditions, high forage production occurs in the rainy season, and low production, in the dry season [2]. Consequently, the forage available in the dry season, in addition to being scarce, does not contain an adequate proportion of nutrients to meet the demands of grazing animals [3]. The use of conserved forage is a viable alternative to maintain food supply in times of scarcity, which causes the need to develop suitable technologies for its production and for the preservation of its nutritional value in harmony with the environment.

The basic principle of haymaking is the rapid dehydration of green material, reducing its water content to around 15% to 20%, interrupting the plant's respiratory activity, reducing microbial activity [3], thus preserving its nutritional value. Hay quality is not only determined by the characteristics of the plant, but is also associated with the cutting height of the forage, dehydration time, climatic conditions during haymaking, and storage care [4]. Therefore, plant characteristics, as well as the technology employed in hay production, influence the chemical composition, digestibility of the forage, and, consequently, animal performance [4, 5].

Regarding cutting time, Dantas & Negrão (6) state that forage should be cut in the morning, after dew evaporation, to accelerate the dehydration process, without, however, observing the aspect of the cutting time that should allow the greatest dry matter accumulation. Studies carried out by De Oliveira et al. [7, 8], Pelletier et al. [9], Morin et al. [10] found that the accumulation of nutrients, especially non-structural carbohydrates, peaks in the afternoon. Ribeiro et al. [11] found a greater accumulation of soluble carbohydrates in the plant when cutting happened in the afternoon, but did not identify an effect on dehydration rate with different cutting times.

During storage, dry matter (DM) losses are mostly associated with a high moisture content in baling, as this boosts the development and activity of microorganisms (fungi and bacteria). Moisture content at baling should be in the range of 10% to 20% [12, 13]. Baling material with a moisture content above these results in large losses of dry matter due to microbial activity, with highlight to fungi, which release toxins and spores that put animal and human health at risk [6]. In this context, studies that associate cutting time (period of greatest nutrient accumulation), moisture content at baling, and losses in hay quality during production and storage are relevant.

Thus, this research work aimed to assess the effect that cutting time and moisture content at baling have on losses in the production and storage process, and on the quality of Paiaguás grass hay (*Urochloa brizantha* cv. BRS Paiaguás).

2. Material and Methods

The experiment was conducted at the Iguatemi Experimental Farm of the State University of Maringá, located in the district of Iguatemi, Paraná, at a longitude of 23º 25' S; 51º 57' W, and a 550-meter altitude. The climate in the region is of the Cfa type – mesothermal humid subtropical, Köppen classification (Iapar, 1994), with an average annual temperature of 22°C, and average annual precipitation of 1,200 mm. Rain has a seasonal distribution, and there are well-defined dry and rainy seasons. The soil is categorized as dystrophic Red Oxisol [14,15].

The experimental period went from February 15th to August 17th, 2017. Paiaguás grass (*Urochloa brizantha* cv. BRS Paiaguás) was established in an area of 1.0 ha, in corrected and fertilized soil, in accordance with the results of a soil analysis (Table 1) conducted by the Maringá Rural Laboratory [*Laboratório Rural de Maringá*] – LRM.

Table 1 Analysis of soils from the experimental area.

pH		A^+	Al^{3+}	H^++Al^{3+}	Ca^{2+}	Mg^{2+}	K^+	Ca^++Mg^+	SB	CTC	V	P	C	MO
CaCl	H2O					Cmol.dm $^{-3}$					%	mg.dm $^{-3}$	g.dm $^{-3}$	
5.60	6.30	3.30	0	3.30	4.41	2.00	0.25	6.41	6.60	9.96	66.9	7.29	8.82	15.2

Source: Maringá Rural Laboratory.

Soil preparation was conventionally performed (disc plow and leveling harrow). Paiaguás grass was established by broadcasting, with a seeding rate of 15 kg ha^{-1}. After establishment, nitrogen fertilizer was applied (60 kg N ha^{-1}), using urea as the source. Visits were made weekly to monitor the development of the crop, and observations regarding invasive plants, pests and diseases were made.

After the standardization cut, at 10 cm from the ground level (February 15, 2017), nitrogen fertilizer was applied (60 kg N ha^{-1}, using urea as the source). Pasture height was monitored by measuring 30 points at random, using a 100 cm ruler, in order to monitor growth.

The Paiaguás grass was cut by means of a simple disc mower coupled to the tractor, 10 cm from the ground level, at a stage of development that enabled a balance between quality and quantity of available forage mass (beginning of flowering). Measurements carried out with an Acupar LP-80 photometer canopy analyzer indicated that the canopy had a light interception (LI) of 95% [16], and the appropriate cutting height was determined to be between 35 and 45 cm for haymaking. This is consistent with other studies, such as that by Gobbi et al. [17], in which Paiaguás grass reached a height of 34 cm.

