Structural carbohydrates, protein and *in vitro* digestibility of eight tropical grasses[1] /

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Resumo

Foi estudado o efeito da idade (21, 42, 63, 94 dias) sobre a composição química e digestibilidade in vitro *de oito gramíneas tropicais. O conteúdo da proteína sofreu uma queda com o aumento da idade em todas as especies, mas a taxa foi diferente em diferentes capins. Os carboidratos estruturais aumentaram com a idade, o conteúdo de hemicelulose foi diferente entre especies em quanto o de celulose foi bastante semelhante. A relação média entre ambos foi del 1.34 ± 0.12. Houve diferenças consideráveis entre especies na digestibilidade* in vitro *da matéria seca, mas o efeito da idade foi semelhante em todas elas. A taxa de diminuição da digestibilidade da matéria seca, hemicelulose e celulose foi de 0.311 ± 0.013, 0.304 ± 0.021 e 0.304 ± 0.014 por dia respectivamente. A porcentagem de holocelulose digestivel na matéria seca digestivel variou entre especies e idades oscilando entre 38 e 70%.*

Introduction

The nutritive value of forages is a complex characteristic, and is partly inherent to each species. Nevertheless, a first assesment can be made if certain chemical and *in vitro* parameters are available. Among the former, the detailed chemical composition is established by direct, as opposed to empirical, method. These data are essential, among other uses, for the development and use of current models of rumen function (8, 15). In these models, as well as in real life, characterization of forage fibre is critical (8).

As it is clear from the review by Bailey (3), there is a limited body of information on structural carbohydrates collected on tropical grasses by application of "definitive" or direct chemical methods. Lesser information is available on the comparative composition of different grass species grown in the same environment.

The objective of the present study was to determine the effect of age on the content of structural carbohydrates and protein, and on the *in vitro* digestibility of several important tropical grasses.

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Materials and methods

The experiment was located in the State of Minas Gerais, Brazil. The soil was classified as a red-yellow latosol. Soil acidity was corrected by application of 700 kg/ha of lime. At planting time, 300 kg/ha of ammonium sulfate, 450 kg/ha of superphosphate and 150 kg/ha of potassium chloride were applied. The experiment began 11 months after planting.

A randomized complete block design with three replications was used. Mainplots consisted of eight grasses, and the subplots were allocated to four ages of harvesting: 21, 42, 63 and 84 days. The species were coded as follows: M = *Melinis minutiflora* Beauv.; J = *Hyparrhenia rufa* Ness, Stapf; T = *Panicum maximum* Jacq. var. *trichoglume*; G = *Panicum maximum* Jacq, var. *gongyloides*; R = *Chloris gayana* Kunth; SN = *Setaria sphacelata* Schum cv. Nandi; SK = *Setaria sphacelata* Schum cv. Kazungula, and N = *Pennisetum purpureum* Schum. Harvests at the different ages were made during the rainy season, after a cut of uniformization made on November 11, 1977.

Samples were dried at 55°C for 48 h in a forced draft oven. Nitrogen was analyzed by Kjeldhal and the *in vitro* dry matter digestibility (IVDMD) by the procedure of Tilley and Terry (14). Cellulose (CEL) and hemicellulose (HCEL) were determined as suggested by Bailey (2). The *in vitro* fermentation of cellulose and hemicellulose (IVCELD and IVHCELD) was determined by analyzing the residues of IVDMD for these two carbohydrates.

The data was subjected to standard analysis of variance and regression.

Results

Chemical composition was modified by age in all species. The content of CP decreased with age (Fig. 1) at rates (Tables 1) that differed between grasses ($P < 0.05$). The mean HCEL content was different between species, while that of CEL was fairly uniform (Table 1). The mean ratio of the two carbohydrate was 1.34 ± 0.12 and was not affected by age, except in species T in which it decreased significantly ($P < 0.05$) with increasing maturity. Both carbohydrates increased with age (Fig. 2 and 3); in the case of HCEL the rate of increase did not differ between species ($P > 0.05$; Table 1) and a single coefficient of 0.121 ± 0.012% day^{-1} was appropriate for all grasses. On the other hand, the rate of increase of CEL with age was characteristic of each species (Table 1).

