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FRACTIONATION AND KINETICS OF *in vitro* RUMINAL FERMENTATION OF THE CARBOHYDRATES OF FIVE SUGAR CANE VARIETIES

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ABSTRACT

The objective of this study was to determine the chemical composition, the carbohydrates fractionation and the kinetics of *in vitro* ruminal fermentation of fibrous and non-fibrous carbohydrates of five sugar cane varieties. Variety SP79-1011 presented the highest value of total digestible nutrients (65.9%), followed by the varieties Java, RB72454, SP80-1842 and RB765418. The accumulated gas in the dry matter, at 48 and 96 hours of *in vitro* incubation was higher for the variety SP79-1011, showing significant difference in comparison with the varieties RB765418, RB72454 and SP80-1842, excepting the variety Java that did not show any difference in relation to the first one. The dry matter partitioning factor decreased with the incubation time, and there was no difference among the evaluated varieties. The characteristics of the production cycle influenced the *in vitro* ruminal fermentation of the evaluated varieties, being the varieties of precocious cycle (SP80-1842 and RB765418) the ones with the worst results. Amongst the varieties tested, SP79-1011 and Java presented the best results of gas production kinetics and total digestible nutrients.

KEYWORDS: *In vitro* true degradability, gas production, *Saccharum officinarum*.

FRACIONAMENTO E CINÉTICA DA FERMENTAÇÃO RUMINAL *in vitro* DOS CARBOIDRATOS DE CINCO VARIEDADES DE CANA-DE-AÇÚCAR

RESUMO

O objetivo deste trabalho foi determinar a composição química, o fracionamento dos carboidratos e a cinética da fermentação ruminal *in vitro* dos carboidratos não fibrosos e carboidratos fibrosos de cinco variedades de cana-de-açúcar. A variedade SP79-1011 apresentou o maior teor de nutrientes digestíveis totais (65,9%), seguida das variedades Java, RB72454, SP80-1842 e RB765418. A produção acumulada de gases na matéria seca às 48 e 96 horas de incubação *in vitro* foi maior para a variedade SP79-1011, apresentando diferença significativa em comparação com as variedades RB765418, RB72454 e SP80-1842, exceção feita à variedade Java, que apresentou valores semelhantes à primeira. O fator de partição da matéria seca diminuiu com o aumento no

tempo de incubação, sendo que não houve diferença entre as variedades avaliadas. As características do ciclo de produção influenciaram na fermentação ruminal *in vitro* nas variedades avaliadas, sendo que as de ciclo precoce SP80-1842 e RB765418 foram as que apresentaram resultados inferiores. Dentre as variedades testadas, as variedades SP79-1011 e Java apresentaram os melhores resultados de cinética de produção de gases e nutrientes digestíveis totais comparativamente superiores.

PALAVRAS-CHAVE: Congelação, ovino, protocolos-refrigeração, sêmen.

INTRODUCTION

Since the late twentieth century, Brazil has become the world's largest producer of sugar cane, with a harvest of 516 million tons in 2007, in a planted area of 6.7 million hectares (IBGE, 2008). Its greatest use is for sugar and alcohol production. However, sugar cane has increasingly attracted attention of the livestock farmers, who use it seasonally as the primary forage food, because it presents the following characteristics: high productivity per unit of cultivated area, relatively easy cultivation, low cost per unit of dry matter (DM) produced, and coincidence of the time of its highest availability with the shortage of forage in the form of pasture (LANDELL et al., 2002).

Animal production is determined primarily by the quality of the ingested forage. It is strongly influenced by the forage digestibility, which is inversely proportional to the content of the fiber plant (fiber carbohydrates). Low ruminal digestion of the ingested forage increases the retention time of food in the rumen and, consequently, decreases the dry matter intake rate and animal performance.