The assessed treatments corresponded to three cutting times: 10:00, 13:00, and 16:00; at each cutting time, the hay was subjected to drying in the sun and subsequently baled at two moisture levels, 15% and 20%, with ten replications (bales) for each treatment. After the forage dried, it was baled with the aid of a Nogueira-brand baler, model AP 41-N, for rectangular bales weighing around 10 kg.

The experimental design adopted for all variables was completely randomized, in a split-plot system. The experimental area was divided into three main plots of 3,000 m^2, corresponding to cutting times, and two sub-plots of 1,500 m^2 that corresponded to moisture contents during baling.

To estimate forage mass production, six samples were collected per plot on the day of cutting, using a 0.25 m^2 square, with the grass being cut 10 cm from the ground. The materials were weighed on a precision scale for green mass production to be measured, and were subsequently homogenized; a sample of approximately 500 g of green material was collected to estimate dry mass percentage and the chemical-bromatological characteristics at the time of cutting.

To assess the dehydration rate in the field until the forage reached baling moisture in the respective treatments, three methodologies were employed. The first methodology was applied with sample collections at three-hour intervals (daytime), randomly in the windrows (8 samples). The samples were sent to the laboratory for dry mass determination through the microwave methodology. In the second methodology, samples were collected simultaneously with the previous process and dried in a forced ventilation oven at 55 ºC, in accordance with the AOAC [(18)]. Moisture was also measured directly in the windrow during the dehydration period, using a hay moisture meter (DELMHORST - Hay moisture tester F-2000). The measurements were carried out at the same time as samples were collected for oven drying.

Field loss assessment

After baling, 5 points were demarcated on the plot using 1 m^2 squares, where leaf and stalk residues were collected, as they were cut by the mower but not collected by the baler. With these data, the physical losses of material in the haymaking process were estimated. Forage harvesting efficiency (FHE) was also estimated through the equation:

FHE = (BFM / AFM) x 100, where:

BFM = baled-forage mass (kg ha^{-1}) and AFM = available forage mass at the time of cutting (kg ha^{-1}). Losses were estimated based on FHE values, DM ha^{-1} losses during the hay production process based on this formula: Losses (%) = (1 – FHE) x 100.

Immediately after baling, the bales of each treatment were stored in a dedicated warehouse (phenyl). The temperature inside the bales was measured using a digital thermometer (model GULTERM 1001). Then, temperature was measured at other times (1, 2, 4, 6, 12, 24, 48, 72 and 96 hours after baling). The moisture inside the bales was assessed simultaneously with the temperature assessments, with the aid of the DELMHORST device (Hay moisture tester F-2000). Relative humidity and room temperature were monitored by the UEM's meteorological station, located 50 m from the storage shed, and are shown in Figures 1 and 2.

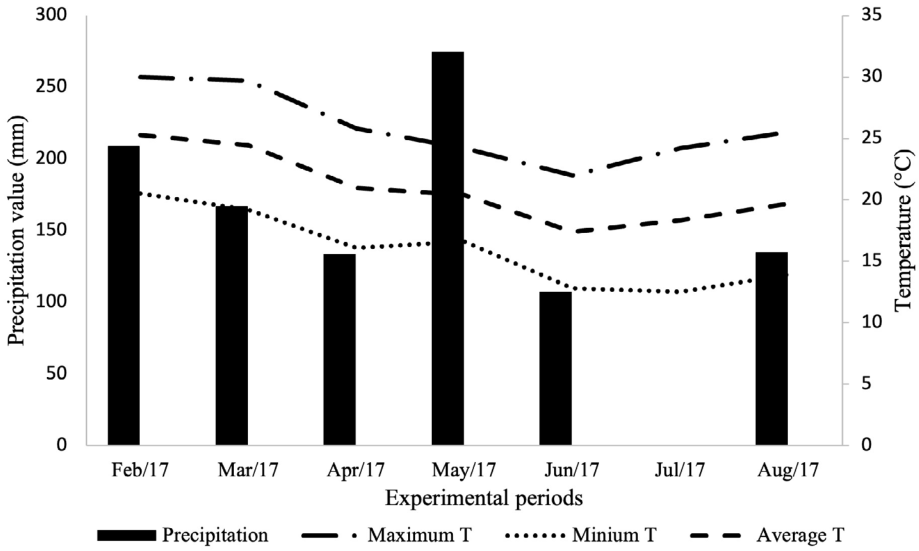

Figure 1 Average precipitation (mm), and maximum, minimum and average temperatures (°C). Source: Meteorological Station of the Iguatemi Experimental Farm, Iguatemi, PR.