There were large differences between species in *in vitro* digestibility (Table 2) but the effect of age was similar in all cases. No significant differences ($P > 0.05$) were observed in the rates of decrease of DM, HCEL and CEL digestibilities with age. Average regression coefficients were – 0.311 ± 0.013, – 0.304 ± 0.021 and – 0.304 ± 0.014 units per day respectively.

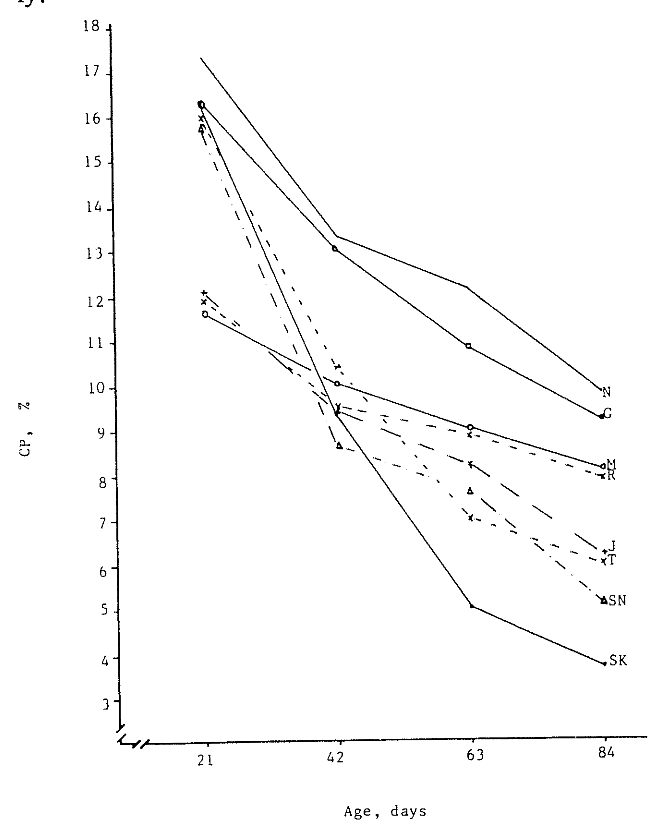

Fig. 1. Effect of age on the crude protein content of eight tropical grasses.

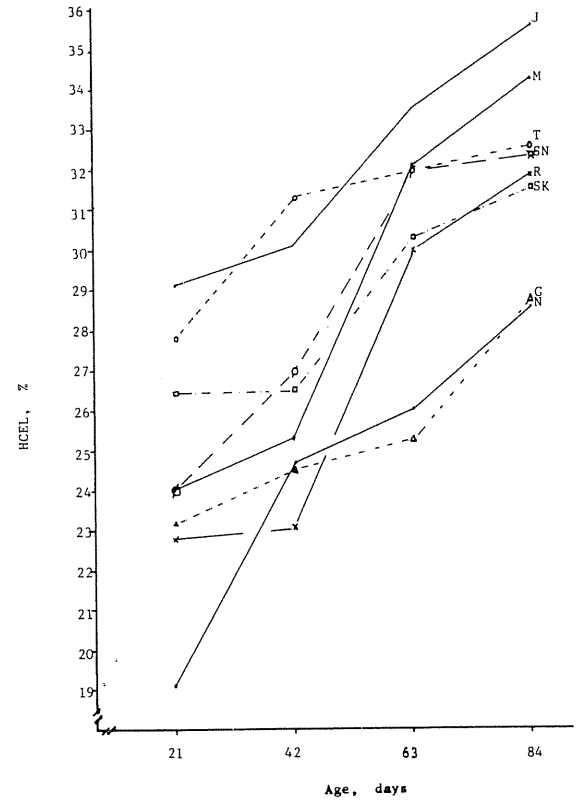

Fig. 2. Effect of age on the content of hemicellulose of eight tropical grasses.