Carbohydrates are the main source of photosynthetic energy in photoautotrophic beings. These compounds constitute about 60% to 80% of the dry matter in forages, being the main source of energy for the living beings of the first trophic levels. For ruminants, carbohydrates become available both indirectly, through the microbial fermentation process in the rumen-reticulum under the form of volatile fatty acids (VFA), and directly by the absorption of their monomer constituents, in the gastrointestinal tract of such animals (VAN SOEST, 1994).

Currently, new systems of ruminant feed evaluation indicate the need to distinguish the fractions that compose the carbohydrate and nitrogen compounds in food, in order to enable the prediction of microbial growth in the rumen, ruminal feed degradability, and animal performance (RODRIGUES & VIEIRA, 2006). Nutritionally, carbohydrates can be classified as non-fibrous and fibrous carbohydrates, being the former fully available in the rumen and the latter partially available (MERTENS, 1997).

Furthermore, considering the limitations of sugar cane intake due to the characteristics of its fiber fraction (AZEVÊDO et al., 2003; FERNANDES et al., 2003), it becomes necessary to differentiate the quality of different varieties regarding the fiber content and the kinetics variables of NDF ruminal degradation. In order to select the best varieties, they are compared by studies on their chemical characteristics, kinetics of rumen fermentation and animal performance tests.

The *in vitro* semi-automatic technique of gas production shows potential in describing the kinetics of fermentation in the rumen, providing the rate and extent of forage degradation as well as in measuring the products of fermentation of soluble and insoluble parts of the substrates. This technique allows the evaluation of a large number of substrates per experiment, with high accuracy in measurements, simplicity in handling equipment and low cost in execution and per analyzed sample (MAURÍCIO et al., 1999).

The objective of this research was to determine the chemical composition, the fractionation of carbohydrates and the kinetics of *in vitro* rumen fermentation of non-fibrous carbohydrate (NFC) and fibrous carbohydrates (FC) fractions of five varieties of sugar cane.

MATERIAL AND METHODS

The field experiment was conducted at the Experimental Farm of the Escola Agrotécnica Federal de Salinas (Federal Agrotechnical School of

Salinas), located in Salinas, State of Minas Gerais, latitude 16 ° 10 'south and longitude 42 ° 18' west, at an average altitude of 472 m. The climate corresponds to the AW type of Koppen classification.

The varieties Java, RB72-454, SP79-1011 (mid-late cycle), RB76-5418 and SP80-1842 (early cycle) were tested. The varieties were chosen because they have already been cultivated by farmers in the region. A randomized complete block design with five treatments (varieties) and four replications was used. Each plot or sampling unit consisted of six 10-m-long rows, 1.3 m spacing between them, totalizing 78 m^2. Plants at ten to twelve months of age were used, chopped in pieces containing three or four buds, and distributed by hand in furrows. The soil on the experimental area was classified as dystrophic Dark-Red Latosol of medium texture, having as chemical composition water pH 5.4; 5 mg/dm^3 of P; 0.63$cmolc/dm^3$ of K; 0.1 $cmolc/dm^3$ of Al; 4.3 $cmolc/dm^3$ of Ca; 2 $cmolc/dm^3$ of Mg; 2.9 $cmolc/dm^3$ of H + Al and 70% V. Planting took place on November 13, 2003, and the harvest occurred between the months of May and June 2004, where the varieties had an average Brix of 20%.

Chemical analysis and *in vitro* ruminal fermentation trials of the whole stems of the five sugar cane varieties were held on the campus of Universidade Estadual do Sudoeste da Bahia (University of Southwest State of Bahia), in the Laboratory of Animal Nutrition, Vitoria da Conquista, BA, Brazil.

After harvest, the individual chopping of the whole stems of the five sugar cane varieties was carried out. The stems were then taken to the forced air circulation hothouse at 55°C for 72 hours and ground in a "Wiley" mill knives grinder, on sieves with 1-mm-diameter screens. A pool was made from the obtained samples, constituting simple variety samples. These samples were used in the trials of *in vitro* rumen fermentation kinetics by the semi-automatic gas production technique (MAURÍCIO et al., 1999).

