# Storage and digestibility, voluntary intake and chemical components of hay of five tropical grasses[1]

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## ABSTRACT

**An evaluation of the hay obtained from tropical grasses coastcross I (*Cynodon dactylon*), stargrass (*Cynodon nlemfuensis*), callie (*Cynodon plectostachyus*), slenderstem (*Digitaria pentzii*), and guinea (*Panicum maximum*) was made at three harvest intervals (35-, 45-, and 55-day) and four storage periods ( γ than 4, 4 to 8, 8 to 12, and < than 12 months). In vivo dry matter digestibility and voluntary intake trials were performed with Holstein steers, weighing from 340 to 390 kg. Mean digestibility was 60.8%, 56.8% and 55.0%, respectively, for 35-, 45- and 55-day harvest intervals. The mean reduction caused by storage was from 60.8 to 50.6%, from 56.8 to 48.8%, and from 55.0 to 47.2% for the 35-, 45-, and 55-day intervals, respectively. The lower digestibility values were measured in callie. Voluntary intake declined 12, 18, and 17% and the digested dry matter voluntary intake declined from 1.47 to 1.1%, from 1.31 to 0.9%, and from 1.15 to 0.82%. Crude protein content decreased by 17.0, 15.4, and 15.6% for the respective intervals. The major detrimental effect in hay quality was observed after a 12-month storage. Plant maturity influenced the mean increase of neutral detergent fiber (NDF) from 69.7 to 72.6 and 76.6%, acid detergent fiber (ADF) from 37.9 to 43.4 and 47.7%; and lignin content, from 5.2 to 9.3% for the three growth intervals. This increase was 9, 16, and 42% for each parameter. However, as storage effect, NDF, ADF, and lignin content were raised by 4.3%, 12.3%, and 5.0%, respectively.**

## RESUMEN

**Almacenamiento y digestibilidad, consumo voluntario y composición química de heno de cinco yerbas tropicales**

**Se preparó heno de 5 gramíneas forrajeras tropicales: cruce I (*Cynodon dactylon*), estrella (*Cynodon nlemfuensis*), callie (*Cynodon plectostachyus*), pangola fina (*Digitaria pentzii*) y guinea (*Panicum maximum*). Los pastos se cosecharon a 3 intervalos de 35, 45 y 55 días y se almacenaron por períodos de menos de 4 meses, de 4 a 8 meses, de 8 a 12 meses y de más de 12 meses para determinar el efecto del almacenamiento en el valor nutritivo. Se hicieron estudios de consumo y digestibilidad siguiendo un diseño factorial con 4 repeticiones con toros castrados cuyo peso vivo fluctuó entre 340 y 390 kg. La digestibilidad media disminuyó de 60.8 a 56.8%**

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**y de 56.8% a 55.0% por efecto de la madurez. La reducción media que se puede atribuir al almacenamiento fue de 60.8 a 50.6%, de 56.8 a 48.8% y de 55.0 a 47.2% para los henos de 35, 45 y 55 días, respectivamente. Las digestibilidad más baja se obtuvo en el heno de la yerba callie. El consumo voluntario bajó 12, 18 y 17% y el consumo de materia seca digerida bajó de 1.47 a 1.10%, de 1.31 a 0.92% y de 1.15 a 0.82% por cada intervalo de corte, respectivamente, como efecto del almacenamiento. El contenido en proteína bruta disminuyó significativamente por efecto de la madurez del forraje en 17.0, 15.4 y 15.6% para los intervalos de 35, 45 y 55 días, respectivamente. Durante los primeros 2 períodos de almacenamiento la digestibilidad, el consumo voluntario y el contenido en proteína bruta no se afectaron significativamente. Los efectos más detrimentales en todos los casos ocurrieron durante el almacenamiento de más de 12 meses. El contenido en fibra neutrodetergente, fibra ácidodetergente y lignina aumentó por 4.3, 12.3 y 5.0%, respectivamente, por cada intervalo como influencia del almacenamiento. Dichos contenidos, no obstante, aumentaron en 9, 16 y 42% como efecto de madurez de la planta.**

## INTRODUCTION

The objective of this study was to determine the effect of in-barn storage on digestibility, voluntary intake, and chemical components of five tropical grasses harvested at 35-, 45-, and 55-day intervals, made into hay and stored for four periods.