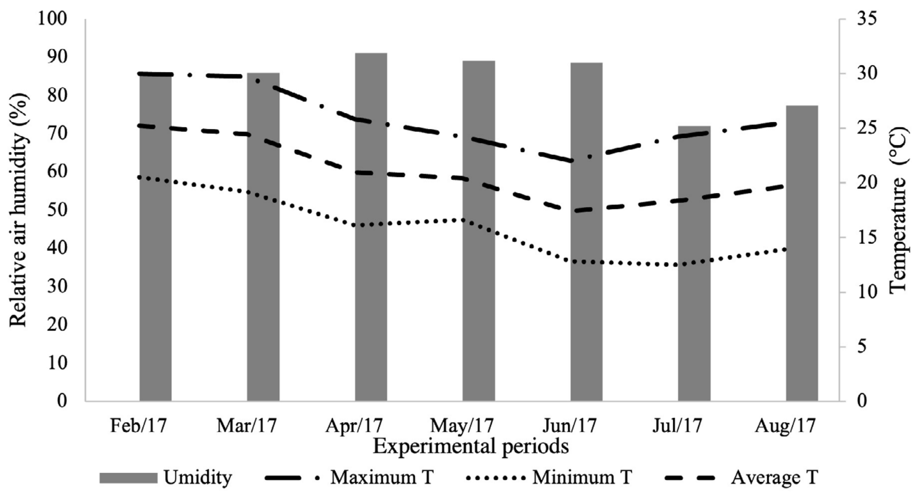

Figure 2 Relative air humidity (%), and maximum, minimum and average temperatures (°C) Source: Meteorological Station of the Iguatemi Experimental Farm, Iguatemi, PR.

Storage loss assessment

The loss of quality of the material during dehydration until baling and during storage was estimated taking as a reference the chemical-bromatological composition of the grass at the time of cutting and at the other assessment times. The samples used to estimate quality losses were the same as those collected to estimate the dehydration rate (oven), characterizing quality losses during this phase.

The samples were ground in a grinder, with a 1 mm mesh sieve, and sent to the Animal Nutrition and Food Laboratory [*Laboratório de Nutrição e Alimentação Animal*] – LANA (belonging to the State University of Maringá), for analyses of dry matter, mineral matter (MM), organic matter (OM), crude protein (CP), acid detergent fiber (ADF), and lignin (LIG), in accordance with the AOAC [(18)]. Neutral detergent fiber (NDF) was determined in accordance with Mertens [19]; soluble carbohydrates (SC) were determined following the methodology proposed by Hall [20], and total-carbohydrate (TC) concentrations were obtained using the equation proposed by Sniffen et al. [21]: TC = OM – (EE + CP).

Storage losses were estimated through sampling at thirty-day intervals over a four-month period. Every thirty days, samples were collected from the bales of each treatment (four samples), taken to a forced ventilation oven at 55 ºC for 72 hours for drying, then ground in a grinder with a 1 mm sieve, and analyzed for DM, OM, CP and EE, NDF, ADF, and lignin determination, as already described. Hemicellulose (HEM) was determined by the equation: HEM = NDF – ADF. Cellulose (CEL) was determined by the equation: CEL = ADF – LIG.

The determination of total carbohydrates (TC) was estimated by the equation proposed by Sniffen et al. [21], and non-fibrous carbohydrates (NFC), by Weis's equation [22]. The non-nitrogenous extractive (NNE) value of foods was calculated by the equation: NEE = 100 – (MM+EE+CF+CP) through the Weende method. Crude fiber (CF) analysis was determined for use in the equation, in accordance with the AOAC [18]. Total digestible nutrients (TDN) were obtained by the equation proposed by Kearl [23]: TDN= -21.9391 + 1.0538 CP + 0.9736 NEE + 3.0016 EE + 0.4590 CF. The "in vitro" dry matter digestibility (IVDMD) was determined in accordance with Holden [24]. Food degradability was determined in accordance with Orskov and McDonald [25].

Statistical analysis

The results of the experiment were subjected to analysis of variance using SAS software [26]. For interactions, factors were broken down, and the results of the variables were subjected to regression analysis. The analysis of variance was carried out in accordance with the models, based on the analyzed variable:

Table 2: Yi = μ + Hi + ei

Table 3: Yij = μ + Hi + Uj + (HU)ij + eij

Figures 4 to 9: Yijk = μ + Hi + Uj + (HU)ij + Dk + (HD)ik + (UD)jk + (HUD)ijk + eijk

Where: Yi = value found for the variable responding to the effect of cutting time i. Yij = value found for the variable responding to the effect of cutting time i and moisture content j; Yijk = value found for the variable responding to the effect of cutting time i, moisture content j, and storage days; μ = mean of the treatments; Hi = time effect i, i = 10:00, 13:00 and 16:00; ei = random error associated with the plot i; Uj = moisture effect j, j = 15% and 20%; (HU)ij= interaction between treatments ij; Ti = storage period effect, k = 0 to 120 days; eijk = random error associated with subplot ijk.

3. Results and discussion

The chemical composition of the forage (Table 2) showed a cutting time effect, with DM, OM and TC levels increasing with cuts in the afternoon (from 13:00 onwards). This is due to the increase in the period of exposure to sunlight (photoperiod) and its consequent absorption, transforming it into organic compounds through the photosynthesis process [27]. In this sense, a higher NFC content (16.2%) was found for plants harvested at 16:00. Studies on different forage species show a greater accumulation of soluble carbohydrates when the plant is cut in the afternoon [28,11].