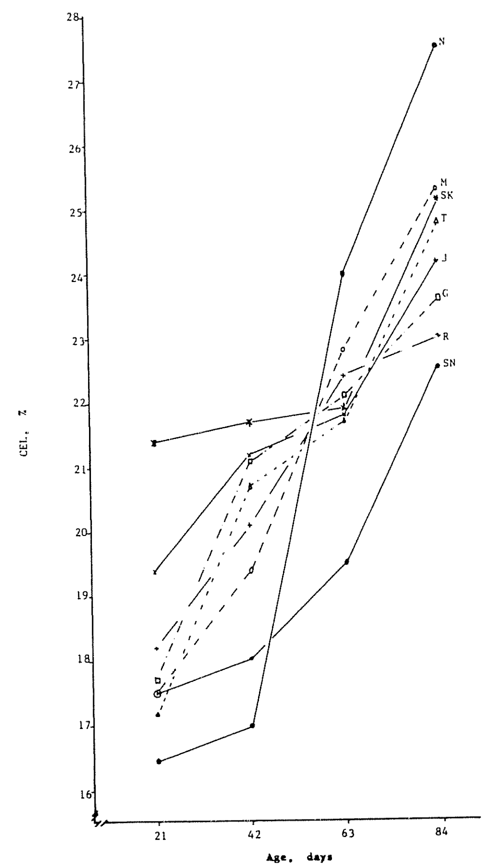

Fig. 3. Effect of age on the cellulose content of eight tropical grasses.

Table 1. Linear regressions of chemical composition on days of age

Species	Mean	Parameters of equation b_0	b_1	r^2	P
			% Crude Protein		
M	7.43	12.55	−0.055 ± 0.0054	0.98	0.05
J	8.98	13.70	−0.090 ± 0.0041	0.98	0.05
T	9.98	18.05	−0.154 ± 0.0354	0.90	0.10
G	12.33	18.20	−0.112 ± 0.0129	0.97	0.05
SN	9.23	17.55	−0.158 ± 0.0463	0.87	0.10
SK	8.58	19.10	−0.201 ± 0.0429	0.92	0.05
R	9.55	12.70	−0.060 ± 0.0078	0.92	0.05
N	13.13	19.05	−0.113 ± 0.0183	0.95	0.05
			% Cellulose		
M	21.25	14.55	0.128 ± 0.0093	0.99	0.01
J	21.65	17.90	0.071 ± 0.0111	0.95	0.05
T	21.10	15.15	0.113 ± 0.0158	0.96	0.05
G	21.15	16.50	0.089 ± 0.0185	0.92	0.05
SN	19.43	15.25	0.080 ± 0.0191	0.90	0.10
SK	22.55	19.65	0.055 ± 0.0250	0.71	0.20
R	21.13	17.15	0.076 ± 0.0159	0.92	0.05
N	21.18	11.10	0.192 ± 0.0461	0.92	0.05
			% Hemicellulose		
M	28.93	19.50	0.180 ± 0.0347	0.93	0.05
J	32.10	26.55	0.110 ± 0.0403	0.96	0.05
T	30.93	27.15	0.072 ± 0.0263	0.82	0.10
G	25.45	21.05	0.084 ± 0.0184	0.90	0.05
SN	28.88	21.30	0.144 ± 0.0309	0.92	0.05
SK	28.70	23.85	0.092 ± 0.0227	0.89	0.10
R	26.95	18.40	0.163 ± 0.0408	0.89	0.10
N	24.60	17.15	0.142 ± 0.0294	0.92	0.05

Holocellulose digestibility was computed as a weighted average of HCEL and CEL digestibilities, and as before, the effect of age was pronounced (Fig. 4) The contribution of digestible holocellulose (DHOLO, Table 2) to digestible dry matter varied between species and ages. This effect is shown in Fig. 5 as a function of IVDMD. The correlactions between IVDMD and holocellulose digestibility (not shown) were as high or higher than those of IVDMD with age.

Discussion

There were fairly large and generally significant differences between several of the species examined in terms of chemical composition. As shown in Table 1, age was a major factor in influencing composition.

The content of structural carbohydrates, although fairly high, was not as high as suggested by results obtained when neutral and acid detergents have been employed (e. g., 10). Also, in the latter case, the effect of age on the contents of cellulose and hemicellulose estimated from NDF, ADF and acid detergent lignin, does not appear to be clear cut; this may be a consequence of the well known defficiencies of the Van Soest procedure for estimating quantitatively these structural carbohydrates (4). It is clear from the reviews by Sullivan (13) and Bailey (3) that direct chemical methods have not been extensively applied to tropical grasses in a systematic way, and therefore comparison with our results is difficult. It is well established that when studying the effect of age, long-term comparisons (200 to 300 days) of yield rates decrease in CP, or increase in HCEL and CEL, that are smaller than those observed over shorter intervals (5, 10, 11). This effect is quite clear in the data of Gomide *et al.* (6) who showed a more pronounced increase in cellulose and decrease in protein content of six tropical grasses during the first

