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Nutrition value of silage from corn hybrids in the State of Mato Grosso, Brazil

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ABSTRACT. Nutrition value of silage from corn hybrids produced in Mato Grosso, State was evaluated. A randomized block design was used with 23 treatments (hybrids) and three replications. The study used hybrids from different seed companies. Fodder was stored in PVC pipes at a density of 600 kg of green mass m^{-3}. The silos were opened 90 days after ensiling, and the following variables were studied: pH, dry matter (DM), ammoniacal nitrogen ($N-NH_3$), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN) and minerals (Ca, P, K and Mg). Rates were estimated for dry matter intake (DMI), dry matter digestibility (DM), net energy for maintenance (NEm), gain (NEg) and lactation (EL). All the characteristics were determined by near-infrared spectroscopy (NIR). With regard to standard fermentation, silage of different hybrids had appropriate values for pH and $N-NH_3$. The silage of hybrids DKB 370, DKB 330, DAS 2C520, DAS 2B710, DAS 2B587, BF 9534, AG 9010, AG 8088, AG 5020, BE 9701, AGN 30A06 e AGN 31A31 showed lower NDF and higher estimated DMI values.

Keywords: bromatological composition, ensiling, intake, NDF, NIRS.

Valor nutritivo da silagem de híbridos de milho no Estado do Mato Grosso, Brasil

RESUMO. Objetivou-se avaliar a composição bromatológica da silagem de híbridos de milho em cultivo de segunda safra no Estado do Mato Grosso. Utilizou-se o delineamento experimental em blocos casualizados com 23 tratamentos (híbridos) e três repetições. A forragem foi acondicionada em tubos de PVC sob densidade de 600 kg de massa fresco m^{-3}. A abertura dos silos ocorreu 90 dias após a ensilagem, sendo avaliados: valor de pH, teores de matéria seca (MS), nitrogênio amoniacal ($N-NH_3$), proteína bruta (PB), fibra em detergente ácido (FDA), fibra em detergente neutro (FDN), nutrientes digestíveis totais (NDT) e minerais (Ca, P, K e Mg).Também foram estimados os valores do consumo de matéria seca (CMS), digestibilidade "in vitro" da matéria seca (DIVMS), energias líquidas de mantença (ELm), ganho (ELg) e de lactação (ELl). Todas as características avaliadas foram determinadas por meio de espectrofotometria de infravermelho proximal (NIRS). Com relação ao padrão fermentativo, as silagens dos diferentes híbridos tiveram valores adequados de pH e NNH_3. As silagens dos híbridos DKB 370, DKB 330, DAS 2C520, DAS 2B710, DAS 2B587, BF 9534, AG 9010, AG 8088, AG 5020, BE 9701, AGN 30A06 e AGN 31A31 apresentaram menor teor de FDN e maior valor estimado de CMS.

Palavras-chave: composição bromatológica, ensilagem, consumo, FDN, NIRS.

Introduction

The concentration of rainfall between October and March in the Brazilian savanna causes seasonality in forage production which is actually one of the main challenges in dairy and meat cattle fed on the pasture system. This is due to the difficulties in product regularity and consequently liabilities in producers' income. The production of forage plants for ensiling is an alternative to minimize the effects of scarcity in roughage during the dry period. Corn is thus highlighted due to its adaptation to different edapho-climatic factors, high productivity and easy cultivation (CRUZ et al., 2001).

Choice of cultivars for ensiling production has been debated due to lack of information on the productive and qualitative agronomic behavior of different items by agricultural improvement firms (BELEZE et al., 2003a and b; SANTOS et al., 2002; ZEOULA et al., 2003a and b). The evaluation of the chemical composition of silage in the case of choice for corn cultivars is highly relevant since it determines food quality available for animal intake. High priority aim would be the reduction of NDF percentage which would increase DM digestibility. The less the NDF rate, the better is the quality of silage and the higher is DM intake (MELLO et al., 2004).

Further, according to Cabral et al. (2002) and Senger et al. (2007), digestibility analysis is a help in the choice of corn cultivars for silage production. The evaluation of NDF, ADF and lignin in ensiling is greatly important since it quantitatively and qualitatively characterizes the structural carbohydrates that may effectively be used by the animals or cause lower digestibility and intake by the animals.

Although several trials have been developed to evaluate the quality of hybrid corn for silage production, few were developed within the edapho-climatic conditions of the State of Mato Grosso, Brazil, where cattle-raising is yearly on the increase. Current study evaluates the nutrition value of corn silage from different hybrids cultivated in the State of Mato Grosso, Brazil.