Now, the CP content registered a higher concentration for the cut at 10:00, that is, in the opposite direction to the carbohydrate concentration. This result corroborates those found by De Oliveira et al. [7,8] in an experiment with *Pennisetum purpureum* cv. Napier and *Urochloa brizantha* cv. Marandu. Moreover, Morin et al. [10], when working with *Phleum pratense*, and Pelletier et al. [9], when assessing six species of grasses and two legumes, observed the same behavior, which indicates that there is interaction between nutrients and their proportions in the plant.

Table 2 Chemical composition of *Urochloa brizantha* cv. BRS Paiaguás, as a function of cutting time, in the haymaking process.

	Cutting time (h)				P value
Item	10:00	13:00	16:00	SEM	H
DM	22.0c	24.8b	25.7a	1.78	<0.01
OM	92.9b	94.7a	94.5a	0.49	<0.01
CP	9.23a	8.4ª	7.13b	5.42	<0.01
NDF	69.2b	73.5a	69.6b	1.28	<0.01
ADF	58.9b	64.2a	58.6b	3.30	0.01
HEM	10.2	10.6	11.0	19.0	0.85
LIG	1.94	1.82	1.91	18.7	0.90
CEL	57.0b	61.1a	56.7b	3.14	0.01
EE	1.36	1.46	1.59	10.0	0.15
IVDMD	54.3	51.5	56.1	7.67	0.34
TC	82.3b	84.9a	85.8a	0.89	<0.01
NFC	13.1b	11.4b	16.2a	7.42	<0.01
TDN	52.3	50.0	53.9	6.77	0.34

DM = dry matter; OM = organic matter; MM = mineral matter, CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEM = hemicellulose; LIG = lignin; CEL = cellulose; EE = ether extract; IVDMD = "in vitro" dry matter digestibility; TC = total carbohydrates; NFC = non-fibrous carbohydrates, and TDN = total digestible nutrients. SEM = standard error of the mean. H = Cutting time effect. Different, lowercase letters in the rows differ by Tukey's test (P<0.05).

Losses during the baling process are shown in Figure 3. The greatest losses represent up to 870 kg ha^{-1} in the cutting at 13:00, and with baling at 15% moisture; while in the treatment in which the cut was made at 10:00, and with baling at 15% moisture, the lowest DM losses were observed, which corresponded to 550 kg ha^{-1}, possibly due to greater exposure to solar radiation, which can accelerate the dehydration process. The forage harvesting efficiency in the field was 93.33%. Losses at different cutting times in the treatment with 20% moisture presented an average value of 790 kg ha^{-1}. According to Collins (29), the greatest changes in nutritional value and nutrients are reported in hays with higher moisture contents (25%) during storage; a moisture level considered adequate to prevent the growth of filamentous fungi is lower than 20%.

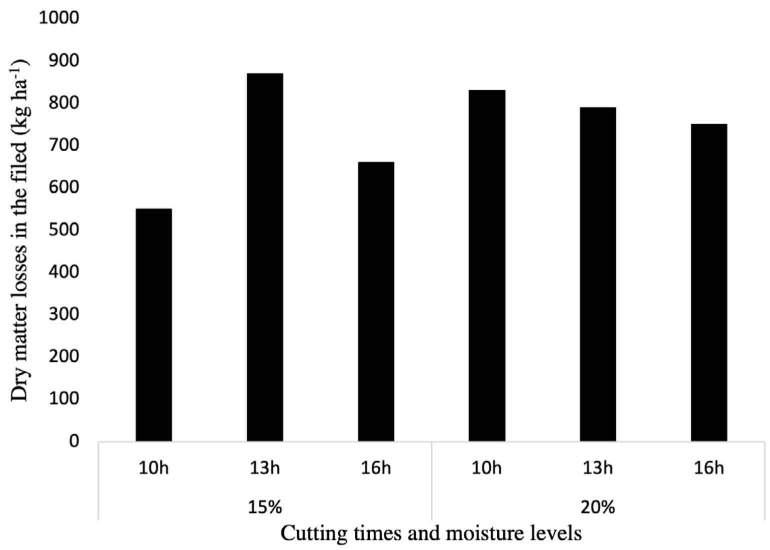

Figure 3 Assessment of losses in the field after the baling process.

The DM content of the hays, during the storage period, showed the same behavior for all treatments, with a progressive increase. Data analysis showed the effect of moisture content on baling, as well as of the storage period, and interaction between cutting time × baling moisture × storage period (Table 3).

Table 3 P values for the variables in Figures 4; 5; 6; 7; 8 and 9 of hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two moisture levels.