It is difficult to feed livestock properly in Puerto Rico strictly on green forage throughout the year. This difficulty is due to the slow and fast forage growing seasons. The slow growing season coincides with the occurrence of cool temperatures (16° C min and 29° C max), short days (11.5 hours mean daylight), and dry periods. These are limiting factors in the production of forage dry matter. Therefore, forage crops do not completely fulfill farm-animal requirements. Inversely, during the forage fast growing season excess forage is produced which may be lost by trampling or may become too fibrous with decreased nutritive quality if not properly managed. Some livestock producers store excess forage produced during the fast growing season to use it during the slow growing season. Some farmers store in zinc and concrete barns, others on a 1-m raised flat structure, covering the crop with canvas or plastic material, whereas others put large round bales into plastic bags. Large losses occur from harvesting to feeding the hay crop to the animals. Storage has been reported as one of the factors responsible for 7% of the forage loss (3). These losses show themselves in reduced dry matter and crude protein content and declined voluntary intake and digestibility (19). Belyea (2) reported that dry matter losses during hay storage increased from 2.5 to 15.0%. However, mean dry matter losses of 3.8% and 0.8% occurred in high moisture (24%) and low moisture (16%) hay, respectively.

## MATERIALS AND METHODS

The five grasses used in this study were coastcross I (*Cynodon dactylon*), stargrass (*Cynodon nlemfuensis*), callie (*Cynodon plectos-*

*tachyus*), slenderstem (*Digitaria pentzii*), and guinea (*Panicum maximum*) grown at the University of Puerto Rico Agricultural Experiment Station at Lajas. Pure stands of these grasses were intensively managed through irrigation, 15-5-10 fertilizer application, and weed and pest control as previously described by Méndez et al. (10). The crop was cut at 35-, 45-, and 55-day intervals (DI) from May 1977 to April 1984, left in the field for natural sun and wind drying until moisture content was reduced to 18-20%. A Delmhorst[3] instrument was used to measure the moisture content. Fifteen different hays (5 varieties x 3 cutting intervals) in rectangular bales of approximately 62 x 45 x 45 cm, with a mean weight of 15 kg were made. The hay was stored for periods of less than 4 (I), 4 to 8 (II), 8 to 12 (III), and more than 12 months (IV). Digestibility trials using the method described by Harris (4) were conducted with Holstein steers with four replicates in a 5 x 3 x 4 factorial arrangement (5 varieties x 3 cutting intervals x 4 storage periods). Fourteen steers were used during the study with liveweight ranging from 340 to 390 kg. Steers were allowed to rest and recuperate between trials. Three steers died during the study because of age. The four steers were randomly housed in individual concrete floor and galvanized pipe side walls designed for hay intake and refuse and for feces output. Dry matter contents of the green forages, hay, orts, and feces was determined by oven drying at 60° C. Nitrogen content was determined by the Kjeldahl method and multiplied by 6.25 to obtain crude protein content (1). Acid detergent fiber (ADF), neutral detergent fiber (NDF), cellulose, and permanganate lignin were determined by the methods described by Harris (4). The data was statistically analyzed by analysis of variance of SPSSX (13) and the minimum significant amplitude between means was determined by the new multiple range test of Steel and Torrie (17).

## RESULTS AND DISCUSSION

Significant differences were measured within and among varieties, cutting intervals and storage periods as to digestibility, voluntary intake, and crude protein content of dry matter. The reduction of dry matter digestibility because of storage periods was similar for the three harvest intervals and for the four stage intervals. However, the harvest intervals had a measurable effect on digestibility (fig. 1). Mean digestibility during period I was 60.8, 56.8, and 55.0% for the 35-, 45- and 55-DI, respectively (table 1). For the 35-DI mean digestibility for all grasses was reduced significantly by 17% (from 60.8 to 50.6) throughout the four periods. The least effect, although significant, was observed for guinea whose digestibility declined by 13% (from 60.5 to 53.2) whereas callie declined by 24% (from 58.0 to 43.0). Inversely, guinea exhibited the most critical storage effect for the 45- and 55-DI. Its digestibility declined 19% throughout period I to period IV, from 59.5 to 48.5% for the 45-DI and from 56.7 to