Material and methods

Trial was undertaken on the experimental farm of the Universidade Federal de Mato Grosso in the municipality of Santo Antônio de Leverger, Mato Grosso State, Brazil, 15°47´5´´S; 56°04´W; average sea water height 140 m; meso-region of mid-southern Mato Grosso; micro-region of Cuiabá.

According to Köppen's classification, climate is Aw, or rather, tropical, megathermal, with two well-defined seasons: a dry season between May and September and a rainy season between October and April. Mean rainfall and evaporation during the experimental period were 479 and 533 mm, respectively, with a deficit of 54 mm (Figure 1).

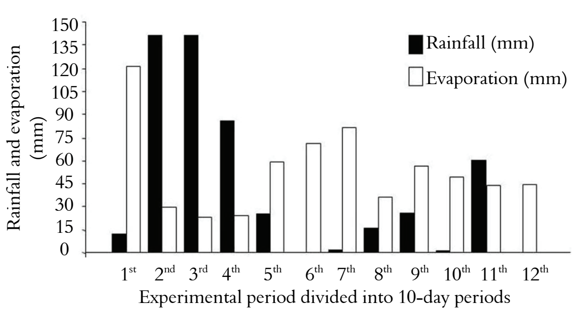

Figure 1. Rainfall and evaporation per 10-day periods (March to June 2009) in the Experimental Farm of UFMT, Santo Antonio de Leverger, Mato Grosso State, Brazil.

The region's predominant soil is moderate allic plintosoil of medium texture, with a plateau landscape. Soil analysis of the experimental area (0 - 20 cm) provided the following characteristics: pH in water = 6.8; P = 9.6 mg dm^{-3}; K^+ = 54 mg dm^{-3}; Ca^{2+} = 2.8 $cmol_c$ dm^{-3}; Mg^{2+} = 1.5 $cmol_c$ dm^{-3}; Al^{3+} = 0.0 $cmol_c$ dm^{-3}; H^++Al^{3+} = 1.7 $cmol_c$ dm^{-3}; SB = 4.5 $cmol_c$ dm^{-3}; T = 6.2 $cmol_c$ dm^{-3}; V = 72.7%; MO = 14.0 g dm^{-3}; sand = 672 g kg^{-1}; silt = 120 g kg^{-1}; clay = 208 g kg^{-1}.

Current experiment, undertaken in March 2009 during the planting of corn, was made up of randomized blocks with 23 treatments (hybrid corn) and three repetitions. Corn hybrids evaluated were AG 5020, AG 6040, AG 8088, AG 9010, DKB 177, DKB 330, DKB 370, DKB 390, DAS 2B587, DAS 2B688, DAS 2B710, DAS 2C520, P 30F98, P 30F80, P 3021, P 3021, BE 8307, BE 9701, BF 9534, BF 9417, BF 9304, BF 9304, AGN 30A06.

Lots were composed of four 5 mm-long rows of plants, with a spacing of 0.90 m. Area consisted of the two central rows, discarding 0.50 m at the ends. Seeding was manual and the population was maintained after the harvest of 55,000 plants ha^{-1}. Manuring was undertaken according to the interpretation of soil analysis and application at sowing time comprised 17.5 kg of N; 105 kg of P_2O_5; 52.5 kg of K_2O per hectare. Anticipated covering fertilization was done 30 days after plant emergence in doses of 80 kg of N and 80 kg of K_2O per hectare.

Herbicides alachlor (300 g i. a. L^{-1}) and atrazine (180 g i. a. L^{-1}) during pre-emergence were applied to control weed plants. The insecticide Lannate for the control of the armyworm (*Spodoptera frugiperda*) was applied twice, 15 and 30 days after emergence.

Harvest and slicing of corn plants for ensiling occurred 100 days after plant emergence when the grains were at the hard flour stage. Forage was cut at an average particle size between 2 and 3 cm. PVC tubes, 10 cm diameter and 50 cm long, with a capacity for approximately 2.50 kg of forage and a density of 600 kg of fresh mass m^{-3}, were used for ensiling. Forage compactness in the silos was done with rams measuring 50 mm at the top. Silos were closed with PVC lids with a Bunsen-like valve and then sealed with adhesive tape.

The silos were opened 90 days after ensiling and silage samples were collected from the mid-third of the silo's length. Samples were homogenized and divided into three portions: one portion was placed in plastic bags and frozen for ammoniacal nitrogen ($N-NH_3$) analysis; another portion was analyzed for its chemical composition; a small portion was used to determine its pH with a digital potentiometer, using 9 g of the sample in 60 mL of distilled water, following Silva and Queiroz (2002).