Variable	P value						
	H	U	H×U	D	H×D	U×D	H×U×D
DM	0.0019	<0.0001	0.0075	<0.0001	<0.0001	<0.0001	0.2719
CP	0.0002	0.0003	<0.0001	0.3845	0.0658	0.0891	0.0941
NFC	<0.0001	0.0059	0.0536	<0.0001	0.3339	0.3105	0.2436
NDF	0.0304	<0.0001	0.0774	<0.0001	0.4894	0.0477	0.1550
EE	0.0130	0.3784	0.1549	<0.0001	<0.0001	0.2090	0.2976
IVDMD	0.0022	0.0207	0.0671	<0.0001	0.0289	0.1407	0.1062

DM = dry matter; CP = crude protein; NFC = non-fibrous carbohydrates; NDF = neutral detergent fiber; EE = ether extract and IVDMD = "in vitro" dry matter digestibility; H = cutting time effect; U = baling moisture; H×U = interaction of cutting time and baling moisture; D = day of collection during storage; H×D = interaction between cutting time and collection day during storage; U×D = interaction between moisture at baling and day of collection during storage; H×U×D = interaction between cutting time, baling moisture and day of collection during storage.

Regarding DM content as a function of storage time, it was found that, after 90 days, there was balance between the materials baled with 15% and 20% moisture (Figure 4). In general, there was an increase in DM concentration as the storage time advanced during the three cutting times (10:00; 13:00 and 16:00), with the same behavior occurring at the two moisture levels at baling (15% and 20%). A slight reduction in DM levels was recorded in the sampling after thirty days of storage, which was attributed to the high relative humidity of the air during the week, since hay is hygroscopic (30).

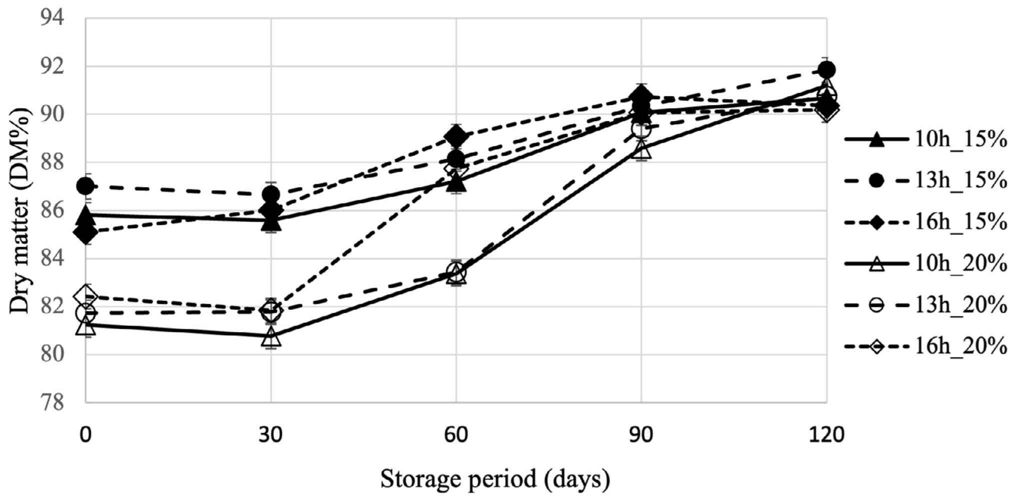

Figure 4 Dry matter content of hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two DM levels, during the storage period.

With respect to CP contents (Figure 5), it was found that there was no defined behavior as a function of cutting time and moisture content during baling. There was a reduction in CP content as the storage time advanced for the treatments with cutting at 10:00 and 13:00, and baling at a 20% moisture, and for the treatment with cutting at 16:00, and baling at a 15% moisture, a behavior similar to that reported by Rotz & Abramsz [31] when working with alfalfa hay. In the hay of the 13-hour and 15%-moisture treatment, there was an increase in CP content after 120 days of storage, which can be attributed to sampling issues.

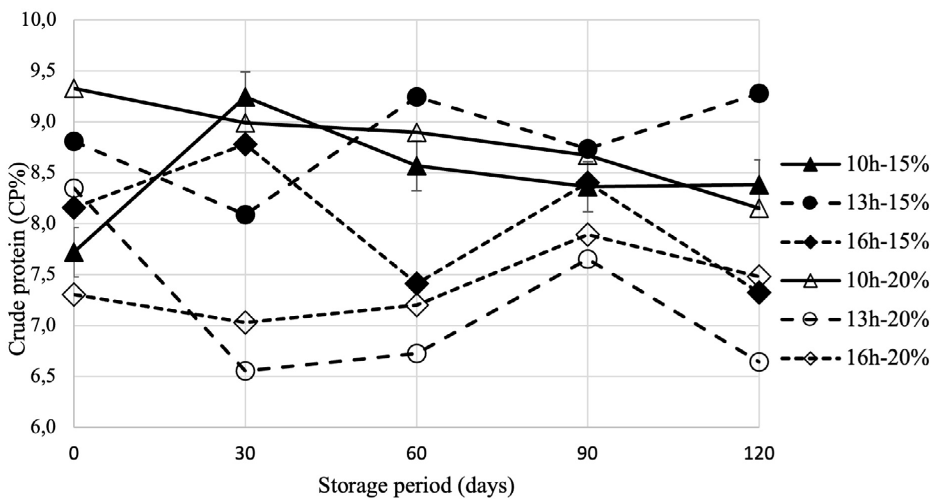

Figure 5 Crude protein (CP) concentration of hay from *Brachiaria brizantha* cv. Paiaguás, produced at different cutting times and baled at two DM levels, during the storage period.

