Revista Brasileira de Zootecnia

ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.39, n.7, p.1538-1547, 2010

Fractions of carbohydrates and of nitrogenous compounds of tropical grasses at different cutting ages[1]

Patrícia Regina de Souza Siqueira Campos[2], José Fernando Coelho da Silva[3], Hernán Maldonado Vásquez[3], Andréa Vittori[4], Martinho de Almeida e Silva[5]

[1] *Pesquisa parcialmente financiada pela FAPERJ.*
[2] *Doutoranda - LZNA-CCTA-Universidade Estadual do Norte Fluminense.*
[3] *LZNA-CCTA-Universidade Estadual do Norte Fluminense. Pesquisador do CNPq.*
[4] *Faculdade Filadélfia – Ribeirão Preto - SP.*
[5] *Universidade Federal de Minas Gerais. Pesquisador do CNPq.*

ABSTRACT - It was evaluated by the Cornell System carbohidrates fractions and nitrogenous compounds of the following grasses at the cutting ages of 14, 28, 42, and 56 days: nilo grass (*Acroceras macrum*), angola grass (*Brachiaria purpurascens)*, aleman grass (*Echinochloa polystachya)*, limpo grass (*Hemarthria altíssima*), setaria grass (*Setaria anceps*), tanner grass (*Brachiaria arrecta)*, and tifton-85 grass (*Cynodon* spp). The experiment was carried out in a complete randomized block design, in a split plot arrangement in a way that the grasses were evaluated in the plots and the ages of cut in the split-plots. The age of cutting had an effect on the composition of the studied grasses. In most of the grasses, total carbohydrate levels, non-fibrous carbohydrates and $A+B_1$ fraction carbohydrates increased linearly according to the age of cutting. The potentially degradable fraction of carbohydrates (fraction B_2) showed a quadratic behavior according to the cutting ages for all grasses. The C fraction of the carbohydrates in tifton-85 grass linearly increased with the age but it did not increase significantly for the other grasses. In setaria grass, the intermediate levels of B_2 and B_3 nitrogenous fractions were high, which might represent a potential source of protein for ruminal degradation and for the small intestine. Except for setaria grass, all studied grasses show similar values of the A, B_1, B_2 and B_3 nitrogenous fractions.

Key Words: chemical composition, Cornell system, forage, neutral detergent fiber, protein

Fracionamento de carboidratos e compostos nitrogenados de gramíneas tropicais em diferentes idades de corte

RESUMO - Avaliaram-se pelo Sistema Cornell as frações de carboidratos e os compostos nitrogenados dos capins acroceres (*Acroceras macrum*), angola, (*Brachiaria purpurascens)*, canarana (*Echinochloa polystachya*), hemarthria (*Hemarthria altíssima*), setária (*Setaria anceps*), tanner grass (*Brachiaria arrecta)* e tifton 85 (*Cynodon* spp) nas idades de corte de 14, 28, 42 e 56 dias. O experimento foi conduzido em blocos ao acaso em esquema de parcelas subdivididas de modo que as gramíneas foram avaliadas nas parcelas e as idades de corte, nas subparcelas. Houve efeito da idade de corte na composição dos carboidratos das gramíneas estudadas. Na maioria das gramíneas, os teores de carboidratos totais, carboidratos não-fibrosos e da fração $A+B_1$ aumentaram linearmente conforme a idade de corte. A fração potencialmente degradável dos carboidratos (fração B_2) apresentou um comportamento quadrático em função da idade, para todas gramíneas. A fração C dos carboidratos do capim-tifton 85 apresentou aumento de forma linear com a idade, mas não aumentou de forma significativa para as demais gramíneas. No capim-setária, os teores médios das frações nitrogenadas B_2 e B_3 foram elevados, o que pode representar um bom aporte protéico para degradação ruminal e para o intestino delgado. Todas as gramíneas avaliadas, à exceção do capim-setária, apresentam valores similares das frações nitrogenadas A, B_1, B_2 e B_3.

Palavras-chave: composição química, fibra detergente neutro, forrageira, proteína, sistema Cornell

Introduction

The quality of the grass forage used in animal feeding is measured by its nutritional value. Recently, in addition to the values of chemical composition, it has been used the proportions of the fractions potentially digestible of carbohydrates and the nitrogenous compounds (Hall, 2007).

Researches have been done in order to characterize the foods based on their composition and to know the interactions between levels of food intake and the profile of

Received August 11, 2009 and accepted October 5, 2009.
Corresponding author: jcoelho@uenf.br

absorbed nutrients, as well as the interactions of the flow of nutrients in the duodenum and the diet consumption (Gill et al., 1989). The accurate estimate of the fractions in the foods has been used to supply databases of tropical foods and consequently to balance ruminant diets.

The systems of nutritional requirements based on metabolizable energy (AFRC, 1993), total digestible nutrients (NRC, 2001) and CNCPS (Cornell Net Carbohydrate and Protein System, Sniffen et al., 1992) have practical application in balancing and evaluating of diets for ruminants. The Cornell system is based on the availability of energy coming from carbohydrates and from nitrogenous compounds for maximization of the microbial growth in the rumen.

CNCPS considers that foods are composed by carbohydrates, crude protein, fat, ash and water. Crude protein involves three categories: non-protein nitrogenous compounds (NPNC), known as the A fraction; true protein, which is B fraction; and the protein linked to the other components , which is C fraction, which represents the acid detergent insoluble protein (ADIP) not available for the digestion (Fox et al., 2004).

The B fraction of the proteins is subdivided in three parts, according to the rumen degradability: B_1, B_2 and B_3 for fast, moderate, and slow rate of rumen degradation, respectively.

Carbohydrates are fractionated into sugars (A fraction), pectic substances (fraction B_1), potentially degraded structural carbohydrates (B_2 fraction), and the undigested fiber that is calculated by the lignin level multiplied by the factor 2.4 (C fraction).

It is important to consider that the adequate ages of cutting allows the rational exploration of the productive potential and the nutritional value of the plant. Plant tissues became lignified as age increases, changing the composition of the cellular wall of the vegetables (Akin & Burdick, 1975).

The objective of the present research was to evaluate the composition of the carbohydrate fractions and the nitrogenous compounds of aleman grass, nilo grass, tanner grass, angola grass, limpo grass, setaria grass, and tifton-85 grass under different cutting ages.

Material and Methods

The experiment was carried out in the Laboratório de Zootecnia e Produção Animal of the Universidade Estadual do Norte Fluminense – Rio de Janeiro, Brazil. Aleman grass (*Echinochloa polystachya*, Hitch), nilo grass (*Acroceras macrum*, Stapf.), tanner grass (*Brachiaria arrecta* (Hack. former T. Durand & Schinz) Stent.), angola grass (*Brachiaria purpurascens*, Henr.), limpo grass (*Hemarthria aliíssima*, Swamp Couch), setaria grass (*Setaria anceps*, Stapf. former Massey) and tifton-85 grass (Cynodon spp) were grown in an experimental area that was divided in three blocks of 35 × 2.5 m (87.5 m^2 / block). Each block contained seven plots measuring 5 × 2.5 m (total of 12.5 m^2), spaced by 1.5 m from each other. In each plot, four areas of 1.25 × 2.50 m were delimited (total 3.125 m^2), for each cutting age, with a central area of 0.75 × 1.5 (1.125 m^2).

