Chemical composition of *Pennisetum purpureum* cv.. Cuba CT-115 used as biomass bank

Dayleni Fortes, R.S. Herrera, M. García, Ana M. Cruz y Aida Romero

Instituto de Ciencia Animal, Apartado Postal 24, José de Las Lajas, Mayabeque, Cuba
Correo electrónico: dfortes@ica.co.cu

A completely random sampling design was used to study the chemical composition of CT-115 used as biomass bank. The treatments corresponded with the re-growth ages of the pasture from the moment the animals went out to the paddock (zero time) to completing each growth cycle, according to the technology of biomass bank. In all the cycles, the re-growth age diminished the CP value ($P < 0.001$) and the cell content ($P < 0.01$) in the basal tillers as in the residue. The higher protein values were found in the leaves of the basal tillers and the residue ($P < 0.001$), with 14.3 % and 11.9 % respectively, at 15 d in cycle one. The cell wall increased ($P < 0.01$) with age in all cycles. The leaves had lower values than the stems. The highest values were, generally, in the residue stems (84.07 %), at 105 d of re-growth for cycle four. The cellulose and lignin contents increased with age in most of the cycles, with maximum values in the leaves of 38.8 % and 7.9 %, respectively. The lignin values were inferior in leaves and stems of the basal tillers. The results of this study allow concluding that the cell wall, cellulose and lignin increased with the re-growth age. The CP and the cell content reduced similarly in the rest of the pastures. However, these indicators in the leaves of CT-115 get to the 105 d with an acceptable quality for cattle. Due to the leaves quality in this variety of Pennisetum, grazing with a high defoliation index up to the height desired by the animal is recommended and, therefore, a higher productivity would be achieved.

Key words: *Pennisetum purpureum* cv.. Cuba CT-115, chemical composition, biomass bank.

Pennisetum purpureum cv. Cuba CT-115 was obtained from issues culture and has been recommended as biomass bank for its favorable characteristics for grazing. Its scarce flowering, good re-growth in grazing, higher proportion of leaves and lower height due to the shortening of the forks make it different from the king grass (Martínez 2002).

The Cuba CT-115 has been released for forage production in direct grazing, due to its low height and acceptable yield (Martínez and Herrera 2006). Besides, it is an important contribution to the germ plasm of the Pennisetum genus (Martínez 2010).

Pasture quality is of vital importance for assessing any species used in a technology for animal production. Besides, it is the necessary complement in respect to agronomical and morfophysiological indicators, offering integral responses to the environmental and management factors. The objective of this study was to assess chemical composition of CT-115 used as biomass bank.

Materials and Methods

Location, climate and soil. The studies were conducted in the cattle unit B of the Institute of Animal Science, in San Jose de las Lajas municipality, Mayabeque province, located between 22º 53 north latitude and 82º 02 west longitude, at 80 a.s.l. (Anon 1989). A paddock of 0.75 ha of *Pennisetum purpureum* cv. Cuba CT-115 integrated to the technology of biomass bank was selected (Martínez and Herrera 2006).

Figures 1 shows the performance of some climatic variables during the experimental period. The data were taken from the Meteorological Station of the Institute of Animal Science.

The soil was classified as spongy-gray brown (Hernández *et al*. 1999), with lightly acid pH and relatively low N and K contents. Its bromatological composition is shown in table 1.

The organic matter of the soil was determined according to the method of Walkley and Black, cited by Jackson (1970), the N according to AOAC (1995), the P by Oniani (1964) and C and Mg from Maslova, cited by Paneque (1965).

Treatment and design. A completely randomized sampling design, (Fortes *et al*. 2007) was used. The treatments consisted of re-growth ages of the pasture from the moment the animals went out to the paddock (zero time) and agreeing to the duration of each growing cycle, according to the technology of biomass bank (Martínez and Herrera 2006) (table 2).