Silage liquid was removed by hydraulic press applying a force of 120 kgf. Consequently, 10 mL were collected and 2 mL of the liquid were used to measure

$N-NH_3$ concentration, following Campos et al. (2004).

Another sample portion, approximately 500 g, was dried in a forced-air buffer at 60-65ºC till constant weight, to determine dry matter rate. Pre-dried samples were ground at 1 mm and conditioned in plastic bags for the analysis of their chemical composition later on.

Dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and minerals Ca, P, K and Mg rates were determined by near infra-red spectroscopy (NIRS). Rates of total digestible nutrients (TDN), net lactation energy (NLE), net energy gained (NEg), net energy for maintenance (NEm), digestibility in vitro of DM (DIVDM) and dry matter intake (DMI) were undertaken by spectrometer Perstorp Analytical Silver Spring, MD, 5000, locked to a microcomputer equipped with ISI 4.1 (Intrasoft International, University, Park, PA).

Data underwent variance analysis and means of treatment were grouped by Scott-Knott's test at 5%.

Results and discussion

Silages from the 23 hybrid corn had adequate pH rates, ranging between 3.40 and 3.69 (Table 1) due to the high rate of soluble carbohydrates normally present in corn forage which caused high production of lactic acid and low degradation from protein to ammonia.

Hybrids with low pH rates (between 3.40 and 3.51) were DKB 390, DAS2C520, DAS2B710, BF 9304, AG 9010, AG 6040, SOMMA, BE 8307, BE 9701, AGN 30A06, P 3021, P 30F80 and P 30F98. In silages with high DM rates (> 35%), pH is a parameter of scanty importance owing to the fact that the development of acid-producing micro-organisms is impaired by lack of water and by high osmotic pressure.

There was no significant difference in ammoniacal nitrogen ($N-NH_3$) of silages, with hybrid corn varying between 1.96 and 2.72% of total N (Table 1). Since protein nitrogen preserved itself within the pH band (from 3.40 to 3.69), this response corroborated the fact that high percentages of DM contributed towards a low microbial activity and, as a consequence, a lower proteolysis. Rates were low when compared with those by Senger et al. (2005) in badly compacted silages and with a DM rate of forage of 20% DM (11.3% of total N). According to Cruz et al. (2001), good quality ensiling must have $N-NH_3$ rates lower than 10% of total N.

Silages of hybrids did not differ ($p > 0.05$) with regard to dry matter (DM), with average rate of 40.25%, similar to those by Mello et al. (2004) with a variation between 33.46 and 43.89%. However, the values were higher than those obtained by Ferreira et al. (2011), which ranged from 27.62 to 35.14%.

Table 1. Rates of pH, ammoniacal nitrogen ($N-NH_3$), dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrients (TDN), Ca, P, K, Mg, DM intake (DMI), digestibility in vitro of dry matter (DIVDM) and of digestible protein (DP), net lactation energy (NLE), net maintenance energy (NEm) and net energy gained (NEg) of silage of corn hybrids.