The cuts were performed 10 cm above the soil surface, at the ages of 14, 28 42 and 56 days of regrowth. Grass samples were dried in forced ventilation oven at 55ºC for 72 hours and grounded into 1-mm particle size for determination of the chemical composition. The analyses of the dry matter (DM), crude protein (CP), mineral matter (MM), ether extract (EE), lignin (LIG), neutral detergent fiber (NDF), neutral detergent fiber corrected for ashes and protein (NDFap), acid detergent fiber (ADF), neutral detergent insoluble nitrogen (NDIN), acid detergent insoluble nitrogen (ADIN) were performed according to the methodology described by Silva & Queiroz (2004). The values of neutral detergent insoluble protein (NDIP) and acid detergent insoluble protein (ADIP) were calculated by multiplying the factor 6.25 by the levels of NIDN and ADIN of the sample, respectively (Table 1).

The total carbohydrates (TCH) and the $A+B_1$, B_2 and C fractions were calculated as described by Sniffen et al. (1992) as it follows: $TCH_{(\% DM)} = 100 - CP_{(\% DM)} - EE_{(\% DM)} - MM_{(\% DM)}$; $B_2 = 100 * (NDF_{(\% DM)} - NDIP_{(\% CP)} * 0.01 * CP_{(\% DM)} - NDF_{(\% DM)} * 0.01 * LIG_{(\% NDF)} * 2.4) \div TCH_{(\% DM)}$; $A + B_1 = 100 - (C + B_2)$; $C = (100 * NDF_{(\% DM)} * 0.01 * LIG_{(\% NDF)} * 2.4) \div TCH_{(\% DM)}$.

The $A+B_1$ fraction, considered as the non structural carbohydrates (NSC) was also obtained as: NSC = OM - (CP + EE + NDFap) and organic matter (OM) = DM - MM.

The nitrogenous compounds of the grasses were divided into A fraction (non protein nitrogen), B_1 fraction (peptides and polypeptides), B_2 fraction (cytoplasmatic proteins), B_3 fraction (neutral detergent insoluble proteins) and C fraction (acid detergent insoluble proteins), according to Krishnamoorthy et al. (1983); Licitra et al. (1996) and Malafaia & Vieira (1997).

The statistical analysis was carried out according to a complete randomized block design, in a split plot arrangement with three replications, so that the grasses were allocated in the main plots and the cutting ages in the split plots. The results were interpreted statistically through variance analysis. The means of the grasses were compared by the Tukey's test and the effects of cutting

Table 1 - Chemical composition of the grasses at different cutting ages, expressed on dry matter basis

Cutting ages (days)	Dry matter(%)	Crude protein	Ether extract	Neutral detergent fiber	Acid detergent fiber	Mineral matter	Neutral detergent insoluble protein	Acid detergent insoluble protein
		% dry matter						
					Aleman grass			
14	10.17	22.96	3.80	55.72	36.45	13.89	16.22	3.53
28	11.13	15.95	5.13	49.42	40.22	13.84	11.19	3.41
42	17.40	9.50	4.89	58.85	42.58	9.86	5.56	2.04
56	24.04	5.35	5.25	65.88	46.54	8.96	2.34	1.31
					Nilo grass			
14	11.54	24.48	4.23	55.00	36.53	14.51	18.94	3.58
28	9.67	18.44	3.68	52.18	38.75	12.59	11.41	3.53
42	15.03	15.36	4.62	44.56	39.27	13.50	7.77	1.94
56	22.30	13.15	5.35	45.09	43.25	8.52	5.16	1.56
					Tanner grass			
14	9.75	24.34	2.71	57.56	35.72	10.36	17.99	5.68
28	10.69	17.97	3.37	47.74	36.37	10.50	12.76	5.86
42	17.19	10.21	4.81	57.47	40.24	8.10	6.02	2.59
56	23.90	8.70	4.03	52.07	41.73	8.13	3.71	1.72
					Angola grass			
14	12.60	21.21	3.41	56.81	36.67	19.12	14.69	4.62
28	11.13	16.72	3.72	51.35	37.07	15.99	11.53	3.32
42	16.48	11.54	4.48	42.36	38.85	13.92	6.75	2.03
56	21.65	8.86	1.79	58.07	42.71	9.65	4.89	1.66
					Limpo grass			
14	11.93	16.66	4.01	49.53	42.00	13.80	13.41	7.87
28	10.16	13.90	2.84	45.98	41.54	9.54	10.98	6.63
42	16.29	8.47	4.38	56.90	41.05	6.83	5.63	2.62
56	22.63	6.42	3.79	59.66	42.34	6.17	4.10	2.10
					Setaria grass			
14	9.83	21.44	7.23	58.09	33.42	13.01	12.66	2.67
28	8.54	15.57	3.20	51.94	37.81	12.27	9.87	2.70
42	12.14	11.34	3.77	57.19	41.85	8.06	6.08	2.12
56	17.84	8.57	2.25	67.12	46.23	7.02	4.14	1.64
					Tifton-85 grass			
14	15.15	21.62	4.01	55.80	24.40	12.59	12.53	3.65
28	14.10	16.14	4.49	45.40	37.48	9.83	10.45	3.26
42	20.01	11.51	3.91	68.18	41.35	7.78	6.52	2.47
56	27.79	8.11	1.68	68.00	44.09	7.85	3.96	1.81

ages were evaluated by regression analysis according to SAEG (UFV, 2000).

For the models of a same variable with significant coefficients, the selection was based on the polynomial model of higher degree. The variables were analyzed based in the following statiscal model: $Y_{ijk} = \mu + \rho_i + \alpha_j + \gamma_{ij} + \beta_k + (\alpha\beta ab)_{jk} + \varepsilon_{ijk}$, in which: Y_{ijk} is the variable of the block i (i = 1, 2, 3), relating to the grass j in the parcel (j = 1, 2, 3, 4, 5, 6, 7) and to the cutting age k is allocated in the sub parcel (k = 1, 2, 3, 4); μ= general average; ρ_i = effect of the block i; α_j = effect of grasses j in the parcel; γ_{ij} = random error of the parcel; β_k = effect of the cutting age k in the sub parcel; $(\alpha\beta)_{jk}$ = effect of the interaction between grass j and the cutting age k; ε_{ijk} = random error of the sub parcel, supposing NID ~ $(0, \sigma^2)$.