Procedure. In the paddock with uniform pasturem populations (Fortes *et al*. 2007), 15 samples (bunch as experimental unit) were taken immediately after grazing and every 15 d, until completing each growing cycle (table 2). During grazing, the paddock was occupied by the animals until achieving 90 % of defoliation. In the first, second, third and fourth grazing 280, 210, 105 and 210 cows/d/ha, respectively were used.

The samples (bunch) were separated in basal tillers and the resting material was called residue (rejection with its new growing). Later, the basal tillers and the residue were fractioned in leaves and stems and the samples were taken to the lab as soon as possible to avoid any altering. Afterwards, they were placed into an air-circulation oven at 60 °C until

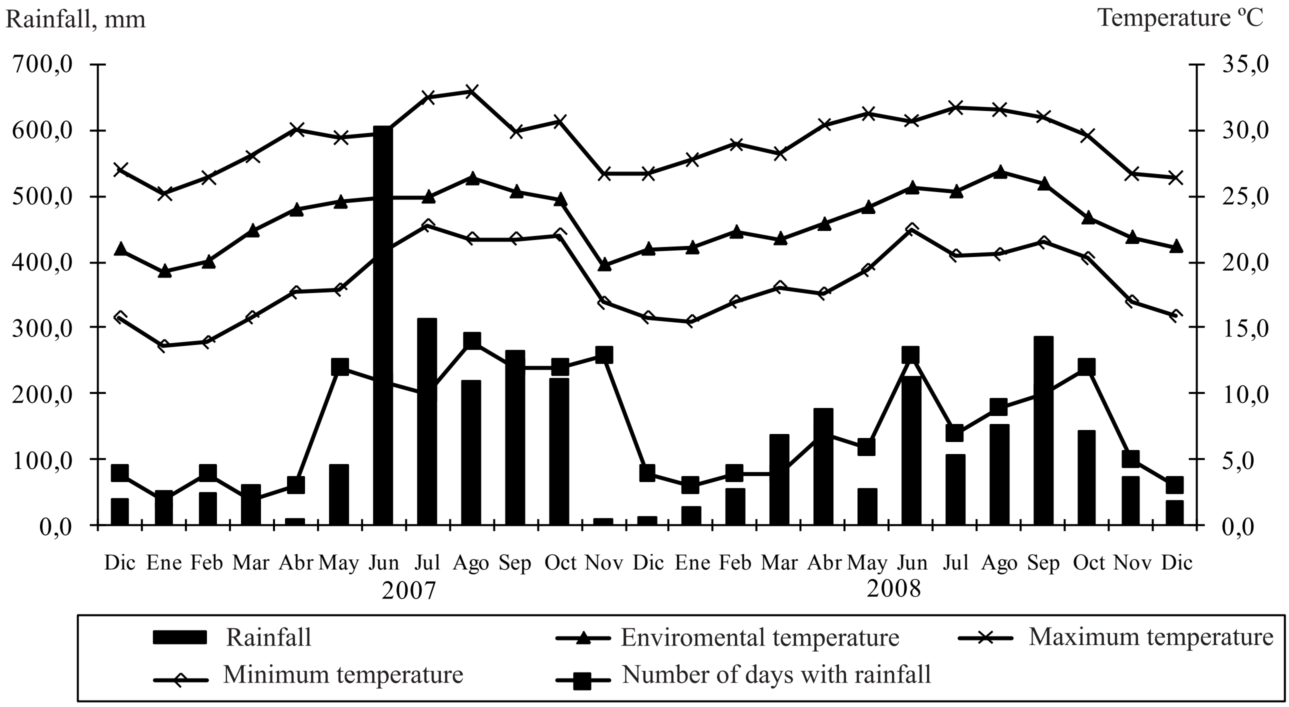

Figure 1. Performance of some climatic factors during the experimental period

Table 1. Chemical composition of the soil of the experimental area

%					pH	ppm
N	P	Ca	Mg	MO		K
0.19	21.55	2.53	0.26	3.20	5.87	54.42

Table 2. Distribution of the growth cycles during the experiments

Growth cycles	Date	Duration, d	Previous resting, d
Cycle 1	December 2006-March 2007	90	105
Cycle 2	March - May 2007	60	90
Cycle 3	May-July 2007	60	60
Cycle 4	August-November 2007	105	60

reaching constant weight. The samples were milled with a 1 mm diameter sieve and packaged in cristal flasks hermetically closed. They were finally stored at room temperature until their processing (Herrera *et al*. 1986).