For the non-fibrous carbohydrates (NFC) variable (Figure 6), there was a cutting time, moisture content and storage period effect, as seen in Table 2. Cutting at 16:00 allowed for greater accumulation of NFC, due to greater exposure to solar radiation and accumulation of photoassimilates occurring in the afternoon [7, 8]. Although all treatments showed a reduction in NFC content with storage, possibly due to the greater initial accumulation, the cut at 16:00 was the one that showed the greatest preservation of the levels of this nutrient; the reduction in the nutritional value of the food with the storage period is a result of microbial activity, as this is the main source of energy for its metabolism. A similar result was found by Ribeiro et al. [11].

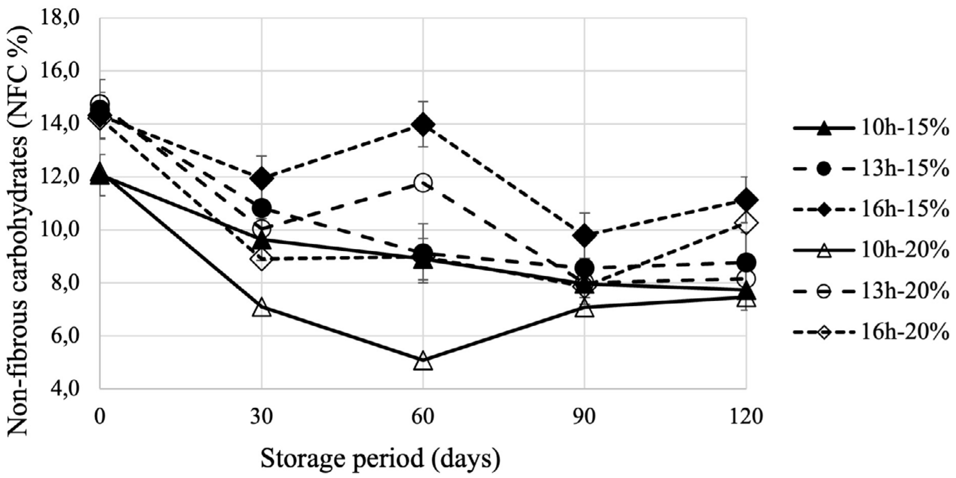

Figure 6 Concentration of non-fibrous carbohydrates (NFC) in hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two DM levels, during the storage period.

The analysis of NDF content as a function of the treatments (Figure 7) showed a significant effect for cutting time, moisture content at baling, days of storage, and interaction between moisture x storage period.

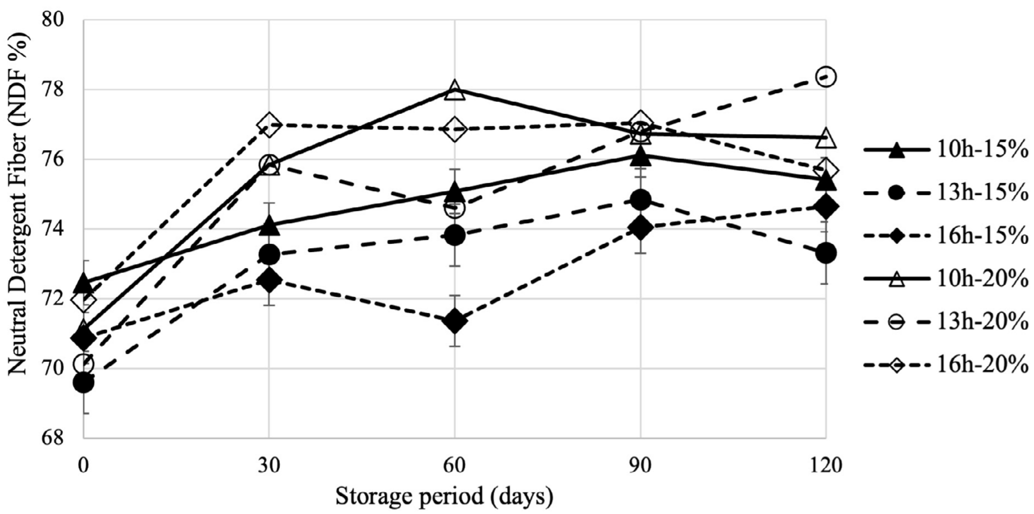

Figure 7 Concentration of neutral detergent fiber (NDF) in hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two DM levels, during the storage period.