Results and Discussion

The levels of total carbohydrates were influenced (P<0.01) by the species of the forage and the cutting age. The level of total carbohydrates of the setaria grass showed a quadratic behavior as a function of the cutting age, while the other grasses showed linear increase. The maximum level of total carbohydrates of the setaria grass was estimated on the 76th day of age, equal to 84.85%. Daily increases in the levels of total carbohydrates of nilo grass, tanner grass, limpo grass, tifton-85 grass, aleman grass and angola grass were 0.36; 0.42; 0.44; 0.49; 0.53 and 0.55 percent units, respectively.

Usually ruminant diets are based on carbohydrates, for this reason it is nutritionally important to know the fractions that compose the total carbohydrates present in the foods. For this comparison, the levels of the carbohydrate fractions were expressed in percentage of the total carbohydrates.

Limpo grass presented high levels of total carbohydrates for all cutting ages. The means of each grass, in each cutting age (Table 2) showed that the largest level of total carbohydrates was found in limpo grass when compared to the nilo grass and angola grass on the 14^{th} day. However, on the 28^{th} day, limpo grass showed higher levels of total carbohydrates than nilo grass, aleman grass and angola grass. At the cutting age of 42 days, the levels of total carbohydrates of the limpo grass was higher than the levels of nilo grass. Nevertheless, on the 56^{th} day, the levels of total carbohydrates of limpo grass, in tifton-85 grass and in the setaria grass were larger than those of the nilo grass.

The values for limpo grass were similar to those found by Lacerda et al. (2004) in a study done in a coastal slope area in Rio de Janeiro,in which the levels of total carbohydrates varied from 78.88% to 83.97% of dry matter. In a similar way, Henriques et al. (2007a), when studying nilo grass, angola grass, limpo grass, and setaria grass found similar average values for total carbohydrates at the cutting ages of 28, 42 and 56 days.

The estimates of the level of total carbohydrates of tifton-85 grass calculated using the regression equation at the age of 60 days obtained the value of 84.78%. This is higher than the observed by Malafaia et al. (1996) at the same cutting age (79.63%).

In the fractioning of the carbohydrates according to the Cornell system, the non-structural carbohydrates (NSC) include A fraction (sugars) and B_1 fraction (starch and soluble fibrous compounds) (Sniffen et al., 1992).

In this study, the levels of non-structural carbohydrates differed among the grasses (P<0.05) and among cutting ages (P<0.01), but the Tukey's test did not detect effect of the cutting age on the levels of non-structural carbohydrates in aleman grass, limpo grass and tifton-85 grass (Table 3).

The maximum level of non structural carbohydrates of angola and setaria grasses was estimated to occur on the 42^{nd} and 39^{th} days and to be 26.54 and 21.25%, respectively. The daily increases of non-structural carbohydrates of the nilo grass and tanner grass were of 0.39 and 0.28 percent units, respectively.

The means of the grasses in each cutting age (Table 3) show that only on the 56^{th} day they differed (P<0.05) on the level of non-structural carbohydrates, with the nilo grass presenting the highest level, and the aleman grass, the lowest value among the grasses.

From all forages evaluated, the percentage of non-structural carbohydrates, on average, represents only a small part of the total carbohydrates. Vieira et al. (2000) evaluated the level of non-structural carbohydrates in native pasture in the east part of Minas Gerais State (Brazil) and they found means of non-structural carbohydrates ranging from 12.5% to 15%, in the dry and rainy seasons of the year, respectively.

Tropical grasses, in general, have relatively low levels of non-structural carbohydrates because they accumulate these carbohydrates in the roots and in the base of the stem, and this process usually happens in an inverse proportion to the leaves production (Wilson, 1975). Quantitatively, starch is the most important non-structural carbohydrates, and it appears in reduced levels in the aerial part of the tropical forages. Such grasses present thicker cellular wall, with high proportions of the following tissues: xylem, esclerenchyma, and parenchymatic sheath of the vascular bunches (Akin, 1989).

The levels of the $A+B_1$ fraction calculated by the difference $NSC = 100 - (B_2 + C)$ showed a behavior similar to that calculated using the formula of NSC = OM - (CP + EE + NDFap). There was a difference among cutting ages (P<0.01) in the levels of the $A+B_1$ fraction and a significant interaction among grasses and cutting age (P <0.05). The levels of the $A+B_1$ fraction of the nilo grass and tanner grass presented

Table 2 - Levels of total carbohydrates (TCH, % DM) of the grasses and their respectives regression equations, in relation to the cutting age (x, in days)

Grass	Cutting age (days)					Equation[1]	r^2
	14*	28*	42**	56*	Mean		
Aleman grass	59.34ab	65.08b	75.75ab	80.44ab	70.15	$\hat{y}$ = 51.66 + 0.53x**	0.91
Nilo grass	56.78b	65.29b	66.52c	72.98b	65.39	$\hat{y}$ = 52.93 + 0.36x**	0.62
Tanner grass	62.60ab	68.16ab	76.87ab	79.13ab	71.69	$\hat{y}$ = 57.11 + 0.42x**	0.86
Angola grass	56.27b	63.57b	70.05bc	79.70ab	67.40	$\hat{y}$ = 48.20 + 0.55x**	0.86
Limpo grass	65.53a	73.73a	80.32a	83.63a	75.80	$\hat{y}$ = 60.58 + 0.44x**	0.92
Setaria grass	58.32ab	68.96ab	76.82ab	82.16a	71.56	$\hat{y}$ = 45.09 + 1.04x** - 0.0068x^2*	0.97
Tifton 85 grass	61.78ab	69.54ab	76.80ab	82.35a	72.62	$\hat{y}$ = 55.38 + 0.49x**	0.98

Means followed by the same letter, in the same column do not differ by Tukey's test.
Significant at 1% (**) and 5% (*) of probability.
[1]$\hat{y}$ in % DM.

Table 3 - Levels of carbohydrate fractions of the grasses and the respective regression equations as a function of cutting ages (x, in days)