The indicators assessed were the CP content, according to AOAC (1995), and the cell content, NDF (cell wall), lignin and cellulose, quantified agreeing Goering and van Soest (1970). All the analyses were conducted by duplicate, per treatment and repetition.

Statistical analysis. An analysis of variance according to SPSS, version 5.0 (Visauta 2007) was carried out. The Duncan's test (1955) was used for comparing the means when necessary. The results are presented for each growing cycle of the pasture according to the technology.

Results

In all the growing cycle, the re-growth age decreased ($P < 0.001$) the CP values in the basal tillers as in the residue, although a discrete diminish of the values was shown in time. The highest CP numbers were found in the leaves of basal tillers and the residue ($P < 0.001$), with 14.3 and 11.9 %, respectively, at 15 d of age in cycle one (table 3). The stems of the basal tillers had superior CP values than those of the residue. It is important to mention that the lowest protein contents were in the longest duration cycle (105 d) for all the fractions.

The cell content also diminished ($P < 0.01$) with the re-growth age of the plant (table 4) in all the growing cycles. The highest values were recorded in the leaves of the residues and of the basal tillers to the lowest re-growth ages.

Table 3. CP content (%) in the different growth cycles

Age, d	Basal tillers		Residue	
	Leaf	Stem	Leaf	Stem
Cycle 1				
0[1]	-	-	10.3[b]	4.8[b]
15	14.3[d]	9.2[b]	11.9[c]	4.8[b]
30	14.0[d]	9.8[b]	11.8[c]	5.0[b]
45	13.4[d]	9.3[b]	11.7[c]	4.1[a]
60	11.9[c]	9.0[b]	11.3[bc]	3.8[a]
75	10.4[b]	7.3[a]	10.3[b]	3.8[a]
90	8.8[a]	6.5[a]	7.8[a]	3.6[a]
SE±	0.3***	0.2***	0.3***	0.1***
Cycle 2				
0[1]	-	-	8.5[a]	3.7
15	-	-	11.4[b]	3.7
30	12.6[b]	5.1[b]	9.7[a]	3.6
45	9.3[a]	3.0[a]	9.0[a]	3.1
60	8.4[a]	3.3[a]	8.2[a]	3.3
SE±	0.3***	0.1***	0.3***	0.2
Cycle 3				
0[1]	-	-	-	3.6[b]
15	13.2[c]	8.9[c]	12.8[c]	3.3[b]
30	11.5[b]	7.1[b]	11.2[b]	3.4[b]
45	10.3[a]	6.7[ab]	8.9[a]	3.2[ab]
60	9.7[a]	5.9[a]	8.6[a]	2.6[a]
SE±	0.2***	0.2***	0.16***	0.1**
Cycle 4				
0[1]	-	-	13.4[f]	3.4
15	13.0[f]	5.1[cd]	10.3[e]	4.0
30	12.0[e]	6.1[d]	9.4[d]	3.9
45	10.5[d]	5.9[d]	9.5[de]	3.8
60	9.7[c]	4.6[bc]	8.8[cd]	3.7
75	9.5[c]	3.7[ab]	8.1[bc]	3.2
90	8.3[b]	3.6[ab]	7.4[ab]	3.4
105	7.4[a]	3.4[a]	6.8[a]	3.2
SE±	0.2***	0.2***	0.2***	0.2

[abcd] values with different letters per row differ at P < 0.05 (Duncan 1955)
[1]Immediately after grazing. ** P < 0.01 *** P < 0.001

The cell wall increased (P < 0.01) with the age in all the growing cycles. The leaves had lower values than those of the stems. The highest values were, generally, in the leaves and the stems of the residue (table 5). The maximum values were found in the stems of the residue (84.07 %) at 105 d of re-growth for cycle four.