The chemical analysis to determine the percentage contents of dry matter (DM), crude protein (CP), ether extract (EE) and mineral matter (MM) was performed following standard procedures of AOAC (1990). The analysis of neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (sulfuric acid 72%) were determined according to GOERING & VAN SOEST (1970), SILVA & QUEIROZ (2004).

Estimates of fractions that constitute the total carbohydrate (TC) were determined as follows, according to SNIFFEN et al. (1992):

CT (%) = 100 - (% CP +% EE +% MM), in which CP, EE and MM correspond to the crude protein, ether extract and mineral matter of the sample.

Non-fibrous carbohydrates (NFC) were calculated as follows:

NFC (%) = 100 - (% CP + (NDF%) +% EE +% MM), in which NDFcp corresponds to the NDF fraction corrected to the mineral matter analyzed content and nitrogen multiplied by a 6.25 factor.

The fraction "C" was obtained by multiplying the lignin content by a 2.4 factor. The fraction "B2" (available fiber) was obtained by subtracting the neutral detergent fiber corrected for ashes and protein (NDFcp) from the fraction "C".

For the *in vitro* fermentation trials of the fibrous carbohydrates (FC) fraction, the initial preparation of the samples was carried out, which consisted of a preliminary analysis of neutral detergent fiber (NDF), by weighing three grams of sample and digesting it in 300 mL of neutral detergent solution (GOERING & VAN SOEST, 1970; & SILVA QUEIROZ, 2004). The residue from filtration in crucibles with number 1 porosity (50 mL) was then sequentially washed five times with hot water, twice with acetone and five times with hot water in order to remove any detergent residue that would impair the *in vitro* fermentation.

The incubations were performed separately for dry matter (DM) of whole stems and residues of NDF. In bottles of 160 mL, CO2, 1 g of sample (1 mm) and 90 ml of culture medium were added (THEODOROU et al., 1994; MAURÍCIO et al., 1999). The donors of ruminal fluid were maintained with daily feeding of 1 kg of minced wheat meal, Napier grass (P. purpureum) and sugar cane (1:1 as natural matter), *ad libitum.*

Replicates were used for whole stems and residues of NDF, totaling four flasks per variety and two more flasks containing only ruminal fluid and culture medium (artificial saliva), which was used as

control.

The schedule of the gas production readings were 2, 4, 6, 8, 10, 12, 14, 17, 20, 24, 28, 32, 48, 72, and 96 hours after the start of the *in vitro* fermentation process. The *in vitro* degradation times were 12, 24, 48 and 96 hours, and the residues of whole stems and the FC fractions from the five sugar cane varieties after *in vitro* fermentation were filtered in crucibles with number one porosity. Pressure readings were carried out semi-automatically with the aid of a T443A-type pressure transducer.

In order to obtain the microbial biomass production and the partitioning factor, the evaluation of the *in vitro* true degradability was performed in different samples. In a sample replication, *in vitro* true degradability (DM and NDF residue) was determined digesting the fermentation residue in 100 mL of NDF solution for an hour, filtering the residue in crucible 1 and drying it at 105°C for 24 hours (GOERING & VAN SOEST, 1970). In another replication, the *in vitro* apparent degradability of dry matter was determined filtering the fermentation residues directly in crucibles number 1, which were then placed in an oven at 105°C for 24 hours (MAURÍCIO et al., 1999).

Microbial biomass (mg.100 mg^{-1} of digestible DM) was obtained by decreasing the true *in vitro* degradability from the *in vitro* apparent degradability. The partitioning factor between the relation of truly degraded substrate (mg) and produced gas volume (mL) was calculated at each degradation time (BLUMMEL et al. 1997; BLUMMEL et al., 1999).