Grass	Cutting ages					Equation[2]	r^2	P values
	14 days	28 days	42 days	56* days	Mean			
Non structural carbohydrates (% of TCH)[1]								
Aleman grass	11.05a	17.47a	16.88a	10.46b	13.96	$\hat{Y}$ = 13.96	-	P>0.05
Nilo grass	13.55a	16.78a	25.04a	28.98[a]	21.09	$\hat{Y}$ = 7.45 + 0.39x**	0.59	-
Tanner Grass	12.14a	24.66a	19.95a	26.59ab	20.84	$\hat{Y}$ = 11.17 + 0.28x*	0.19	-
Angola	11.56a	19.82a	29.19a	21.38ab	20.49	$\hat{Y}$ = -9.29 + 1.71x** - 0.0204x^2*	0.51	-
Limpo grass	25.28a	30.33a	23.39a	23.60ab	25.65	$\hat{Y}$ = 25.65	-	P>0.05
Setaria	7.35a	18.00a	20.55a	13.69ab	14.90	$\hat{Y}$ = -12.37 + 1.72x** - 0.022x^2*	0.45	-
Tifton-85	11.25a	25.87a	11.98a	14.36ab	15.86	$\hat{Y}$ = 15.86	-	P>0.05
Fraction A+B_1 (% of TCH)								
Aleman grass	12.38a	26.75a	23.01ab	18.25a	20.10	$\hat{Y}$ = 20.10	-	P>0.05
Nilo grass	11.25a	23.27a	33.76ab	39.14a	26.85	$\hat{Y}$ = 3.32 + 0.67x**	0.79	-
Tanner grass	14.91a	33.37a	26.03ab	34.73a	27.26	$\hat{Y}$ = 14.23 + 0.37x*	0.19	-
Angola	4.25b	22.15a	40.30a	27.79a	23.62	$\hat{Y}$ = -36.59 + 3.35x**-0.039x^2**	0.72	-
Limpo grass	27.78a	39.69a	29.67ab	29.18a	31.58	$\hat{Y}$ = 31.58	-	P>0.05
Setaria	4.95a	27.00a	26.60ab	18.73a	19.32	$\hat{Y}$ = -28.33 + 2.96x** -0.038x^2**	0.62	-
Tifton-85	14.06a	37.16a	12.14b	17.82a	20.30	$\hat{Y}$ = 20.30	-	P>0.05
Fraction B_2 (% of TCH)								
Aleman grass	62.24a	46.74ab	42.53a	51.33a	50.71	$\hat{Y}$ = 90.32 – 2.43x** + 0.031x^2**	0.76	-
Nilo grass	66.02a	48.85a	36.67a	31.89b	45.86	$\hat{Y}$ = 74.49 – 0.82x**	0.86	-
Tanner grass	59.22a	40.94ab	46.65a	38.07ab	46.22	$\hat{Y}$ = 60.65 – 0.41x**	0.34	-
Angola	66.28a	54.21a	41.88a	47.70ab	52.52	$\hat{Y}$ = 91.90 – 2.08x** + 0.023x^2*	0.61	-
Limpo grass	37.08b	26.71b	47.02a	40.85ab	37.92	$\hat{Y}$ = 37.92	-	P>0.05
Setaria	74.63a	48.36a	36.90a	52.79a	53.17	$\hat{Y}$ = 125.12 – 4.31x** + 0.054x^2**	0.85	-
Tifton-85	63.61a	43.12ab	46.10a	49.87ab	50.68	$\hat{Y}$ =90.57 – 2.44x** + 0.031x^2*	0.53	-
Fraction C (% of TCH)								
Aleman grass	25.38a	26.51a	34.46ab	30.43a	29.19	$\hat{Y}$ = 29.19	-	P>0.05
Nilo grass	22.73a	27.89a	29.57ab	28.97a	27.29	$\hat{Y}$ = 27.29	-	P>0.05
Tanner grass	25.87a	25.69a	27.32ab	27.20a	26.52	$\hat{Y}$ = 26.52	-	P>0.05
Angola	29.47a	23.64a	17.82b	24.50a	23.86	$\hat{Y}$ = 23.86	-	P>0.05
Limpo grass	35.14a	33.60a	23.31ab	29.96a	30.50	$\hat{Y}$ = 30.50	-	P>0.05
Setaria	20.42a	24.64a	36.50ab	28.48a	27.51	$\hat{Y}$ = 27.51	-	P>0.05
Tifton-85	22.32a	19.72a	41.76a	32.30a	29.03	$\hat{Y}$ = 16.03 + 0.37x*	0.31	-

[1]Non structural carbohydrate = OM - (CP + EE + NDFap).
Means followed by the same letter, in the same column do not differ by Tukey's test.
Significant at 1% (**) and 5% (*) of probability.
[2]$\hat{Y}$ in % DM.
TCH = Total carbohidrates.

a linear increase as a function of the cutting age while for the angola and setaria grasses they presented a quadratic behavior. The equations of linear and quadratic regression of the aleman grass, limpo grass and tifton-85 grass were not significant (Table 4); the same was true for the non structural carbohydrates (Table 3).

On the 14^{th} day, the level of the A+B_1fraction of the angola grass was smaller than the others grasses, while on the 42^{nd} day, it was larger than that of tifton-85.

The values calculated for the A+B1 fraction using the equation A + B1 = 100 - (C + B2) seems to overestimate, on average, the levels of NSC, although the tendency of the regression equations, in function of the cutting age, have been similar.

The non-structural carbohydrates (A+B_1 fraction) are sources of quickly available energy, because these carbohydrates are rapidly digested by ruminal microorganisms. B_2 fraction includes carbohydrates of slow degradation, which is the potentially degradable neutral detergent fiber fraction (Sniffen et al., 1992).

B2 fraction (% TCH) differed among grasses and cutting ages and there was interaction between grasses and cutting age (P <0.01). The levels of this fraction in the aleman grass, angola grass, setaria grass and tifton-85 grass showed a quadratic behavior in function of the cutting age, while the nilo grass and tanner grass presented a linear decrease. The equations for linear and quadratic regression of limpo grass were not significant (Table 3).

The daily decreases of the B_2 fraction of the nilo grass and tanner grass were of 0.82 and 0.41 percent units, respectively, and the limpo grass showed an average value of 37.92%. In general, as the physiological age of the plant advanced, an increase of cell wall constituents was found with a consequent reduction in the levels of non-structural carbohydrates (Van Soest, 1994). The increase in the proportion of the B_2fraction is correlated with the level of neutral detergent fiber in the forage that supplies energy in a relatively slow rate causing an impact on the efficiency of microbial synthesis, consequently negatively interfering in the animal behavior.

On the 14th day, limpo grass presented the lowest level of B_2 fraction (% TCH). The levels of the B_2 fraction of tifton-85 grass at 28, 42 and 56 days of age (43.12; 46.10 and 49.87%, respectively) were smaller than those found by Ribeiro et al. (1998), for tifton-85 hay at the same cutting ages (87.45; 88.54 and 85.93%, respectively), and than those related by Malafaia et al. (1996) for tifton-85 grass at 60 days of age (74.38%), estimated by the regression equation obtained for this grass (Table 3) at the same cutting age (55.77%).

The C fraction corresponds to the non-degradable percentage of the neutral detergent fiber (Sniffen et al., 1992). The increase of this fraction results in a larger effect in the ruminal repletion and a decrease of the energy availability due to indigestibility along the digestive tract (Jung & Allen, 1995).

It should be noted that the digestibility of the fiber is not affected by the fibrous content, but rather by the non-digestible fraction, the digestion rate and passage rate. Therefore, it is interesting to reduce the non-digestible fraction of the cell wall of forages to provide animals sources of a good rumen degradability fiber (Jung & Allen, 1995).

For the carbohydrate C fraction, which is considered unavailable in the rumen and intestines (Sniffen et al., 1992; Mertens, 1993), it was found, in this study, an interaction among grasses and cutting ages ($P<0.05$). The level of the C fraction of the tifton-85 grass showed a linear increase as a function of the cutting ages while the regression equations for the others grasses were not significant (Table 3).