There was a marked effect of the re-growth age (P < 0.01) in the cellulose (table 6). The leaves had the lowest values, especially in the first growth stages. The highest values were detected in the residue's stems, with maximum values of 49.10 % at 60 d of the cycle three (May-June).

Lignin increased (P < 0.05) with the re-growth age in all the growing cycles (table 7), except in the leaves and stems of the basal tillers of the cycle two. The leaves of the basal tillers had similar values to those of the residue, while they were lower in the stems.

It may be affirmed that the growing cycle four was the one with less protein and cell content. Besides, it showed the highest values of cell wall, lignin and cellulose at the oldest re-growth ages (90 and 105 d).

Discussion

Table 4. Cell content (%) in the different growth cycles

Age, d	Basal tillers		Residue	
	Leaf	Stem	Leaf	Stem
Cycle 1				
0[1]	-	-	29.6[a]	26.6[a]
15	27.9[a]	26.9[a]	27.4[b]	24.7[ab]
30	26.5[b]	24.6[b]	26.4[bc]	23.7[bc]
45	25.7[b]	23.8[bc]	25.5[c]	23.0[bcd]
60	24.4[c]	23.4[cd]	23.8[d]	22.1[cd]
75	24.0[c]	22.8[de]	23.0[d]	21.2[de]
90	23.4[c]	22.5[e]	22.6[d]	20.0[e]
SE±	0.2***	0.1***	0.2***	0.3***
Cycle 2				
0[1]	-	-	29.63[a]	26.52[a]
15	-	-	28.94[ab]	25.83[ab]
30	27.43[a]	26.00[a]	26.90[bc]	23.83[b]
45	26.87[ab]	24.60[ab]	25.53[cd]	21.47[c]
60	25.26[b]	23.21[b]	24.47[d]	20.03[c]
SE±	0.33**	0.18***	0.27***	0.23***
Cycle 3				
0[1]	-	-	-	22.31[a]
15	25.47[a]	24.03[a]	24.50[a]	20.80[ab]
30	24.33[b]	23.77[ab]	23.42[ab]	20.33[bc]
45	24.10[bc]	22.63[bc]	22.93[bc]	19.87bc
60	23.40[c]	21.80[c]	22.00[c]	18.73[c]
SE±	0.19**	0.14**	0.24**	0.24***
Cycle 4				
0[1]	-	-	26.53[a]	24.13[a]
15	27.62[a]	25.07[a]	25.50[ab]	23.04[ab]
30	26.90[a]	23.68[ab]	25.33[abc]	21.18[bc]
45	24.20[b]	24.43[bc]	24.00[bc]	20.47[cd]
60	22.43[bc]	21.67[c]	23.50[c]	19.52[cd]
75	20.64[cd]	19.93[d]	20.56[d]	18.34[de]
90	19.45[de]	18.20[e]	19.53[d]	16.57[ef]
105	18.60[e]	17.30[e]	18.63[d]	15.93[f]
SE±	0.26***	0.19***	0.29***	0.34***

[abcd] values with different letters per row differ at $P < 0.05$ (Duncan 1955)
[1]Immediately after grazing. ** $P < 0.01$ *** $P < 0.001$

Several studies refer to the diminish of CP content as the re-growth age increases and to the season performance of tropical grasses (Ramírez *et al*. 2008, Valenciaga *et al*. 2009 and Nave *et al*. 2010). These phenomena are related with several elements: N availability on the soil, hydric balance of the plant, root and soil, diminishing of the metabolic activity, reduction of the cell content, management and climatic factors, among others.