To determine the values of total digestible nutrients (TDN) of sugar cane cultivars, calculations according to Weiss (1993) were carried out at maintenance level, as follows:

TDN (%) = 0.98 * (100 - NDFn% -% CP - MM% -% EE - (0.7% PIDA *) + ((exp (-0.0012 x% PIDA)) *% CP) + 2.70% EE (- 1) + 0.75 * ((FDNn% -% LIG) * (1 - (% ON / FDNn%) 0.667)) - 7, in which crude protein digestibility is calculated using the acid detergent insoluble protein (ADIP), through the equation DVPB (%) = exp (-0.0012 *% PIDA); CP, crude protein; EE, ether extract; NDFn, neutral detergent fiber corrected for nitrogen; MM, mineral matter; LIG, lignin. All values, except for crude protein linked to the neutral and acid detergent fiber (% CP), should be expressed as a percentage of dry matter.

To calculate the parameters of gas production, the bicompartimental model proposed by SCHOFIELD et al. (1994) was used; it is described below:

V = Vf1 / (1 + exp(2 - 4*C1*(T - L))) + Vf2 / (1 + exp(2 - 4*C2*(T - L))), in which Vf1 is equivalent to the maximum volume of gas production of non-fibrous carbohydrates (NFC); C1 corresponds to the degradation rate (%. h-1) of the same fraction; Vf2 refers to the maximum volume of gas production of the fibrous carbohydrates fraction (FC); C2 represents the degradation rate (%. h-1) of FC; and T and L refer to incubation time (in hours) and latency (in hours), respectively.

The experimental design of *in vitro* fermentation trials was in randomized blocks, and the treatments consisted of five sugar cane tested varieties and the replications, besides three donors of ruminal fluid. Means were compared by Tukey test at 5% probability with the aid of SAS (1996). The parameters estimates described in the mathematical model were developed using nonlinear interactive methods. The adjusted results for least square estimates were obtained from the Gauss ï Newton method, within NLIN procedure with the aid of SAS (1996).

RESULTS AND DISCUSSION

The values of dry matter (DM), mineral matter (MM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (LIG) ranged between 26.8% and 30.1%, 1.4% and 2.3%, 1.6% and 2.8%, 0.37% and 0.59%, 39.0% and 46.4%, 22.8% and 29.3%, and 3.9% and 7.4%, respectively (Table 1). These results are within the range of variation by Valadares Filho et al. (2006). The greatest variation occurred in the NDF, ADF and LIG, thus changing the rates of non-fibrous carbohydrates (NFC), available fiber (B2), unavailable fiber (C) and total digestible nutrients (TDN).

Regarding the estimate of total digestible nutrients (TDN), the variety SP79-1011 showed the highest value (65.9%), followed by the varieties

Java, RB72454, SP80-1842 and RB765418 (64.0, 60.8, 57.3 and 54.3%, respectively). The NFC rates influenced the TDN values of the tested varieties, considering that those carbohydrates show almost complete nutrients availability for ruminants (VAN SOEST, 1994).

MELLO et al. (2006), evaluating the chemical composition of nine varieties of sugar cane, found values of DM, MM, CP, EE, NDF, ADF, TC, NFC, B2 and C ranging between 22.6% and 26.9 %, 2.3% and 3.5%, 1.9% and 3.3%, 0.61% and 0.89%, 44.2% and 52.1%, 28.4% and 33.5 %, 92.8% and 95.2%, 41.0% and 50.1%, 31.4% and 38.3%, 12.1% and 14.8%, respectively. These data are consistent with the current study.

The CGPDM of the variety SP79-1011 at 48 and 96 hours was higher (P <0.05) compared with the varieties RB765418, RB72454 and SP80-1842 (Table 2).