The daily increment of the C fraction of the tifton-85 was of 0.37 percent units. Only on the 42nd day there was difference among the levels of the C fraction of the grasses. Tifton-85 presented larger level than angola grass. Ribeiro et al. (1998) found levels of the C fraction of tifton-85 hay at the ages of 28, 42 and 56 days at the values of 8.01; 9.43 and 10.79%, respectively, which were smaller than the values related in the present work, for the same ages (19.72; 41.76 and 32.30%); however Malafaia et al. (1996) observed higher level for tifton-85, on the 60th day of age (38.23%) compared with the estimated value by the regression equation from this work.

Levels of the C fraction of the total carbohydrates ranged from 30.50 to 23.86%. This fraction is composed by the unavailable cell wall, or non-digestible fiber, which is not used by ruminal microorganisms. In fact, it is undesirable to have high values because as plant age advances, the leaf area increases. In general, studies done on the morphogenic characteristics of these grasses show changes in the proportions of the vegetable tissues, explained by the thickness of the cell wall. Rosa et al. (1999), when studying angola grass, identified significant increases in the leaf:stem relationship, which were 0.22; 0.33; and 0.59 at the cutting ages of 14, 28 and 56 days, respectively.

Although the tanner grass showed low levels of C fraction, what would be an attractive characteristic, nutrionally speaking, its utilization has not been indicated because of a suspicion of intoxication in bovine. Besides, this is the favorite grass of thumbtack-grasses (*Blissus antillus*) in the states of Minas Gerais, Mato Grosso do Sul and Rio de Janeiro, because its vegetative propagation aids in the spread of the thumbtack (Tokarnia et al., 1997; Valério, 2000).

Gonçalves et al. (2003) evaluated the fractions of carbohydrates of Tifton 85 hay at the cutting ages of 28, 42, 63 and 84 days and they observed increases in the C fraction as age advanced, which ranged from 10.9 to 14.3%. This is due to an increased lignin fraction instead of the other fractions.

Therefore, studies that describes the kinetic parameters of degradation of these grasses are pertinent for a better characterization of their nutritional value. And the accuracy in the prediction of the animal requirements by CNCPS depends on the accuracy on the description of the feed composition.

The levels of the A fraction as a percentage of the crude protein were influenced by the forage species and cutting age ($P<0.01$). And in aleman grass, angola grass, limpo grass and tifton-85 grass, the levels of the A fraction showed a quadratic behavior in relation to the cutting age, while the nilo grass presented linear increases. The regression equations for tanner grass and setaria grass were not significant (Table 4).

The minimum levels of the A fraction of crude protein of the aleman grass, angola grass, limpo grass and tifton-85 grass were estimated to occur on the 39th and 40th, days of age and they were 18.49; 18.53; 4.45 and 19.95%, respectively. The daily linear increment of the A fraction of the nilo grass was of 0.24 percent units.

Ribeiro et al. (1998) reported levels for the A fraction of tifton-85 hay, on the 28th, 42nd and 56th days, of 24.63; 25.13 and 35.53%, respectively, which were larger than those observed in the present work for the tifton-85 grass at the same ages (20.82; 22.02 and 24.02%, respectively). Malafaia et al. (1997) observed a level of 17.38% for tifton-

Table 4 - Levels of the A fraction (% crude protein) of the grasses and the respective regression equations in relation to the cutting age (x, in days)

Grass	Cutting ages (days)					Equation[1]	r^2	P value
	14*	28**	42**	56**	Mean			
Aleman grass	28.79a	20.88ab	18.03ab	23.26ab	22.74	$\hat{y} = 44.03 - 1.31x^{**} + 0.0168x^{2**}$	0.63	-
Nilo grass	24.21ab	28.38a	27.13a	35.79a	28.87	$\hat{y} = 20.50 + 0.24x^{*}$	0.45	-
Tanner grass	27.15ab	25.06a	23.67a	30.31a	26.54	$\hat{y} = 26.55$	-	P>0.05
Angola grass	27.22ab	21.32ab	17.70ab	23.45ab	22.42	$\hat{y} = 40.72 - 1.15x^{*} + 0.0149x^{2*}$	0.29	-
Limpo grass	15.29b	6.80b	4.48b	8.34b	8.73	$\hat{y} = 29.97 - 1.27x^{**} + 0.0158x^{2*}$	0.59	-
Setaria grass	25.49ab	19.28ab	21.25a	24.89a	22.73	$\hat{y} = 22.73$	-	P>0.05
Tifton-85 grass	32.34a	20.82ab	22.02a	24.02ab	24.79	$\hat{y} = 47.63 - 1.38x^{**} + 0.0172x^{2**}$	0.31	-

Means followed by the same letter, in the same column do not differ by Tukey's test.
Significant at 1% (* *) and 5% (*) of probability. [1]$\hat{y}$ in % DM.

85, on the 60th day of age, which was smaller than the values presented in this research, described in Table 4 (26.75%).

Henriques et al. (2007b) observed reduced levels of non-protein nitrogen at advanced age of harvest for angola grass, nilo grass, limpo grass and setaria grass. This tendency was not observed for the referred grasses in this study.

The level of the B_1 fraction of the nitrogenous compounds was only influenced by the cutting age (P<0.01). Aleman grass, tanner grass, angola grass, limpo grass and setria grass showed a linear increment in the level of the B_1 fraction of the nitrogenous compounds, depending on the cut. However the regression equations for the others grasses were not significant (Table 5). The daily increments of the B_1 fraction in the crude protein of the setaria grass, tanner grass, angola grass, limpo grass and aleman grass were 0.11; 0.12; 0.14; 0.16 and 0.22 percent units, respectively.

The levels of the B_1 fraction in the tifton-85 on the 28th, 42nd and 56th days (8.60; 6.51 and 7.00%, respectively), were larger than the observed by Ribeiro et al. (1998) in tifton-85 hay, at the same ages (2.56; 2.72 and 0.24%, respectively) and by Malafaia et al (1997), for tifton-85 on the 60th day (2.54%).

The high proportions of the crude protein A and B_1 fractions, with their high digestion rates, can cause larger

Table 5 - Levels of the fractions B_1, B_2, and B_3 (% CP) of the grasses and the respective regression equations in relation to the cutting age (x, in days)