Table 2. **Mean *in vitro* digestibilities of dry matter (IVDMD), hemicellulose (IVHCELD) and cellulose (IVCELD) and the contribution of digestible holocellulose of digestible dry matter (DHOLO).**

Species	IVDMD	IVHCELD	IVCELD	DHOLO
M	51.4	59.8	57.8	57.9
J	58.8	64.0	60.3	57.2
T	63.9	71.7	68.1	57.6
G	52.5	55.5	54.2	48.4
R	60.9	70.1	63.0	53.3
SN	63.8	73.3	68.4	54.3
SK	60.9	71.3	63.9	57.7
N	67.3	74.2	71.7	49.7
Tukey, 5%	7.6	11.4	9.8	6.6

12 weeks of growth, than later on. The same comment applies to the behaviour of *in vitro* digestibility of cellulose (6).

The present study has confirmed that, contrary to temperate grasses, tropical species have a higher HCEL content than that of CEL (13). Further, there appears to be larger differences in HCEL between species, than in CEL content. Also, the behaviour of the former with age appears to be even more species-dependent than that of CEL. It should be noted that when the Van Soest procedure has been used, the calculated HCEL content has been higher (10) or much lower (12) than that of CEL, while the effect of age on chemical composition has been erratic (10).

The results in Table 1 also suggest that species such as N, that at early ages are low in structural carbohydrates and high in protein, change their chemical composition at faster rates than species such as J, which are, at least in terms of chemical composition, of lower quality at those same ages.

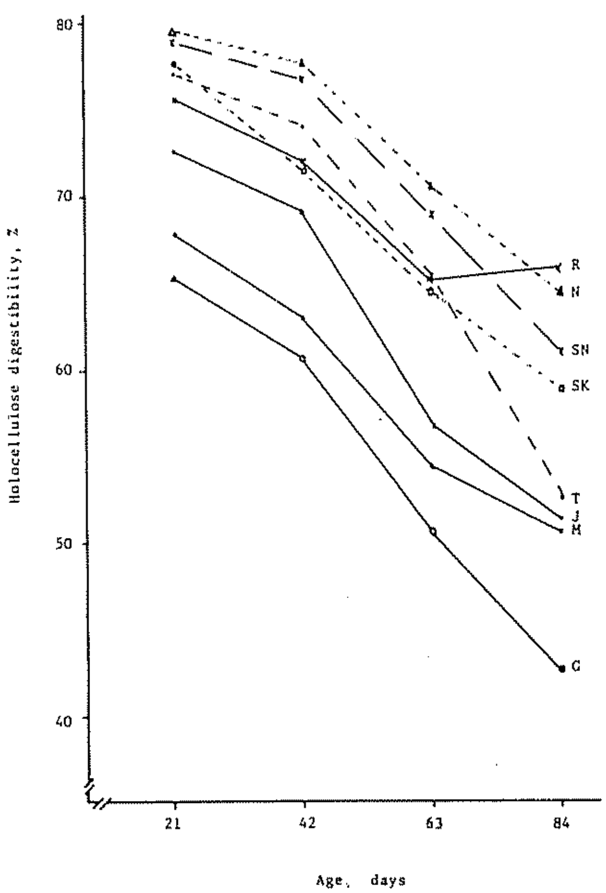

Fig. 4. Holocellulose digestibility as a function of age.