TABLE 1. Chemical composition of five sugar cane varieties

Item (%DM)	Varieties				
	Java	RB72454	RB765418	SP79-1011	SP80-1842
DM (%	26.8 ±0.38	28.5 ±0.65	28.8 ±0.34	29.4 ±0.87	30.1 ±1.30
MM (%	2.0 ±0.37	2.1 ±1.22	1.9 ±1.12	2.3 ±0.84	1.4 ±0.07
CP (%)	2.7 ±0.10	2.8 ±0.01	2.3 ±0.05	1.6 ±0.08	2.9 ±0.30
EE (%	0.50 ±0.09	0.37 ±0.10	0.37 ±0.09	0.45 ±0.04	0.59 ±0.20
NDF (%	40.1 ±0.33	42.4 ±0.26	46.4 ±0.72	39.0 ±0.55	45.8 ±0.69
ADF (%	24.5 ±1.60	26.4 ±0.70	29.3 ±0.90	22.8 ±0.43	28.5 ±0.30
LIG (%)	4.5 ±0.03	5.3 ±0.09	7.4 ±0.03	3.9 ±0.71	6.4 ±0.18
TC (%)	94.8	94.7	95.7	95.7	95.1
NFC (%)	56.2	54.0	50.6	57.3	50.7
B2 (%)	27.8	28.0	27.3	29.0	29.0
C (%)	10.8	12.7	17.8	9.4	15.4
TDN[1] (%)	64.0	60.8	54.3	65.7	57.3

[1]NDT estimated according to Weiss (1993) to 1x requirement for maintenance. TDN (%) = 0.98 * (100 - NDFn% -% CP - MM% -% EE - (0.7% PIDA *) + ((exp (-0.0012 x% PIDA)) *% CP) + 2.70% EE (- 1) + 0.75 * ((NDFn% -% LIG) * (1 - (% LIG / NDFn%) $^{0.667}$)) - 7.
Statistical analysis was not performed, taking into account the need to conduct a pool in the plots for *in vitro* fermentation trials.

TABLE 2. Mean values of total gas production (CGPDM; mL), partitioning factor (PFDM; mg.mL-1), and microbial biomass (BIODM; mg.100mg-1 digestible DM) of dry matter (DM) of five varieties of sugar cane at 12, 24, 48 and 96 hours of *in vitro* incubation

Item	Varieties					CV (%)
	Java	RB72454	RB765418	SP79-1011	SP80-1842	
CGPDM12	104.5^{a}	98.3^{ab}	88.1^{c}	102.3^{ab}	96.3^{b}	2.28
CGPDM24	147.0^{a}	139.4^{ab}	125.2^{c}	147.5^{a}	136.8^{b}	8.43
CGPDM48	197.7^{ab}	187.9^{bc}	167.2^{d}	202.1^{a}	182.5^{c}	2.12
CGPDM96	236.4^{ab}	225.9^{bc}	201.6^{d}	241.2^{a}	220.0^{c}	1.65
PFDM12[1]	5.5^{a}	5.7^{a}	5.9^{a}	5.7^{a}	5.7^{a}	2.67
PFDM 24[1]	4.2^{a}	4.3^{a}	4.4^{a}	4.2^{a}	4.3^{a}	2.63
PFDM 48[1]	3.5^{a}	3.7^{a}	3.8^{a}	3.5^{a}	3.6^{a}	2.47
PFDM 96[1]	3.1^{a}	3.2^{a}	3.2^{a}	3.2^{a}	3.2^{a}	2.13
BIODM12	4.37^{a}	4.20^{a}	5.93^{a}	3.93^{a}	5.13^{a}	21.44
BIODM24	1.80^{a}	3.37^{a}	2.47^{a}	3.47^{a}	3.70^{a}	66.36
BIODM48	3.87^{a}	4.53^{a}	4.87^{a}	2.83^{a}	2.37^{a}	37.29
BIODM96	2.85^{a}	2.27^{a}	2.30^{a}	2.33^{a}	2.57^{a}	34.04

Means followed by different letters in the line differ by Tukey test at 5% probability (P <0.05).
[1] mg of true degraded substrate / volume of produced gas in mL.

NOGUEIRA et al. (2006) evaluated the kinetics of *in vitro* ruminal fermentation of different forages by the semiautomatic technique of gas production, and found mean values of total accumulated gas production of 263 mL at the end of the *in vitro* incubation for sugar cane, similar to those described in Table 2.