Hay with 20% moisture at baling had a higher NDF content after 120 days of storage, which means greater loss of non-structural components. In general, there was an increase in NDF content in all hays with longer storage times. This behavior may be due to a reduction in the concentration of non-structural components of the plant, such as NFC, causing a dilution effect.

At the time of baling, the NDF content in hay harvested at 10:00, 13:00 and 16:00 and baled with a 15% moisture was 72.5; 69.6 and 70.9%; while for baling with a 20% moisture, it stood at 71.1; 70.1 and 72.0%, respectively. After 90 days of storage, these values for hay harvested at 10:00, 13:00 and 16:00, at a 15% moisture level, were 76.1, 74.8 and 74.0%; at the same cutting times and with 20% moisture content at baling, the values stood at 76.7%; 76.8 and 77.0%, respectively. Representing an average increase of 6.02%, 7.80% and 5.35%

for cutting at 10:00, 13:00 and 16:00, respectively. This result corroborates those reported by Ribeiro et al. [11] when assessing hay quality changes during storage, and by Coblentz et al. [32] in an experiment with Bermuda grass hay after 60 days of storage.

Figure 8 shows that the ether extract (EE) content in hay was affected only by the storage period, with an interaction for cutting time × storage days. Regarding the cutting time in haymaking, cutting at 10:00 and 15% humidity at the time of baling had a higher EE content (1.5%) than cuts at 13:00 (1.0%) and 16:00 (1.0%). However, after 30 days of storage, there was a balance between all treatments, resulting in reduced EE concentration.

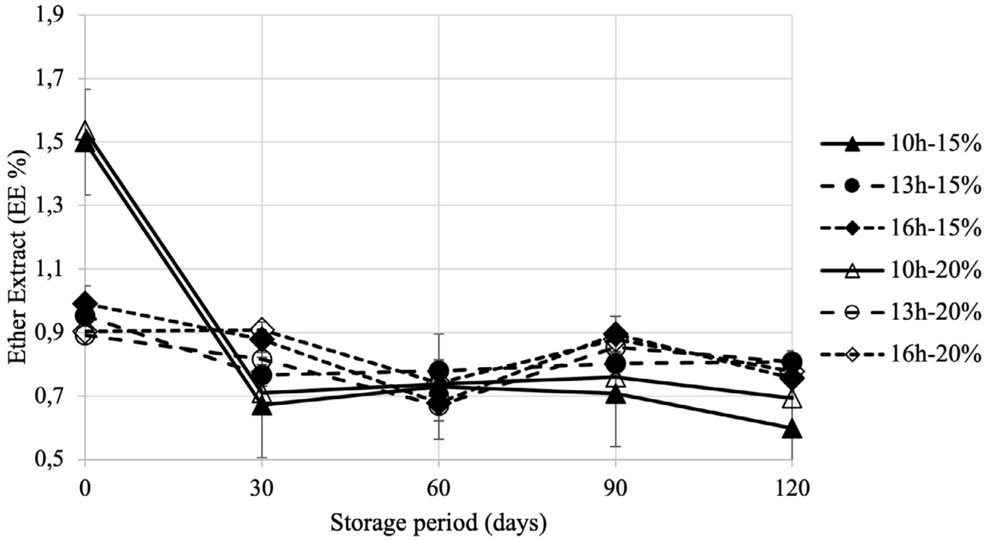

Figure 8 Ether extract (EE) concentration of hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two DM levels, during the storage period.

In general, there was a reduction of 12.28% comparing the EE content of the forage at the time of baling (1.1%) and after 120 days of storage (0.7%). This behavior was similar to the results reported by Greenhill et al. [33], during nine months of assessment of changes in the chemical composition of ryegrass, clover and alfalfa hay at different moisture levels (7,12 and 17%) and temperatures (16 to 36°C).

Regarding the IVDMD of hay produced with different technologies (Figure 9), a significant effect was found for cutting time, moisture at baling, storage period, and for the moisture × storage period interaction. Comparing the IVDMD values at the time of baling and after 90 days of storage, at a 15% moisture level, there was a 4.12% reduction in forage digestibility. This reduction in forage quality can be attributed to the loss of non-structural components of the forage during storage, and to the concentration of fibrous components, as displayed in Figure 7.

According to Coblentz et al. [34], the action of microorganisms and oxidation reactions during storage reduce mainly the levels of soluble components, which represent the most digestible fraction. As is generally evident in this study, the storage time resulted in a reduction in non-fibrous carbohydrates, an increase in the NDF fraction, with a consequent decrease in digestibility, with more evident effects in hay baled at 20% moisture.