[3]Mention of a trade name does not constitute a warranty of equipment or material by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

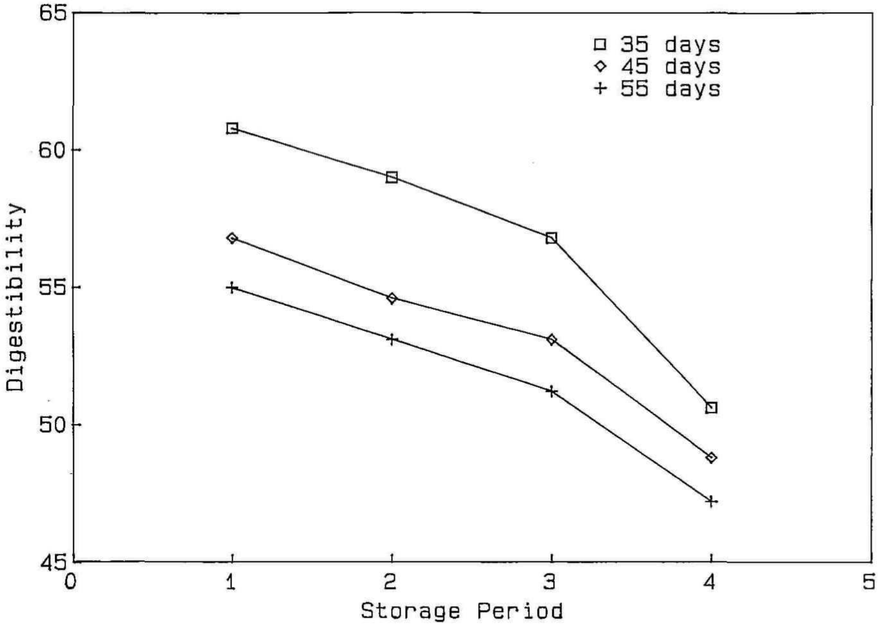


FIG. 1.—Mean dry matter digestibility (DMD) of five tropical grasses cut at three intervals and four storage periods.

46.2% for the 55-DI. The in vivo dry matter digestibility did not decline significantly for coastcross at the three cutting intervals as an effect of storage during the first three periods for the three DI. This was also true in the case of slenderstem at the 45-DI and callie at both the 45- and 55-DI. For most of the grasses, differences in dry matter digestibility were not significant during the first two storage periods. Period IV was crucial for the five grasses for the three cutting intervals (fig. 1).

Minimum dry matter losses during storage insure higher digestibility of the preserved forage crop for ruminants (20). A decline in in vivo dry matter disappearance (IVDMD) from 70.5 to 60.5% during storage was reported by Knapp et al. (7). Lechtenberg et al. (8) attributed the decline in IVDMD to respiratory losses of highly digestible non-structural carbohydrates during the final stage of drying. Even though they studied the deterioration of hay in large round bales stored outside, they observed a reduction in IVDMD from 56.5 to 54.4% in the unweathered portion of the packages. However, Nelson et al. (12) reported no reduction in IVDMD for ryegrass hay stored in barn and outside covered on racks for 7 and 12 month periods. Johnson and McCormic (6) studied the influence of preservatives on stored coastcross I hay at high moisture (24%) and low moisture (16%). They reported an apparent digestibility of 59.2% for stored untreated low moisture versus 58.7% for stored untreated high moisture hay. Verma and Von Borgen (19) studied the deterioration in