AZEVÊDO et al. (2003) also observed that early cycle varieties were inferior, and the mid-late cycle varieties (SP79-1011 and RB845257) presented CGPDM higher than those of early cycle (SP80-1842). This result can be explained by the fact that the mid-late production cycle varieties can provide more energy for microorganisms that ferment non-fibrous carbohydrates (NFC), presenting more efficient microbial protein synthesis.

The values of the partitioning factor of DM (PFDM), which relate the amount of truly degraded substrate (mg) and gas production (mL), decreased with the incubation time among the tested varieties (P> 0.05).

No significant difference was found for the values of BIODM at 96 hours of *in vitro* incubation, which ranged from 2.27 to 2.85 mg.100 mg^{-1} of truly degraded substrate. The CGPNDF at 12, 24, 48 and 96 hours of incubation was higher (P <0.05) for the variety RB72454 than for the varieties SP79-1011 and RB765418 at 96 hours of incubation (Table 3).

The high variability of the results found for PFNDF and BIONDF, reflected in high coefficients of variation (CV), has made the detection of differences among the varieties (P> 0.05) more difficult. This high variation occurred probably due to difficulties in gravimetric measurements of residues before and after treatment with neutral detergent.

The results presented in this study are consistent to those observed by SCHOFIELD & PELL (1995), who assessed (48 hours *in vitro* incubation) the curves for total gas production by the method of subtracting the curves in the grass (*Panicum maximum*).

NOGUEIRA et al. (2006) evaluated the *in vitro* fermentation of the DM and of the material washed in sugar cane water by the semi-automatic technique of gas production and found an *in vitro* fermentation profile similar to this study, characterized by a faster fermentation of NFC and a slower on of the sugar cane fibrous fraction

TABLE 3. Mean values of total gas production (CGPNDF; mL), partitioning factor (PFFDN; mg.mL-1) and microbial biomass (BIOFDN; mg.100mg-1 of digestible DM) of neutral detergent fiber (NDF) of five varieties of sugar cane at 12, 24, 48 and 96 hours of incubation

Item	Varieties					CV
	Java	RB72454	RB765418	SP79-1011	SP80-1842	(%)
CGPNDF12	6.9^{c}	38.8^{a}	6.4^{c}	8.4^{c}	16.2^{b}	8.85
CGPNDF24	13.7^{c}	50.2^{a}	11.4^{c}	12.8^{c}	26.9^{b}	8.02
CGPNDF48	34.1^{bc}	72.4^{a}	22.2^{c}	25.0^{c}	47.4^{b}	13.15
CGPNDF96	59.7^{ab}	94.4^{a}	38.3^{b}	47.3^{b}	65.4^{ab}	20.75
PFNDF12[1]	3.0^{a}	0.3^{a}	4.4^{a}	1.8^{a}	1.2^{a}	86.41
PFNDF24[1]	3.9^{a}	0.6^{a}	5.1^{a}	1.7^{a}	1.1^{a}	78.42
PFNDF48[1]	3.3^{a}	1.1^{a}	3.3^{a}	3.0^{a}	1.8^{a}	31.81
PFNDF96[1]	2.6^{a}	1.3^{a}	2.9^{a}	2.4^{a}	2.0^{a}	22.90
BIONDF12	1.77^{a}	1.13^{a}	2.20^{a}	1.17^{a}	2.17^{a}	44.45
BIONDF24	2.87^{a}	1.63^{a}	1.80^{a}	0.77^{a}	2.40^{a}	82.86
BIONDF48	3.53^{a}	3.73^{a}	3.57^{a}	5.90^{a}	4.17^{a}	45.08
BIONDF96	2.93^{a}	3.60^{a}	3.43^{a}	Nd	4.13^{a}	30.98

Means followed by different letters in the line differ by Tukey test at 5% probability (P <0.05).