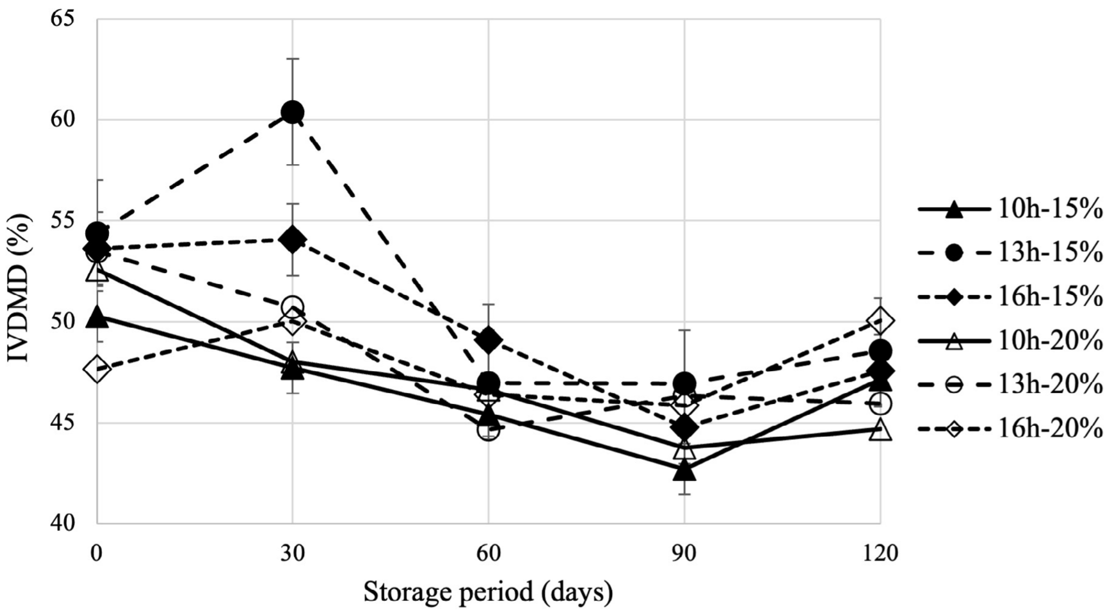

Figure 9 "In vitro" dry matter digestibility (IVDMD) of hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two DM levels, during the storage period.

In the ruminal degradation study (Table 4), regardless of cutting time and moisture content at baling, there was no significant change for the a and b fractions of the hay. However, there was a moisture-at-bailing effect on the passage rate and effective degradability, with 15% moisture being higher than 20% moisture. This result can be attributed to the higher NDF content of hay baled at 20% moisture (Figure 7), associated with the NFC levels in each treatment (Figure 6). As the passage rate increases, the effective degradability decreases. This result corroborates the findings of De Carvalho et al. [35], in their study with Guinea, Tifton and Brachiaria hay.

Table 4 Ruminal degradability of hay from *Urochloa brizantha* cv. BRS Paiaguás, produced at different cutting times and baled at two moisture levels.

Variable	Cutting time			Baling Moisture		SEM	P value		
	10:00	13:00	16:00	15%	20%		H	U	H×U
Fraction a	60.2	60.5	59.8	60.8	59.6	0.38	0.79	0.14	0.59
Fraction b	39.8	39.5	40.2	39.2	40.4	0.38	0.79	0.15	0.59
kd, %/h	2.1	2.3	2.1	2.4a	2.0b	0.10	0.43	0.04	0.32
ED 4%	73.7	74.8	73.5	75.2a	72.8b	0.56	0.49	0.03	0.29
ED 6%	70.4	71.40	70.1	71.8a	69.5b	0.53	0.5	0.03	0.30
ED 8%	68.4	69.3	68.1	69.7a	67.5b	0.51	0.53	0.03	0.31

DM = Dry matter, kd = Degradation rate of fraction b, ED = Effective degradability, considering a passage rates of 4%, 6% and 8%/h. H = cutting time effect, U = moisture effect, HxU = effect of the interaction between cutting time and moisture. Equal, uppercase letters in the columns, and lower case letters in the rows do not differ by Tukey's test (P<0.05); SEM = standard error of the mean

4. Conclusion

Cutting forage in the afternoon increases field losses for low-moisture baled forage and reduces losses in high-moisture baling. The best time to cut forage for haymaking is in the afternoon, between 13:00 and 16:00. The extension of the storage period associated with a higher moisture content at baling has negative implications on the chemical composition of hay, with a consequent reduction in effective ruminal degradability and dry matter digestibility.

Declaration of conflict of interests

The authors declare no conflict of interest.

Author contribution statement

Conceptualization: Saute, J.M., Methodology: Jobim, C.C., Software: Jobim, C.C., Data curation: Saute, J.M., Investigation: Saute, J.M., Validation: Jobim, C.C., Formal analysis: Saute, J.M., Supervision: Jobim, C.C., Funding acquisition: Jobim, C.C., Visualization: Tres, T.T., Project administration: Jobim, C.C., Resources: Jobim, C.C., Writing – original draft: Saute, J.M., Tres, T.T., Writing – review & editing: Tres, T.T.

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