The differences between the lowest CP values in stems of the residue, in respect to those of the stems of the basal tillers are because the lasts are younger, therefore their protein contents are higher. The same happens in the leaves, but this is the fraction of the plant with the highest nutritive quality, as, compared with the stems, it has high amount of protein and non-structural carbohydrates. Silva (2007) obtained similar performance in clones of *Pennisetum purpureum*.

The protein synthesis takes place in the leaves from the chemical elements on the cell content. This depletes the re-growth age, due to the different processes as senescence and the diminishing in the nutrients absorption through the roots. For these reasons, the performance described in this study is logic.

For the adequate ruminal fermentation, the minimum

Table 5. Cell wall content (%) in the growth cycles

Age, d	Basal tillers		Residue	
	Leaf	Stem	Leaf	Stem
Cycle 1				
0[1]	-	-	70.4[a]	73.4[a]
15	72.1[a]	73.1[a]	72.6[b]	75.3[ab]
30	73.5[b]	75.4[b]	73.6[bc]	76.3[bc]
45	74.3[b]	76.2[bc]	74.5[c]	77.0[bcd]
60	75.6[c]	76.6[cd]	76.2[d]	77.9[cd]
75	76.0[c]	77.2[de]	77.0[d]	78.8[de]
90	76.6[c]	77.5[e]	77.4[d]	80.0[e]
SE±	0.2***	0.1***	0.2***	0.3***
Cycle 2				
0[1]	-	-	70.37[a]	73.48[a]
15	-	-	71.06[ab]	74.17[ab]
30	72.57[a]	74.00[a]	73.10[bc]	76.17[b]
45	73.13[ab]	75.40[ab]	74.47[cd]	78.53[c]
60	74.74[b]	76.79[b]	75.53[d]	79.97[c]
SE±	0.33**	0.18***	0.27***	0.23***
Cycle 3				
0[1]	-	-	-	77.69[a]
15	74.53[a]	75.97[a]	75.50[a]	79.20[ab]
30	75.67[b]	76.23[ab]	76.58[ab]	79.67[bc]
45	75.90[bc]	77.37[bc]	77.07[bc]	80.13[bc]
60	76.60[c]	78.20[c]	78.00[c]	81.27[c]
SE±	0.19**	0.14**	0.24**	0.24***
Cycle 4				
0[1]	-	-	73.47[a]	75.87[a]
15	72.38[a]	74.93[a]	74.50[ab]	76.96[ab]
30	73.10[a]	76.32[ab]	74.67[abc]	78.82[bc]
45	75.80[b]	75.57[bc]	76.00[bc]	79.53[cd]
60	77.57[bc]	78.33[c]	76.50[c]	80.48[cd]
75	79.36[cd]	80.07[d]	79.44[d]	81.66[de]
90	80.55[de]	81.80[e]	80.47[d]	83.43[ef]
105	81.40[e]	82.70[e]	81.37[d]	84.07[f]
SE±	0.26***	0.19***	0.29***	0.34***

[abcd] values with different letters per row differ at $P < 0.05$ (Duncan 1955)
[1]Immediately after grazing. ** $P < 0.01$ *** $P < 0.001$

value of proteins in the feeds may be higher to 7 % (Minson 1990) up to the 105 d of re-growth. The protein contents of leaves were over this value in all the growth cycles. This performance is of great advantage for this plant, as during the maturation process this indicator does not lowers rapidly.

The higher cell wall content of the residue's stems compared to that of the basal tillers is because these last are younger and more mature. Similar performance had the leaves as the re-growth age increased. This could be due to the physiological changes occurring in the plant as it gets old, which decreases the cytoplasmic cell content. Besides, the cell lumen is reduced with its soluble components and those fibrous increases (Nogueira Filho *et al*. 2000). Similar results found Nave (2007) in *Brachiaria brizantha* and Valenciaga *et al*. (2009) in Cuba CT-115. The highest reduction on the pasture quality in cycle four, at 105 d of re-growth could be due to the climatic conditions of the rainy season, favoring growth, and to the higher duration of this growth cycle.