TABLE 1.—*Hay digestibility of five tropical grasses cut at three intervals and four storage periods*

| Cutting Intervals | Storage periods[1] | Varieties | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | Coastcross | Slenderstem | Callie | Stargrass | Guinea | |
| *Days* | | | | | | | |
| 35 | I | 63.2 a[2] | 61.7 a | 58.0 a | 60.5 a | 60.5 a | 60.8 a |
| | II | 60.7 a | 62.5 a | 53.5 b | 59.0 a | 59.0 a | 59.0 ab |
| | III | 60.0 a | 58.2 b | 52.0 b | 55.0 b | 58.7 a | 56.8 b |
| | IV | 54.5 b | 53.7 c | 43.0 c | 48.7 c | 53.2 b | 50.6 c |
| 45 | I | 56.2 a | 57.5 a | 52.5 a | 58.5 a | 59.5 a | 56.8 a |
| | II | 55.2 a | 56.2 a | 49.7 a | 56.7 ab | 55.0 b | 54.6 ab |
| | III | 54.5 a | 55.2 a | 50.2 a | 53.7 b | 52.0 bc | 53.1 b |
| | IV | 48.2 b | 49.7 b | 46.5 b | 51.2 b | 48.5 c | 48.8 c |
| 55 | I | 54.0 a | 57.0 a | 52.0 a | 55.2 a | 56.7 a | 55.0 a |
| | II | 52.5 a | 56.0 a | 51.2 a | 52.7 ab | 53.0 bc | 53.1 ab |
| | III | 52.2 a | 52.5 b | 50.0 a | 50.2 b | 51.0 c | 51.2 b |
| | IV | 48.2 b | 48.2 c | 45.5 b | 48.0 c | 46.2 d | 47.2 c |

[1]I = less than 4 months;
II = 4 to 8 months;
III = 8 to 12 months;
IV = greater than 12 months.
[2]In each block values in columns followed by a common letter do not differ significantly at P = 0.05.

stored large round bales. They reported 65% digestible dry matter for both compressed core sectioning. Moir et al. (11) attributed the differences in digestibility between grass species to laboratory variations in analytical techniques.

Dry matter intake is a criterion to take into consideration when making a decision for preservation and storage of a forage crop. In the study herein reported mean dry matter voluntary intake (DMVI) exhibited almost the same pattern during the four storage periods for the three DI (table 2). Nevertheless, a drastic decline was observed from period III to period IV for the 45-DI (fig. 2). A 2.6 kg/100 kg liveweight (% LW) DMVI was observed for coastcross. This was the highest value observed for the 35-DI. For the 45- and 55-DI a 2.4 and 2.3% LW, respectively, were obtained for stargrass.

A 10% mean reduction in VI was caused by cutting intervals from the 35-DI to the 55-DI. Mean DMVI of the crop corresponding to the 35-, 45-, and 55-DI declined 12%, 18%, and 17%, respectively, as an effect of storage. The effects were similar for slenderstem, callie, and stargrass whose intake was significantly different only for period IV on the 35-DI. The differences were not significant for coastcross at the 35- and 45-DI; for callie and guinea, at the 45-DI; or for slenderstem, callie, and guinea at the 45-DI. Similar effects were obtained for slenderstem, callie and guinea at the 55-DI. Period IV caused the most negative effect on the VI for the five grasses during the three cutting intervals.

A correlation equation involving neutral detergent fiber has been suggested for predicting voluntary dry matter intake for temperate and sub-tropical forage species (16). The "fill unit" has been used to build up a system which predicts the intake of forages when they are fed alone or in forage-based diet (5).

Hay making does not imply immediate use after harvesting. In Puerto Rico most of the crop is stored to be used during slow growing season or whenever any difficult unforseen situation arises. Method of storage as well as forage species influence protein, cell wall and cell content intake (14). The magnitude of hay losses with different storage methods for large round bales (LRB) was studied by Nelson et al. (12). They reported ranges in animal refusal from 1.2% for in-barn storage to 22% for outside storage on the ground. Lechtenberg (8), using different systems, fed LRB hay stored on winter pasture, and reported that all hay not stored on racks and concrete was consumed, whereas 4.9% of the hay stored on racks and 5% of the hay from small square bales was not consumed. Johnson and McCormick (6) reported a mean daily intake of 2.3% LW and 2.8% LW for 24% and 16% moisture hay not treated with preservatives, respectively. Belyea et al. (2) reported feeding losses of 12.4%, 14.0%, and 24.7% for LRB stored in barn, covered outside barn, and uncovered outside barn with dry forage intake of 2.35% LW, respectively.