[1] mg true degraded substrate / produced gas volume in mL.

nd: not determined

There was no significant difference (P> 0.05) among the evaluated sugar cane varieties regarding the kinetic parameters of *in vitro* gas production. FERNANDES et al. (2003) evaluated the rate of carbohydrate digestion of sugar cane varieties with different production cycles (early and intermediate) and obtained values for Vf1, Vf2, C1 and C2 of 98.8 and 98.6 mL.g^{-1}, 168.6 and 170.6 mL.g^{-1}, 0.182 and 0.185 .h^{-1}, 0.023 and 0.023 .h^{-1}, respectively. The values of C1 and C2 were similar to the ones found in this study (0.182 to 0.220. h^{-1} and 0.021 to 0.023. h^{-1}), but Vf1 Vf2 values were slightly above the values presented in this paper. In order to compare the *in vitro* fermentation kinetic parameters, the results (Vf1 and Vf2) by FERNANDES et al. (2003) were extrapolated to 1 g of sample, as 100 mg of sample were used for incubation.

TABLE 4. Estimates of the kinetic parameters of *in vitro* gas production of dry matter (DM) of five sugar cane varieties

Item	Varieties					CV (%)
	Java	RB72454	RB765418	SP79-1011	SP80-1842	
Vf1 (mL.g^{-1})	86.9^{a}	79.9^{a}	77.4^{a}	85.0^{a}	80.6^{a}	11.13
C1 (h^{-1})	0.214^{a}	0.218^{a}	0.182^{a}	0.220^{a}	0.195^{a}	13.97
L (h)	5.68^{a}	5.51^{a}	5.69^{a}	6.11^{a}	5.42^{a}	16.34
Vf2 (mL.g^{-1})	140.7^{a}	136.6^{a}	117.0^{a}	147.1^{a}	130.9^{a}	12.14
C2 (h^{-1})	0.022^{a}	0.022^{a}	0.021^{a}	0.023^{a}	0.022^{a}	5.91

Means followed by different letters in the line differ by Tukey test at 5% probability (P <0.05).
Vf1: maximum volume of gas production from the NFC fraction; C1 - digestion rate for the NFC fraction; L: lag time; Vf2: maximum volume of gas production from the FC fraction; C2: digestion rate for FC fraction.

CAMPOS et al. (2001) assessed the *in vitro* gas production of different ruminant feed with an automatic monitoring system described by PELL & SCHOFIELD (1993), and found estimates of the kinetic parameters of gas production for the variety RB72454 of 9.8 mL. g^{-1}, 7.5 mL.g^{-1}, 0.20. h-1, 0.031. h^{-1} and 1.3 h for Vf1, Vf2, C1, C2 and L, respectively. The kinetic parameters of gas production were lower than the ones in the present work. This can be explained by the difference between the techniques used, taking into account that the automatic technique performed by CAMPOS et al. (2001) provided parameters estimates quickly (48 hours of incubation and 100 mg of sample).

The variety RB72454 presented higher CGPNDF, but with lower values of PFNDF in relation to the others (Table 3). These PFNDF values imply a smaller *in vitro* degradability of NDF. The major limitation of sugar cane is the low digestibility of FC fraction (AZEVÊDO et al., 2003; NOGUEIRA et al., 2006). Thus, materials that present more digestible FC can be used in genetic improvement programs of sugar cane for forage.

In Figure 1, the CGPDM, CGPNFC CGPFC are graphically shown together at different incubation times for the five sugar cane varieties. The varieties SP79-1011 and Java presented the highest CGPDM, followed by varieties RB72454, SP80-1842 and RB765418.

The major contribution of NFC in gas production in DM is presented here according to several studies published in the literature (SCHOFIELD & PELL, 1995; MALAFAIA et al. 1999; CAMPOS et al., 2001, AZEVÊDO et al., 2003; NOGUEIRA et al., 2006).