Híbrido[1]	pH	$N-NH_3$[2]	DM	CP	NDF	ADF	TDN	Ca	P	K	Mg	DMI	DIVDM	DP	NLE	NEm	NEg
		(% of total N)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(% LW)	(%)	(%)	(Mcal kg^{-1})	(Mcal kg^{-1})	(Mcal kg^{-1})
DKB 370	3.57 b	0.16	44.56	8.20	42.75 b	21.23	71.98	0.14	0.21	0.76	0.20 b	2.81 a	72.37	5.90	1.65	1.80	1.08
DKB 390	3.40 c	0.19	36.31	8.28	46.88 a	27.38	67.67	0.24	0.19	0.70	0.24 a	2.58 b	67.57	5.96	1.54	1.68	0.96
DKB 177	3.54 b	0.19	42.18	7.81	44.12 a	23.35	70.49	0.18	0.20	0.70	0.20 b	2.72 b	70.71	5.62	1.61	1.76	1.04
DKB 330	3.61 a	0.15	38.30	7.65	41.65 b	20.46	72.52	0.12	0.21	0.46	0.23 a	2.88 a	72.96	5.51	1.66	1.82	1.10
DAS 2C520	3.46 c	0.16	38.84	8.49	42.35 b	21.90	71.51	0.20	0.21	0.77	0.22 a	2.84 a	71.84	6.11	1.64	1.79	1.06
DAS 2B688	3.62 a	0.15	46.11	8.47	46.20 a	26.65	68.18	0.24	0.20	0.49	0.24 a	2.61 b	68.14	6.10	1.56	1.69	0.97
DAS 2B710	3.43 c	0.17	39.60	7.94	41.87 b	20.40	72.56	0.13	0.20	0.74	0.20 b	2.89 a	73.01	5.71	1.66	1.82	1.10
DAS 2B587	3.69 a	0.14	45.36	8.50	39.97 b	19.51	73.19	0.17	0.24	0.83	0.22 a	3.00 a	73.71	6.12	1.68	1.83	1.11
BF 9534	3.54 b	0.15	39.42	7.90	39.88 b	18.59	73.83	0.13	0.21	0.71	0.20 b	3.01 a	74.42	5.69	1.70	1.86	1.14
BF 9417	3.54 b	0.18	37.98	7.76	44.37 a	25.64	68.89	0.19	0.20	0.93	0.17 c	2.71 b	68.93	5.59	1.57	1.71	0.99
BF 9304	3.50 c	0.16	40.75	7.82	45.09 a	26.99	67.95	0.27	0.22	1.12	0.18 c	2.67 b	67.88	5.63	1.55	1.68	0.96
AG 9010	3.50 c	0.14	46.01	7.99	40.82 b	18.64	73.79	0.11	0.22	0.75	0.21 b	2.95 a	74.37	5.75	1.69	1.85	1.13
AG 8088	3.56 b	0.13	46.54	8.23	42.11 b	19.93	72.89	0.13	0.21	0.64	0.22 a	2.86 a	73.37	5.93	1.67	1.83	1.11
AG 5020	3.55 b	0.13	43.41	8.31	41.02 b	19.74	73.02	0.17	0.21	0.59	0.23 a	2.93 a	73.53	5.98	1.67	1.83	1.11
AG 6040	3.44 c	0.19	35.21	8.88	46.33 a	28.69	66.76	0.31	0.20	0.78	0.25 a	2.59 b	66.55	6.39	1.52	1.65	0.93
SOMMA	3.50 c	0.21	37.35	8.69	43.35 b	24.29	69.84	0.22	0.19	0.67	0.24 a	2.78 b	69.98	6.25	1.59	1.74	1.02
BE 8307	3.45 c	0.21	37.41	8.11	48.09 a	30.01	70.79	0.26	0.20	0.89	0.22 a	2.50 b	65.52	5.84	1.50	1.62	0.90
BE 9701	3.48 c	0.15	40.62	7.27	42.80 b	22.93	65.83	0.17	0.22	0.94	0.18 c	2.80 a	71.04	5.23	1.62	1.77	1.04
AGN 30A06	3.51 c	0.16	41.17	7.44	38.43 b	16.23	75.48	0.11	0.20	0.51	0.20 b	3.15 a	76.26	5.36	1.74	1.90	1.18
AGN 31A31	3.57 b	0.18	40.17	8.30	43.30 b	24.44	69.73	0.28	0.22	1.05	0.21 b	2.79 a	69.86	5.98	1.59	1.74	1.02
P 3021	3.47 c	0.16	36.93	8.23	43.64 b	23.37	70.48	0.21	0.21	0.98	0.21 b	2.75 b	70.70	5.93	1.61	1.76	1.03
P 30F80	3.51 c	0.19	37.92	8.09	46.09 a	28.03	67.22	0.27	0.22	1.05	0.18 c	2.61 b	67.07	5.82	1.53	1.66	0.94
P 30F98	3.41 c	0.20	33.64	7.94	48.89 a	29.43	66.24	0.23	0.16	0.23	0.24 a	2.47 b	65.97	5.72	1.51	1.64	0.92
CV (%)	1.47	20.52	12.77	6.36	6.87	21.98	5.15	52.49	8.78	40.10	8.66	6.76	5.72	6.36	5.58	5.98	10.18

[1]Means followed by different letters in the vertical column statistically differed among themselves by Scott-Knott test ($p < 0.05$). [2]Data were transformed in arc-sen $\sqrt{x}$ 100^{-1}.

Amplitude in DM rates of silages was due to the hybrid cycle that defined higher or lower contribution of the corn ears in the biomass. Early hybrids had a high DM rate in the plant when they reached the ideal score for ensiling. Higher DM percentage impaired the occurrence of undesirable fermentations caused by Clostridia without jeopardizing lactic fermentation.

No difference ($p > 0.05$) was found between silages with corn hybrids when CP rates were taken into account even though there was a variation between 7.27 and 8.88% (Table 1), very close to those by Rocha Junior et al. (2003), with 7.25%; Silva et al. (2005), with 7.68%; Rodrigues et al. (2004), with 8.07%; Velho et al. (2008), with 8.07%. High CP rates were relevant when silages with high nutrition rates were required.