The nutritive quality of forages differs among growing environmental conditions. Grasses grown in the tropics are high in non-digestible com-

TABLE 2.—*Hay dry matter voluntary intake (kg/100 kg liveweight/day) (% LW), of five tropical grasses cut at three intervals and four storage periods*

| Cutting intervals | Storage periods[1] | Varieties | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | Coastcross | Slenderstem | Callie | Stargrass | Guinea | |
| *Days* | | *% LW* | *% LW* | *% LW* | *% LW* | *% LW* | *% LW* |
| 35 | I | 2.56 a[2] | 2.43 a | 2.35 a | 2.47 a | 2.35 a | 2.43 a |
| | II | 2.51 a | 2.40 a | 2.29 a | 2.42 a | 2.19 ab | 2.36 a |
| | III | 2.47 a | 2.56 a | 2.25 a | 2.35 ab | 2.05 b | 2.28 ab |
| | IV | 2.41 a | 2.12 b | 2.03 b | 2.22 b | 1.91 b | 2.14 b |
| 45 | I | 2.33 a | 2.35 a | 2.13 a | 2.42 a | 2.35 a | 2.32 a |
| | II | 2.34 a | 2.28 a | 2.04 a | 2.32 ab | 2.42 a | 2.28 a |
| | III | 2.29 a | 1.96 b | 2.07 ab | 2.19 b | 2.25 a | 2.15 a |
| | IV | 2.02 b | 1.86 b | 1.87 b | 1.83 c | 1.93 b | 1.90 b |
| 55 | I | 2.09 a | 2.03 a | 2.04 a | 2.26 a | 2.01 a | 2.09 a |
| | II | 2.04 ab | 2.02 a | 1.99 a | 2.03 b | 2.02 a | 2.02 ab |
| | III | 1.88 b | 1.95 ab | 1.85 ab | 1.83 bc | 1.90 ab | 1.88 b |
| | IV | 1.65 c | 1.81 b | 1.70 b | 1.76 c | 1.71 b | 1.73 b |

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IV = greater than 12 months.

[2]In each block values in columns followed by a common letter do not differ significantly at P= 0.05.

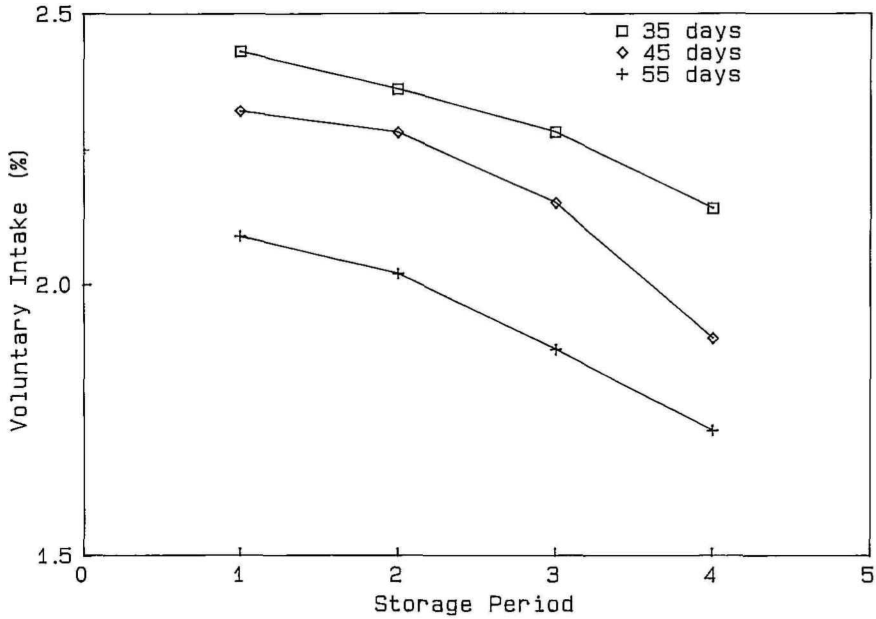


FIG. 2.—Mean dry matter voluntary intake (Kg/100 kg liveweight/day) (% LW) of five tropical grasses cut at three intervals and four storage periods.