The highest cell wall content during the cycles of the rainy season (table 2) was also reported in Bermuda grass (Herrera 1981), Mombaza (Bueno

Table 6. Cell content (%) in the growth cycles

Age, d	Basal tillers		Residue	
	Leaf	Stem	Leaf	Stem
Cycle 1				
0[1]	-	-	30.50[a]	41.10[a]
15	31.50[a]	34.30[a]	31.90[b]	41.20[a]
30	32.20[ab]	35.20[ab]	32.10[b]	42.30[b]
45	33.10[bc]	35.90[bc]	33.00[c]	42.60[bc]
60	33.50[cd]	36.90[c]	33.60[cd]	43.10[cd]
75	33.50[cd]	38.30[d]	33.70[d]	43.90[de]
90	34.20[d]	39.50[d]	34.30[d]	44.30[e]
SE±	0.20***	0.20***	0.10***	0.10***
Cycle 2				
0[1]	-	-	31.99[a]	43.40[a]
15	-	-	31.84[a]	43.79[a]
30	33.10[a]	34.12[a]	33.33[ab]	44.23[a]
45	34.26[ab]	35.42[ab]	34.57[b]	45.13[ab]
60	34.82[b]	36.23[b]	35.23[b]	46.83[b]
SE±	0.27**	0.30**	0.30***	0.33***
Cycle 3				
0[1]	-	-	-	42.57[a]
15	30.60[a]	36.47[a]	31.43[a]	43.19[a]
30	31.43[ab]	37.58[ab]	32.57[ab]	46.10[b]
45	32.10[bc]	39.02[bc]	32.85[ab]	48.13[bc]
60	32.73[c]	40.41[c]	33.20[b]	49.10[c]
SE±	0.19**	0.26***	0.30**	0.28***
Cycle 4				
0[1]	-	-	32.87[a]	36.57[a]
15	34.17[a]	35.27[a]	33.90[ab]	37.37[ab]
30	35.04[ab]	36.57[a]	35.20[bc]	38.80[abc]
45	36.03[bc]	37.23[ab]	36.27[cd]	39.69[bc]
60	36.61[cd]	39.37[bc]	37.53[de]	40.58[cd]
75	37.53[de]	40.69[cd]	37.80[e]	43.10[de]
90	37.77[de]	41.88[d]	38.40[f]	44.77[e]
105	38.30[e]	42.47[d]	38.80[g]	45.73[e]
SE±	0.17***	0.31***	0.22***	0.43***

[abcd] values with different letters per row differ at $P < 0.05$ (Duncan 1955)
[1]Immediately after grazing. ** $P < 0.01$ *** $P < 0.001$

2003) and in some varieties of Pennisetum (Mistura *et al*. 2007).

In this period, the favorable climatic factors such as abundant rainfall, higher temperatures and luminosity (figure 1) contribute to the high value of the cell wall and to the higher availability of nutrients and mineral in the soil solution, which propitiate higher growth and plant development, as well as higher issue production in the stems compared with the leaves (Mistura *et al*. 2007). Alves de Brito *et al*. (1999) refer that the high metabolic activity of the plant during the rainy season increased the constituents of the cell wall hence the cells does not break down because of the high water absorption.

The cell of this study increased also with the re-growth age, as reported in the previous studies with this pasture and other varieties (Valenciaga *et al*. 2009, Ramírez 2010 and Ramírez *et al*. 2010). This increase could be the result of the fattening of the cell wall thickening occurring with the plant age (Paciullo 2002), as the cellulose forms compact microfibers provokes the strength and rigidity required by the cell wall.