Significant difference ($p < 0.05$) existed among corn hybrids with regard to NDF rate in silage. Hybrids with lowest NDF percentages (between 38.40 and 43.60) were DKB 370, DKB 330, DAS2C520, DAS2B710, DAS2B587, BF 9534, AG 9010, AG 8088, AG 5020, SOMMA, BE 9701, AGN 30A06, AGN 31A31 and P 3021. Rates were lower than those by Neumann et al. (2007), ranging between 50.6 and 55.35%, and by Mittelmann et al. (2005), ranging between 52.6 and 57.1%. NDF rates above 60% had a negative correlationship with DM intake and digestibility. According to Cruz et al. (2001), Tedeschi et al. (2002) and Velho et al. (2007), ideal NDF rate should be close to 50%. In current research, NDF rates of all hybrids was lower than 50%.

NDF rates were also lower than those by Mello et al. (2005), who evaluated corn hybrids harvested 116 days after emergence and reported variation between 49.75 and 62.18%. The above-mentioned authors attributed high rates of NDF to the differences in the participation of the stem (average 34.64% in DM) and in the NDF of the stem (average 62.55%).

No difference ($p > 0.05$) was reported among the hybrids with regard to ADF rates in the silage, with mean rate 23.38%. ADF lower than 30% for corn silages has been recommended by Velho et al. (2006a and b) and Pedó et al. (2009), since it indicated the quantity of non-digestible fiber and contained a higher proportion of lignin. Quality of fiber in the stem was due to the characteristics of differentiated agronomic behavior as a result of genetic improvement to increase stem resistance to bedding and pathogenic agents. Plants' material with high digestibility of their structural components and, at the same time, resistant to bedding and breaks were required.

There was no difference ($p > 0.05$) among corn hybrids with regard to TDN in silage, with mean rate 70.47%, which was close to that by Rosa et al. (2004), who reported TDN rates between 68.62 and 69.39%, and higher than that by Costa et al. (2005), with rates between 60.2 and 62.5%. In their review of TDN rates in corn silages, Capelle et al. (2001) registered a minimum of 55.47% and a maximum of 63.87%.

No difference existed ($p > 0.05$) among corn hybrids with regard to DIVDM in silage, with mean rate 70.79 % (Table 1). This rate lay between that found by Cabral et al. (2002), or rather, between 62.19 and 83.21%, and higher than that reported by Mittelman et al. (2005), or rather, between 64.2 and 67.6%. Rates were higher than those by Rosa et al. (2004), with DIVDM ranging between 57.79 and 60%. This fact may be due to plant cutting when the grains were transforming themselves from the paste to the flour stage, with a phenological age lower than that in current research.

Difference ($p < 0.05$) in DMI was reported in corn hybrids due to higher rates of fiber in the stem when compared to that in the ears. Hybrids with higher DMI (between 2.79 and 3.15%) were DKB 370, DKB 330, DAS2C520, DAS2B710, DAS2B587, BF 9534, AG 9010, AG 8088, AG 5020, BE 9701, AGN 30A06 and AGN 31A31.

Silages of different hybrids did not differ in Ca, P and K rates. However, differences were registered ($p < 0.05$) with regard to Mg rate in corn ensiling (Table 1), with the best hybrids featuring rates between 0.22 and 0.25%. Ca and K rates in current analysis were lower than those reported by Valadares Filho et al. (2002), ranging between 0.30 and 0.41% and between 1.04 and 1.09%, respectively. However, P and Mg rates were close to those registered by the same author, or rather, between 0.17 and 0.19% for P and between 0.12 and 0.40% for Mg.

According to NRC (2001), diet mineral requirements for milking cows should be between 0.43 and 0.77% Ca; 0.20% Mg; between 0.25 and 0.48% P and 0.70% K. Therefore, silages of all hybrids had insufficient rates for Ca and P. Ensiling of hybrids under analysis did not differ ($p > 0.05$) with regard to net energy for maintenance (NEm), gain (NEg) and lactation (LE), with averages 1.76, 1.04 and 1.61 Mcal kg^{-1}.

Conclusion

Ensiling of different hybrids showed adequate rates for pH and $N\text{-}NH_3$.

Silages of the hybrids DKB 370, DKB 330, DAS 2C520, DAS 2B710, DAS 2B587, BF 9534, AG 9010, AG 8088, AG 5020, BE 9701, AGN 30A06 and AGN 31A31 had lower NDF rates and estimated higher DMI rates.

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