ponents, which in turn affect digestibility of other forage components to the point that animals have difficulty obtaining adequate nourishment from the amount they are able to consume (16, 18). Digestibility and intake are somewhat interdependent. However, when referred to forage they are separate parameters of quality (16). Indigestible NDF becomes the intake-limiting constituent of forages as its content increases above 15% (9). According to Rohweder et al. (15) the digestible dry matter intake, a factor which determines feed value of hay, is an effective guideline of animal performance. They used the relation of ADF to in vivo digestible dry matter and NDF to dry matter intake estimated by regression analysis to determine the relative value index of temperate and subtropical forage hays. In the study herein reported the in vivo dry matter digestibility and DMVI were utilized to estimate digestible dry matter intake (DDMI) (table 3). The reduced effect caused by maturity was 15% for the 35- to the 45-, and 13% for the 45- to the 55- DI (1.47 to 1.31, and 1.31 to 1.15, respectively). The storage effect on mean DDMI was similar for all grasses since variation was not significant during storage periods I and II for the three DI. The hay in storage period IV was the most adversely affected. It may be concluded that hay crops should not be stored for periods longer than 12 months under tropical conditions.

There were no substantial differences among varieties as to NDF, ADF and lignin content. Therefore, all are considered as one unit for the

TABLE 3.—*Digestion of dry matter voluntary intake (kg / 100 kg liveweight/day) (% LW) of hay from five tropical grasses cut at three intervals and four storage periods*

| Cutting intervals | Storage periods[1] | Varieties | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | Coastcross | Slenderstem | Callie | Stargrass | Guinea | |
| *Days* | | *% LW* | *% LW* | *% LW* | *% LW* | *% LW* | *% LW* |
| 35 | I | 1.62 a[2] | 1.50 a | 1.31 a | 1.49 a | 1.42 a | 1.47 a |
| | II | 1.36 a | 1.51 a | 1.32 a | 1.43 a | 1.30 a | 1.42 a |
| | III | 1.48 b | 1.31 b | 1.17 b | 1.29 b | 1.20 b | 1.29 b |
| | IV | 1.32 c | 1.13 c | 0.87 c | 1.14 c | 1.02 c | 1.10 c |
| 45 | I | 1.31 a | 1.28 a | 1.12 a | 1.42 a | 1.40 a | 1.31 a |
| | II | 1.29 a | 1.28 a | 1.01 a | 1.31 a | 1.33 a | 1.24 a |
| | III | 1.25 a | 1.07 b | 1.04 a | 1.18 b | 1.18 b | 1.14 b |
| | IV | 0.97 b | 0.92 c | 0.87 b | 0.93 c | 0.93 c | 0.92 c |
| 55 | I | 1.13 a | 1.15 a | 1.06 a | 1.25 a | 1.14 a | 1.15 a |
| | II | 1.07 a | 1.13 a | 1.02 a | 1.07 b | 1.07 a | 1.07 a |
| | III | 0.98 b | 1.02 a | 0.92 b | 0.92 c | 0.97 b | 0.96 b |
| | IV | 0.80 c | 0.88 b | 0.78 c | 0.84 c | 0.79 c | 0.82 c |

[1]I = less than 4 months;
II = 4 to 8 months;
III = 8 to 12 months;
IV = more than 12 months.
[2]In each block values in columns followed by a common letter do not differ significantly at P= 0.05.

TABLE 4.—*Mean neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin (Lig.) content of five tropical grasses cut at three intervals and four storage periods*

| Storage period[1] | NDF % | | | ADF % | | | Lig. % | | |
|---|---|---|---|---|---|---|---|---|---|
| | 35- | 45- | 55- | 35- | 45- | 55- | 35- | 45- | 55- |
| | | *day* | | | *day* | | | *day* | |
| I | 69.7 | 72.6 | 76.6 | 37.9 | 43.4 | 47.7 | 5.17 | 7.27 | 9.29 |
| II | 69.6 | 73.6 | 77.3 | 39.9 | 45.9 | 47.1 | 5.21 | 7.31 | 8.86 |
| III | 71.0 | 74.6 | 78.0 | 42.0 | 47.1 | 49.2 | 5.38 | 7.46 | 9.04 |
| IV | 71.9 | 76.3 | 78.8 | 45.1 | 48.8 | 51.7 | 5.57 | 7.73 | 9.35 |

[1] I = less than 4 months;
II = 4 to 8 months;
III = 8 to 12 months;
IV = more than 12 months.