Grass	Cutting ages (days)					Equation[1]	r^2	P value
	14	28	42	56	Mean			
					B^1 fraction			
Aleman grass	0.59a	6.86a	8.98a	10.14a	6.64	$\hat{y} = -1.05 + 0.22x^{**}$	0.51	-
Nilo grass	4.46a	5.61a	5.54a	6.98a	5.65	$\hat{y} = 5.65$	-	P>0.05
Tanner grass	2.47a	5.12a	5.15a	8.13a	5.22	$\hat{y} = 0.97 + 0.12x^{*}$	0.32	-
Angola grass	4.68a	8.04a	8.88a	10.91a	8.13	$\hat{y} = 3.25 + 0.14x^{**}$	0.68	-
Limpo grass	3.81a	9.46a	8.68a	11.73a	8.42	$\hat{y} = 2.67 + 0.16x^{**}$	0.42	-
Setaria grass	2.35a	5.28a	4.88a	7.72a	5.06	$\hat{y} = 1.13 + 0.11x^{*}$	0.46	-
Tifton-85 grass	4.13a	8.60a	6.51a	7.00a	6.56	$\hat{y} = 6.56$	-	P>0.05
					B_2 fraction			
Aleman grass	1.60a	2.66a	14.45a	22.77a	10.37	$\hat{y} = -8.46 + 0.54x^{**}$	0.84	-
Nilo grass	0.00b	5.78a	16.65a	18.01a	10.11	$\hat{y} = -6.12 + 0.46x^{**}$	0.68	-
Tanner grass	1.80a	1.03a	13.00a	18.86a	8.67	$\hat{y} = -7.11 + 0.45x^{**}$	0.71	-
Angola grass	0.32b	1.98a	14.63a	12.50a	7.36	$\hat{y} = -4.94 + 0.35x^{**}$	0.47	-
Limpo grass	3.44a	5.97a	20.24a	15.88a	11.38	$\hat{y} = -1.52 + 0.37x^{**}$	0.55	-
Setaria grass	13.24a	11.78a	19.42a	18.52a	15.74	$\hat{y} = 15.74$	-	P>0.05
Tifton-85 grass	5.68a	5.85a	14.35a	19.87a	11.44	$\hat{y} = -1.32 + 0.36x^{**}$	0.66	-
					B_3 fraction			
Aleman grass	55.37ab	48.75a	37.08a	18.83a	40.01	$\hat{y} = 55.78 + 0.17x^{ns} - 0.0148x^{2*}$	0.91	-
Nilo grass	62.78a	42.57ab	37.86a	27.31a	42.63	$\hat{y} = 70.41 - 0.79x^{**}$	0.83	-
Tanner grass	49.79abc	39.52ab	32.51a	22.74a	36.14	$\hat{y} = 58.18 - 0.63x^{**}$	0.64	-
Angola grass	47.30abc	49.05a	41.04a	34.52a	42.98	$\hat{y} = 54.56 - 0.33x^{**}$	0.38	-
Limpo grass	33.37c	31.41b	35.64a	31.01a	32.86	$\hat{y} = 32.86$	-	P>0.05
Setaria grass	46.46abc	46.28ab	35.39a	29.40a	39.38	$\hat{y} = 54.90 - 0.44x^{**}$	0.78	-
Tifton-85 grass	41.04bc	44.60ab	35.3a	26.93a	36.97	$\hat{y} = 34.95 + 0.69x^{ns} - 0.0152x^{2*}$	0.73	-

Means followed by the same letter, in the same column do not differ by Tukey's test.
Significant at 1% (* *) and 5% (*) of probability and ns = non significant (P >0.05).
[1]$\hat{y}$ in % DM.

losses of ammonia, when sources of fast degradation carbohydrates are not available in the rumen. It requires a good synchronism in the fermentation of proteins and carbohydrates, for efficient microbial synthesis in the rumen and consequent improvement in the animal performance (Nocek & Russel, 1998). The crude protein fraction B_3, that may represent 1/3 of the crude protein of the hays, approximately, and have lower digestion rate, consequently will result in larger escape to the intestines.

The level of the B_2 fraction of the crude protein was only affected by the cutting age (P<0.01). All the grasses showed linear increase in the B_2 fraction of the crude protein in function of the cutting age, except the setaria grass in which the linear and quadratic equations were not significant (Table 5).

The daily increases in the levels of the B_2 fraction of the crude protein of the angola grass, tifton-85 grass, limpo grass, tanner grass, nilo grass and aleman grass were 0.35; 0.36; 0.37; 0.45; 0.46 and 0.54 percent units, respectively. The general average for the setaria grass was 15.74%.

By examining the interaction of grasses and cutting age, there were significant differences among grasses. On the 14th day, the levels of the B_2 fraction of crude protein of the nilo grass and angola grass presented the smallest values.

Ribeiro et al. (1998) reported levels of 31.34; 30.37 and 28.78% of B_2 in the crude protein at 28, 42, and 56 days of re-growth, respectively, for tifton-85 hay, which were larger than the observed ones in this work, at the same cutting ages (5.85; 14.35 and 19.87%). Malafaia et al. (1997) found 26.95% for tifton-85 at 60 days of age, which was larger than the estimated value (20.28%) calculated by the regression equation (Table 5).

Henriques et al. (2007b) evaluated nilo grass, angola grass, limpo grass and setaria grass in the northern Rio de Janeiro state and found larger values for the B_1+B_2 fractions at 56 days of age for the setaria and limpo grasses, and at 28 days of age for angola grass and nilo grass .

The level of B_3 fraction of the crude protein differed among cutting age and there was an interaction among grasses and cutting ages (P<0.01). The levels of the B_3 fraction of the aleman grass and tifton-85 grass showed a quadratic behavior in function of the cutting age (Table 5), while the nilo grass, tanner grass, angola grass and setaria grass showed a linear decrease. The equations for linear and quadratic regression of the limpo grass were not significant. The maximum levels for the B_3 fraction of the crude protein for the aleman grass and tifton-85 grass were estimated on the 6th and 23rd days, equal to 56.27 and 58.86%, respectively. Angola grass, setaria grass, nilo grass and tanner grass showed daily decreases of 0.33; 0.44, 0.79 and 0.63 percent unities, respectively. The general average for the limpo grass was of 32.86%.

Ribeiro et al. (1998) found for the B_3 fraction of the crude protein in tifton-85 hay at 28, 42 and 56 days of age, levels of 35.73; 35.02 and 29.01%, respectively, which were lower than the values obtained in the present work at 28 and 42 days of age (44.60 and 35.31%, respectively) and higher than those found at 56 days of age (26.93%). Malafaia et al. (1997) reported a level of 26.95% for tifton-85 at 60 days of age, which was higher than the value estimated by the regression equation for this grass in the present work (21.63%).

The level of C fraction corresponds to the acid detergent insoluble protein, considered to be no degradable in the rumen and indigestible in the intestines. This fraction was influenced only by the forage species (P<0.01) and it was observed a quadratic behavior for the tanner grass and a linear decrease for the angola grass, in function of the cutting age while for the others grasses, the regression equations were not significant (Table 6). The maximum level of the C fraction in tanner grass (29.52%) was estimated at 31 days of age and the daily decrease in limpo grass was of 0.41 percent units.

Limpo grass showed the highest level of the C fraction of crude protein on the 14th day. On the 28th day, the level in the limpo grass was higher than those of aleman grass, nilo grass, angola grass, setaria grass and tifton-85 grass. On the 42nd and 56th days, the level of the limpo grass was larger than in nilo grass.

Gonçalves et al. (2003) reported increases in the C fraction of the crude protein of Tifton 85 hay at the cutting ages of 28, 42, 63 and 84 days, varying from 17.4 to 22.8%. Similarly, the B_3 fraction of the crude protein increased and B_2 presented little variation, according to the increase of the cutting age.