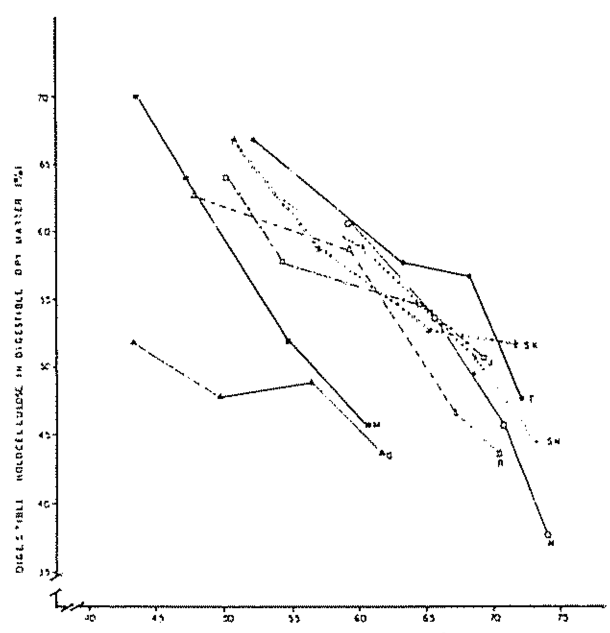

Fig. 5. Contribution of digestible holocellulose to the digestible dry matter, as a function of dry matter digestibility.

Differences in chemical composition were generally reflected on the *in vitro* digestibility of the species under study. Although the observation of Pezo and Vohnout (10) that the effect of age on *in vitro* digestibility is more pronounced than that of species is esentially correct, there were some large and significant differences between grasses. Generally, species such as N were clearly superior to M or J, although the effect of age was similar in all of them (Table 2). In agreement with Raymond (11), the rate of decrease in digestibility with age observed in this experiment was larger than those reported in longer term studies (6, 9). Also, not surprisingly, the rate of decrease in IVDMD was almost identical to that of IVHCELD and IVCELD. A little discussed but frequently reported aspect, is the higher digestibility of structural carbohydrates found when compared *in vitro* with that of dry or organic matter (Table 2, 1, 7).

The composition of the digestible dry matter has been suggested as a major factor influencing voluntary intake of roughages (11), due to the effect of the digestible structural carbohydrates on the rates of fermentation and passage of the potentially digestible organic matter. Our results (Table 2 and Figure 5) indicate important differences between species. Comparison between species at a similar digestibility, as suggested by McLeod and Minson (7), may give contradictory results depending upon the digestibility choosen, since as shown in Figure 5, there are large differences between species in the relationship of dry matter digestibility and composition of the digestible dry matter. Furthermore, the effect of age on this relationship is fairly species-dependent, at least in some of the grasses studied. Also, it is evident that for a given content of digestible holocellulose in the digestible dry matter, a very wide range of IVDMD is possible.

This paper has shown that there is considerable variation in chemical composition and digestibility of tropical grasses, but that the effect of age is consistent and predictable. It has also indicated the existence of inherent differences in structural carbohydrate digestibility, either when compared at the same age or at similar dry matter digestibilities, factors which could account for substantial differences in animal performance.

Resumen

Se estudió el efecto de la edad (21, 42, 63, 84 días) sobre la composición química y digestibilidad *in vitro* de ocho gramíneas tropicales. El contenido de proteína disminuyó con el aumento de la edad en todas las especies, pero a diferente velocidad en diferentes pastos. Los carbohidratos estructurales aumentaron con la edad en todas las especies; el contenido de hemicelulosa fue diferente entre especies y el de celulosa fue bastante uniforme. La relación media entre ambos fue de 1.34 ± 0.12. Hubo diferencias considerables entre especies en digestibilidad *in vitro* de la materia seca, pero el efecto de la edad fue semejante para todas ellas. La tasa de disminución de la digestibilidad de materia seca, hemicelulosa y celulosa fue de 0.311 ± 0.013, 0.304 ± 0.021 y 0.304 ± 0.014 por día, respectivamente. El porcentaje de holocelulosa digestible en la materia seca digestible varió entre especies y edades, oscilando entre 38 y 70%

Summary

The effect of age (21, 42, 63, 84 days) on chemical composition and *in vitro* digestibility of eight tropical grasses was studied. Crude protein decreased with age at different rates in different species. Structural carbohydrates increased with age in all the grasses; the content of hemicellulose was different between grasses but that of cellulose was fairly uniform. The mean ratio between the two carbohydrates was 1.34 ± 0.12. Large differences in *in vitro* dry matter digestibility were observed between species, but the effect of age was similar in all of them. The mean daily rate of decrease in dry matter, hemicellulose and cellulose digestibility was 0.311 ± 0.013, 0.304 ± 0.021 and 0.304 ± 0.014 respectively. The content of digestible holocellulose in the digestible dry matter was variable between species and ages, ranging from 38 to 70%.

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