The stems of the basal tillers had lower values than those of the residue. However, the leaves of both showed similar results. This result could be because the animals consumed, at the end the grazing, almost

Table 7. Lignin percentage in the different growth cycles

Age, d	Basal tillers		Residue	
	Leaf	Stem	Leaf	Stem
Cycle 1				
0[1]	-	-	2.8[a]	5.9[a]
15	3.0[a]	4.8[a]	3.0[a]	6.0[a]
30	4.3[b]	6.1[b]	4.8[b]	6.5[b]
45	5.0[c]	6.2[b]	5.1[bc]	6.7[bc]
60	5.2[cd]	6.4[b]	5.3[cd]	7.0[cd]
75	5.4[cd]	6.6[b]	5.6[d]	7.1[b]
90	5.7[d]	6.9[b]	5.8[b]	7.2[b]
SE±	0.1***	0.2***	0.1***	0.1***
Cycle 2				
0[1]	-	-	5.2[a]	8.2[a]
15	-	-	5.5[a]	9.3[b]
30	6.3	7.0	6.7[b]	10.4[c]
45	6.4	7.3	7.1[b]	10.5[c]
60	6.7	7.7	7.3[b]	10.9[c]
SE±	0.2	0.2	0.2***	0.2**
Cycle 3				
0[1]	-	-	-	6.6[a]
15	3.4[a]	4.1[a]	3.7[a]	7.4[a]
30	4.0[b]	5.2[b]	4.5[b]	9.3[b]
45	5.3[c]	6.1[c]	5.5[c]	10.0[b]
60	6.0[b]	7.2[d]	6.1[c]	11.2[c]
SE±	0.1***	0.2***	0.1***	0.2***
Cycle 4				
0[1]	-	-	4.3[a]	6.7[a]
15	4.7[a]	6.3[a]	5.2[b]	7.6[b]
30	5.1[ab]	6.8[a]	5.8[bc]	8.2[b]
45	5.9[bc]	7.2[a]	6.5[cd]	9.6[c]
60	6.3[cd]	8.4[b]	6.9[de]	9.8[c]
75	6.8[de]	9.0[b]	7.4[ef]	10.4[cd]
90	7.3[ef]	10.0[c]	7.6[ef]	11.0[de]
105	7.7[f]	10.7[c]	7.9[f]	11.9[e]
SE±	0.2***	0.2***	0.2***	0.2***

[abcd] values with different letters per row differ at $P < 0.05$ (Duncan 1955)
[1]Immediately after grazing. ** $P < 0.01$ *** $P < 0.001$

all the leaves and new leaves grew from the axial sprouts of the residue stems. They had, probably, similar physiological ages than those of the basal tillers. That is why their values were probably similar. Nevertheless, this hypothesis needs to be confirmed in further studies. The lignin of the leaves and stems of the basal tillers and residue increased with the re-growth age (Valenciaga *et al*. 2009, Ramírez 2010 and Ramírez *et al*. 2010). Logically, the stems had higher values than those of the leaves, as in the cellulose. In general, the values were similar for the leaves of the residue and the basal tillers. Probably, the explanation offered for the cellulose contributes to the interpretation of the results.

In spite of the increases of lignin with the age, it is valid to highlight that this variety has low lignin contents, compared with other *Pennisetum purpureum* varieties. In respect to the king grass, they were always inferior (Martínez and Herrera 2006). Deschamps and Alves de Brito (2001) referred lignin contents in three cultivars of *Pennisetum purpureum* Schumach, that varied between 12-22 % in the different plant fractions studied. These contents are very superior in respect to those found for CT-115. This fact is cheering for using this variety as biomass bank, as the increase of the plant age does not reduce significantly the pasture quality, especially in the leaf fraction, the most consumed by the animals.

It is concluded that the cell wall, cellulose and lignin increased with the re-growth age. The CP and the cell content were reduced similarly in respect to the rest of the pastures. However, these indicators in the CT-115 leaves get to 105 d with an acceptable quality for the cattle. Grazing with a high defoliation index up to the height left by the animal is recommended due to the quality of the leaves in this Pennisetum variety. Therefore, a higher animal productivity will be achieved.

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