Ribeiro et al. (1998) found levels of the protein C fraction of tifton-85 hay on the 28th, 42nd and 56th days of 5.74; 6.76 and 6.44%, respectively, which were smaller than the values obtained in this work on the 28th, 42nd and 56th days (20.13; 21.80 and 22.19%, respectively). However, Malafaia & Vieira (1997) reported level of 16.95% for tifton-85 at 60 days of age.

Most of the studied grasses showed a linear increase in the levels of total carbohydrates, non structural carbohydrates and in the level of the A+B_1 fraction of the carbohydrates in function of the cutting age. The B_2 fraction of the carbohydrates presented a quadratic behavior for the aleman grass, angola grass, setaria grass and tifton-85 grass. The C fraction of the carbohydrates showed a linear

Table 6 - Levels of the fraction C (% CP) of the grasses and the respective regression equations in relation to the cutting age (x, in days)

Grass	Cutting ages (days)					Equation[1]	r^2	P value
	14**	28**	42*	56**	Mean			
Aleman grass	15.28b	21.31b	21.44ab	25.00ab	20.76	$\hat{y}$ = y = 20.76	-	P>0.05
Nilo grass	14.66b	19.06b	12.82b	11.90b	14.61	$\hat{y}$ = y = 14.61	-	P>0.05
Tanner grass	23.70b	31.36ab	25.66ab	19.96ab	25.17	$\hat{y} = 12.69 + 1.07x^{ns} - 0.0170x^{2*}$	0.27	-
Angola grass	22.19b	19.99b	17.75ab	19.18ab	19.77	$\hat{y}$ = y = 19.78	-	P>0.05
Limpo grass	46.76a	47.52a	30.95a	33.03a	39.57	$\hat{y} = 54.00 - 0.41x^{**}$	0.37	-
Setaria grass	12.47b	17.38b	19.06ab	19.47ab	17.09	$\hat{y}$ = y = 17.09	-	P>0.05
Tifton-85 grass	16.81b	20.13b	21.80ab	22.19ab	20.23	$\hat{y}$ = y = 20.23	-	P>0.05

Means followed by the same letter, in the same column do not differ by Tukey's test.
Significant at 1% (* *) and 5% (*) of probability and ns = non significant (P>0.05).
[1] $\hat{y}$ in % dry matter.

behavior for the tifton-85 and no significant differences for the others grasses.

The average levels of the fraction B_1 of the crude protein (% CP) varied from 8.42 to 5.06%. Considering that the degradation rate of the B_1 fraction is in the range from 100 to 350%/h, the lower its percentage, fewer losses of nitrogen can occur in the rumen. However, the average level of the B_2 fraction (% CP) was in the range from 15.74 to 7.36%. This fraction is composed by structural carbohydrates that are effectively degraded in the rumen, with a rate of degradation varying from 8 to 15%/h, therefore, as larger its content, the higher will be the microbial growth, provided there is an available source of protein and appropriate amounts of it. In this research, the level of the B_2 fraction of crude protein was relatively low. The best values found by Gonçalves et al. (2001) for this fraction of crude protein were at 21 days of age. However, the B_2 fraction of crude protein was not affected by the cutting age.

The B_3 fraction of crude protein (% CP) varied from 42.98 to 32.86%. The rate of degradation of the B_3 fraction is in the range from 0.08 to 1.3%, and it could be degraded in the rumen, but it is mainly supplying amino acids for the small intestine.

The level of the C fraction of the crude protein (% CP) varied from 39.57 to 14.61%. This fraction is composed by nitrogenous compounds associated to the lignin fraction (acid detergent insoluble protein) and because it is resistant to the attack of the microbial enzymes and of the host it could not be absorbed along the digestive tract.

Limpo grass presented the smallest levels of non-protein nitrogenous compounds and larger levels of the acid detergent insoluble nitrogen fraction (% CP) and of C fraction of carbohydrates (% total carbohydrates), in relation to the others grasses, and high percentage of neutral detergent insoluble nitrogen as reported by Lima et al. (1999) and Newman et al. (2002). The largest levels of B_2 fraction of the total carbohydrates and of crude protein were observed at 42 and 56 days of age.

For crude protein, setaria grass had an average level of crude protein of 14.23% and the levels of B_2 and B_3 fractions equal to 15.74 and 39.38% of the crude protein, respectively. This represents a good protein contribution for ruminal fermentation and for the amino acids absorption in the small intestine. The others grasses presented similar values for A, B_1, B_2, B_3 and C fractions of the crude protein, emphasizing that the levels of the C fraction were even larger for nilo grass and setaria grass.

The purpose of evaluating the proteins and carbohydrates fractions for their appropriate characterization is to look for the maximization of the efficiency of growth of the ruminal microorganisms (Russell et al., 1992). The levels of the carbohydrates fractions and nitrogenous compounds of the foods together with the parameters of kinetics of ruminal degradation supply more adequate information on the nutritional value of the foods than only the chemical composition values.

Conclusions

Among the studied grasses, setaria is the one that has the best chances to be used by the animal. Their levels of B_2 fractions of the total carbohydrates, and B_2 and B_3 fractions of the crude protein are high, what makes it possible the maximum income and the rate of growth of the ruminal microorganisms, as well as a high exit of protein of the B_3 fraction for absorption in the intestine. Nilo grass and angola grass also would be very well used by the animal, in a similar way to the setaria grass, but with larger protein contribution for the intestine. Limpo grass is the least suitable due to its high levels of C fraction (carbohydrates and protein). For selection of an ideal forage, not only the proportion of the digestible fractions of the carbohydrates should be considered but also the biomass production per unit of area, a factor that is intimately related to the cutting age.

References

AGRICULTURAL AND FOOD RESEARCH COUNCIL - AFRC. **Energy and protein requirements of ruminants**. Wallingford: CAB International, 1993. 159p.

AKIN D.E.; BURDICK, D. Percentage of tissue types in tropical and temperate grass leaf blades and degradation of tissues by rumen microorganisDM. **Crop Science**, v.15, p.661-668, 1975.

AKIN, D.E. Histological and physical factors affecting digestibility of forages. **Agronomy Journal**, v.81, p.17-25, 1989.

FOX, D.G.; TEDESCHI, L.O.; TYLUTKI, T.P. The net carbohydrate and protein system for evaluating herd nutrition and nutrient excretion. **Animal Feed Science and Technology**, v.112, p.29-78, 2004.

GILL, M.; BEEVER, D.E.; FRANCE, J. Biochemical bases needed for the mathematical representation of whole animal metabolism. **Nutrition Research Reviews**, v.2, n.1, p.181-200, 1989.

GONÇALVES, G.D.; SANTOS, G.T.; JOBIM, C.C. et al. Determinação do consumo, digetibilidade e frações protéicas e de carbohydrates do feno de tifton 85 em diferentes idades de corte. **Revista Brasileira de Zootecnia**, v.32, n.4, p.804-813, 2003.