TABLE 5.—*Hay crude protein content of five tropical grasses cut at three intervals and four storage periods*

| Cutting intervals | Storage periods[1] | Varieties | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | Coastcross | Slenderstem | Callie | Stargrass | Guinea | |
| *Days* | | % | % | % | % | % | % |
| 35 | I | 13.7 a[2] | 13.3 a | 14.7 a | 14.4 a | 12.0 a | 13.6 a |
| | II | 13.2 ab | 13.1 a | 14.0 ab | 13.9 a | 12.3 a | 13.3 a |
| | III | 12.0 bc | 12.2 a | 13.0 b | 13.7 a | 11.9 a | 12.6 ab |
| | IV | 11.0 c | 10.3 b | 11.0 c | 13.4 a | 11.7 a | 11.3 b |
| 45 | I | 11.6 a | 11.7 a | 13.7 a | 13.5 a | 11.1 a | 12.3 a |
| | II | 11.7 a | 11.8 a | 12.0 b | 13.0 ab | 10. 5a | 11.8 a |
| | III | 10.7 a | 10.9 ab | 11.7 bc | 13.2 a | 10.0 ab | 11.3 ab |
| | IV | 10.1 b | 10.3 b | 10.5 c | 11.7 b | 09.5 b | 10.4 b |
| 55 | I | 09.1 a | 11.7 a | 09.2 a | 09.0 a | 09.1 a | 09.6 a |
| | II | 08.9 a | 10.5 a | 08.7 a | 08.5 a | 08.9 a | 09.6 a |
| | III | 08.7 a | 09.9 bc | 07.9 ab | 08.2 a | 08.3 ab | 08.6 a |
| | IV | 08.5 a | 09.1 c | 07.6 b | 07.7 a | 07.6 a | 08.1 b |

[1]I = less than 4 months;
II = 4 to 8 months;
III = 8 to 12 months;
IV = more than 12 months.
[2]In each block values in columns followed by a common letter do not differ significantly at P= 0.05.

values shown in table 4. The mean increase in NDF from periods I to IV was 4.3% and it increased to 9%. Mean lignin increased from 5.26 to 9.10% because of maturity. Nelson et al. (12) reported that the NDF changed significantly during 12 months of storage from 68.5 to 73.0. The ADF concentration increase attributable to storage effect was 12%. Nevertheless, the increase attributable to maturity was 16%. This component is the chemical choice for estimating digestibility of cell wall and cell solubles for subtropical grasses (16).

Significant reduction in CP content was obtained among varieties, even though this effect was not significant for stargrass at the 35- and 55- DI or for guinea at the 35- DI (table 5). Initial CP content for ryegrass storage was 9.7%, as reported by Nelson et al. (12), whereas for stored bermudagrass it was 11.7% (6). The highest effect in the reduced CP content was attributable to increased ID. There was a decline caused by maturity from 13.6%, 12.3%, and 8.17% to 11.3%, 10.4%, and 8.10%, respectively, for each growth interval, whereas the mean CP was reduced from period I to IV as an effect of storage within the 35-, 45 and 55- DI, respectively. In this study the major reduction effect in CP content occurred during storage period IV. This result does not agree with the findings of Nelson et al. (12), which reported a tendency of CP content to increase during 7 storage months, although no difference was obtained during 12-month storage. Knapp et al. (7) also reported an increase in total nitrogen during storage, especially if stored before it is adequately cured. It should be pointed out that heat generated inside the bale during storage binds CP to the fiber fraction. Therefore not all CP content is available for animal utilization (12). Crude protein content has been one of the major parameters used for hay grading (15, 16). Considering the CP content in this study and the grading proposed by Rohweder et al. (16), the hay cut at 35- DI could be in the grade 3 category (13-18% CP) during storage periods I and II, and the crop cut at 45- and 55- DI could be classified in grade 4 (8-12% CP), although that stored after 12 months could be reduced to grade 5 (< 8% CP).

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