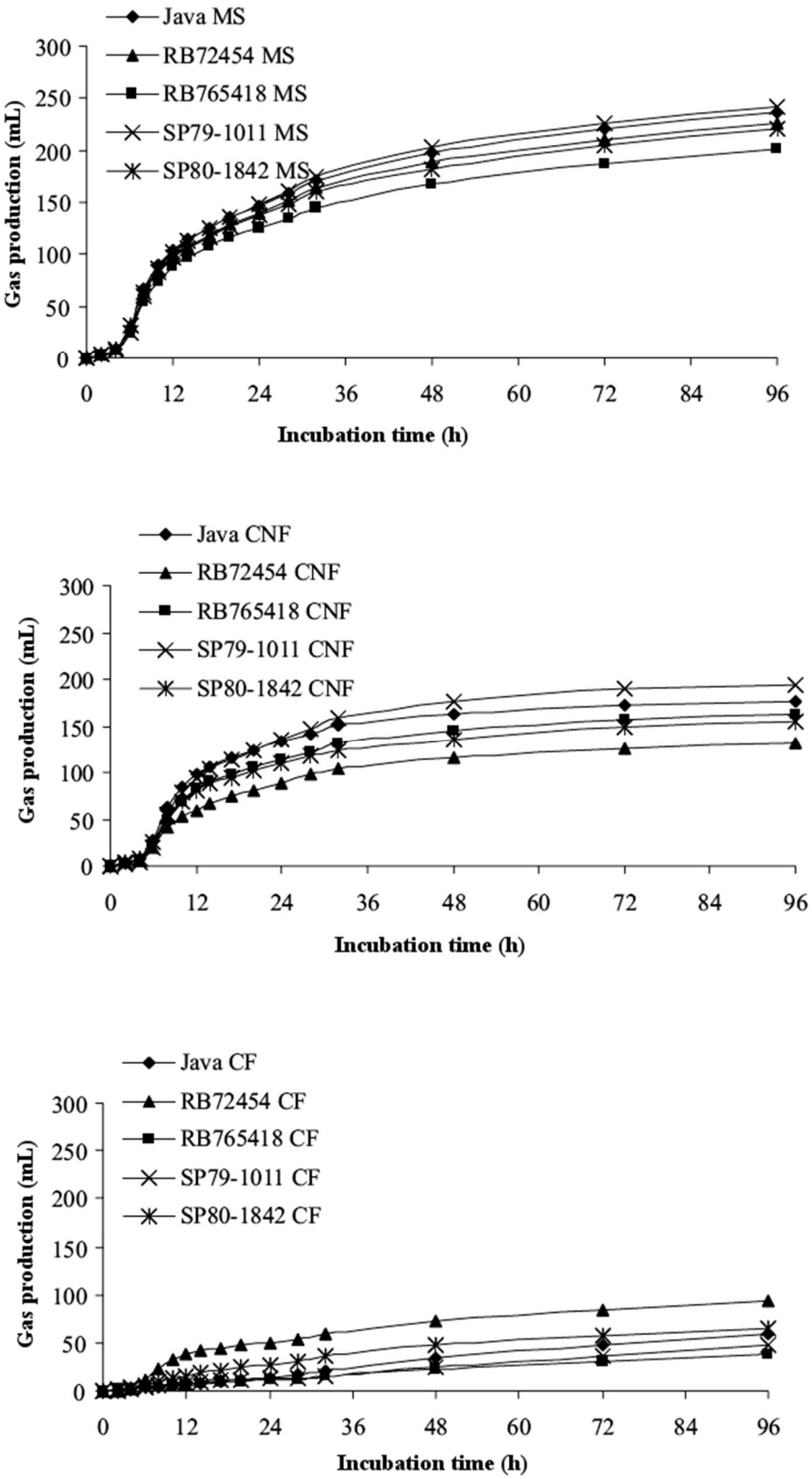

FIGURE 1. Cumulative gas production of dry matter (CGPDM) of non-fibrous carbohydrates (CGPNFC) and fibrous carbohydrates (CGPFC) of five sugar cane varieties.

CONCLUSION

Among the tested varieties, SP79-1011 and Java stand out, because they show better results of gas production kinetics and better chemical composition in relation to the NFC, C and TDN.

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