GONÇALVES, G.D.; SANTOS, G.T.; JOBIM, C.C. et al. Determinação das frações de proteína e de carbohydrates de Grasss do gênero *Cynodon* em idades ao corte. **Acta Scientiarum**, v.23, n.4, p.789-794, 2001.

HALL, M.B. Methodological challenges in carbohydrate analyses. **Revista Brasileira de Zootecnia**, v.36, p.359-367, 2007 (supl.).

HENRIQUES, L.T.; COELHO DA SILVA, J.F.; DETMANN, E. et al. Frações de carbohydrates de quatro Grasss tropicais em diferentes idades de corte e doses de adubação nitrogenada. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.59, n.3, p.730-739, 2007a.

HENRIQUES, L.T.; COELHO DA SILVA, J.F.; DETMANN, E. et al. Frações dos compostos nitrogenados de quatro Grasss tropicais em diferentes idades de corte e doses de adubação nitrogenada. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.59, n.3, p.740-748, 2007b.

JUNG, H.G.; ALLEN, M.S. Characteristics of plant cell wall affecting intake and digestibility of forages by ruminants. **Journal of Animal Science**, v.73, n.9, p.2774-2790, 1995.

KRISHNAMOORTHY, U.; SNIFFEN, C.J.; STERN, M.D. et al. Evaluation of a mathematical model of rumen digestion and an in vitro simulation of rumen proteolysis to estimate the rumen-undegraded nitrogen content of feedstuffs. **British Journal of Nutrition**, v.50, n.3, p.55-568, 1983.

LACERDA, P.D.; MALAFAIA, P.A.M.; VIEIRA, R.A.M. et al. Variação anual da composição bromatológica de duas forages cultivadas nas baixadas litorâneas do estado do Rio de Janeiro, Brasil. **Ciência Rural**, v.34, n.2, p.523-529, 2004.

LICITRA, G.; HERNANDEZ, T.M.; VAN SOEST, P.J. Standardization of procedures for nitrogen fractionation of ruminant feeds. **Animal Feed Science Technology**, v.57, n.4, p.347-358, 1996.

LIMA, G.F.C.; SOLLENBERGER, L.E.; MOORE, J.E. et al. Concentração e fracionamento do nitrogênio em grass forages tropicais e subtropicais. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 36., 1999, Brasília. **Anais...** Brasília: Sociedade Brasileira de Zootecnia, 1999. p.115-117.

MALAFAIA, P.A.M.; VIEIRA, R.A.M. Técnicas de determinação e avaliação dos compostos nitrogenados em alimentos para ruminantes. In: TEIXEIRA, J.C. (Ed) **Digestibilidade em ruminantes**. Lavras, 1997. p.29-54.

MALAFAIA, P.A.M.; VALADARES FILHO, S.C.; COELHO DA SILVA, J.F. et al. Determinação das frações que constituem os carbohydrates totais de alguns volumosos e concentrados. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 33., 1996, Fortaleza. **Anais...** Fortaleza: Sociedade Brasileira de Zootecnia, 1996. p.306-308.

MALAFAIA, P.A.M.; VALADARES FILHO, S.C.; VIEIRA, R.A.M. et al. Determinação e cinética ruminal das frações protéicas de alguns alimentos para ruminantes. **Revista Brasileira de Zootecnia**, v.26, n.6, p.1243-1251, 1997.

MERTENS, D.R. Kinetics of cell wall digestion and passage in ruminants. In: JUNG, H.G., BUXTON, D.R.; HATFIELD, R.D. et al. (Eds.) **Forage cell wall structure and digestibility**. Madison: American Society of Agronomy, 1993. p.535-570.

NATIONAL RESEARCH COUNCIL - NRC. **Nutrient requirements of beef cattle**. 7.ed. rev. Washington, D.C.: National Academy Press, 2001. 381p.

NEWMAN, Y.C.; SOLLENBERGER, L.E.; KUNKLE, W.E. et al. Crude protein fractionation and degradation parameters of limpograss herbage. **Agronomy Journal**, v.94, p.1381-1386, 2002.

NOCEK, J.; RUSSEL, J.B. Protein and carbohydrate as an integrating system. Relationship of ruminal availability to microbial contribution and milk production. **Journal Dairy Science**, v.71, n.5, p.2070-2075, 1998.

RIBEIRO, K.G.; PEREIRA, O.G.; VALADARES FILHO, S.C. et al. Determinação das frações que constituem a crude protein e os carbohydrates totais do feno de tifton-85. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 35., 1998, Botucatu. **Anais...** Botucatu: Sociedade Brasileira de Zootecnia, 1998. p.122-124.

ROSA, B.; OLIVEIRA, L.E.M.; ROCHA, G.P. Crescimento do capim-angola (Brachiaria mutica) em função da densidade das plantas e idades de corte. **Pesquisa Agropecuária Tropical**, v.29, n.2, p.157-163, 1999.

RUSSEL, J.B.; O'CONNOR, J.D.; FOX, D.G. et al. A net carbohydrate and protein system for evaluating cattle diets: I. Ruminal fermentation. **Journal of Animal Science**, v.70, n.11, p.3551-3561, 1992.

UNIVERSIDADE FEDERAL DE VIÇOSA - UFV. **SAEG (Sistemas para Análises Estatísticas e Genéticas***)* versão 8.0 - Manual de instruções. Viçosa, MG: CPD/UFV, Divisão de Pesquisa e Desenvolvimento, 2000. 142p.

SILVA, D.J.; QUEIROZ, A.C. **Análise de alimentos** - métodos químicos e biológicos. 3.ed. Viçosa, MG, UFV: Imprensa Universitária, 2004. 235p.

SNIFFEN, C.J.; O'CONNOR, J.D.; VAN SOEST, P.J. et al. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. J**ournal of Animal Science**, v.70, n.11, p.3562-3577, 1992.

TOKARNIA, C.H.; CHAGAS, B.R.; CHAGAS, A. D. et al. Anemia hemolítica causada por Ditaxis desertorum (Euphorbiaceae) em bovinos. **Pesquisa Veterinária Brasileira**. v.17, n.3, p.112-116, 1997.

VALERIO, J.R. **Percevejo-das-Grass**: *Blissus leucopterus* ou *Blissus antillus*. Campo Grande: Embrapa Gado de Corte, 2000. 3p. (Circular Técnica, 43).

VAN SOEST, P.J. **Nutritional ecology of the ruminant**. New York, 1994. 476p.

VIEIRA, R.A.M.; PEREIRA, J.C.; MALAFAIA, P.A.M. et al. Fracionamento dos carbohydrates e cinética de degradação *in vitro* da Neutral detergent fiber da extrusa de bovinos a pasto. **Revista Brasileira de Zootecnia**, v.29, n.3, p.889-897, 2000.

WILSON, J.R. Influence of temperature and nitrogen on growth, photosynthesis and accumulation of non-structural carbohydrates in a tropical grass, *Panicum maximum* var.trichoglume. **Netherlands Journal of Agricultural Science**, v.23, n.2, p.48-61, 1975.