Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v34i2.12853

Nutritive value of diferents silage sorghum (*Sorghum bicolor* L. Moench) cultivares

Luis Felipe Pereira Borba[1*], Marcelo de Andrade Ferreira[1], Adriana Guim[1], José Nildo Tabosa[2], Luiz Henrique dos Santos Gomes[1] and Viviany Lúcia Fernandes dos Santos[1]

[1]*Departamento de Zootecnia, Universidade Federal Rural de Pernambuco, Rua D. Manoel de Medeiros, s/n, 52171-900, Recife, Pernambuco, Brazil.*
[2]*Departamento de Pesquisa e Desenvolvimento, Instituto Agronômico de Pernambuco, Universidade Federal Rural de Pernambuco, Recife, Pernambuco, Brazil. *Author for correspondence: E-mail: luisfelipeborba@hotmail.com*

ABSTRACT. Nutrition values of silages from different sorghum cultivars are evaluated. Five 26-kg castrated crossbred lambs, housed in pens equipped with feces and urine collectors for the study of their metabolism, were employed in a 5 x 5 Latin square experimental design. Treatments consisted of silage from five different sorghum cultivars: IPA 1011 and IPA 2564 (grain sorghum), IPA 2502 (dual purpose sorghum), IPA FS-25 and IPA 467 (forage sorghum). Protein level was corrected to 12% by adding a mixture of urea: ammonium sulfate (9:1). Treatments IPA 1011, IPA 2564 and IPA 2502 provided high intake of dry matter, total carbohydrate and total digestible nutrients, and low intake of neutral detergent fiber. Cultivars IPA 1011 and IPA 2564 provided high apparent crude protein digestibility coefficient, whereas cultivars IPA 1011 and IPA 2564 had high total digestible nutrient levels. All cultivars provided positive nitrogen. Owing to nutrient intake and digestibility values, grain sorghum silages evidenced high potential in ruminant nutrition.

Keywords: nitrogen balance, composition, intake, digestibility, forage.

Avaliação nutricional de silagens de cultivares de sorgo (*Sorghum bicolor* L. Moench)

RESUMO. Objetivou-se avaliar o valor nutritivo de silagens de diferentes cultivares de sorgo. Foram utilizados cinco ovinos machos, castrados, sem padrão racial definido, com peso corporal médio de 26 kg. Os animais foram distribuídos em delineamento experimental quadrado latino (5 x 5), e alojados em gaiolas para estudo de metabolismo, equipadas com coletores de fezes e urina. Os tratamentos consistiram de silagem de cinco cultivares de sorgo: IPA 1011, IPA 2564 (graníferos), IPA 2502 (duplo propósito), IPA SF-25 e IPA 467 (forrageiros). O teor de proteína das silagens foi corrigido para 12% com a adição da mistura ureia-sulfato de amônio (9:1). As cultivares 1011, 2564 e 2502 proporcionaram maiores consumos de matéria seca, carboidratos totais, nutrientes digestíveis totais e menores teores de fibra em detergente neutro. As cultivares 1011 e 2564 proporcionaram maiores coeficientes de digestibilidade aparente da matéria seca e orgânica, e juntamente com o 467 e o SF-25, os maiores coeficientes de digestibilidade aparente da proteína bruta. As cultivares 1011 e 2564 proporcionaram maiores teores de nutrientes digestíveis totais. Todos as cultivares proporcionaram balanço de nitrogênio positivo. Em função dos valores observados para consumo e digestibilidade dos nutrientes, as silagens das cultivares graníferas apresentam maior potencial para a alimentação de ruminantes.

Palavras-chave: balanço de nitrogênio, composição, consumo, digestibilidade, volumoso.

Introduction

The semiarid region of Brazil extends over an area of 928 km². The soils are shallow and settled on the crystalline substrate, predominantly covered by vegetation caducifoliar of caatinga, typical of the region. The precipitation generally ranges between 250 and 600 mm year^{-1} and can reach up to 800 mm year^{-1}. The semiarid region has high temperatures with little annual variation, added to strong sunlight, exert a strong effect on evapotranspiration, causing shallow water reservoirs are depleted rapidly (FERREIRA et al., 2009).

Since ruminants' productive system in northeastern Brazil shows low productivity rates due to low quality forage and seasonality, difficulties in the supple of animal produce throughout the year are evidenced since the animals fail to offer a satisfactory performance during the period of forage scarcity.

The seasonality of pasture products and the intensification of production systems in Brazil have triggered sorghum silage with increasing relevance year after year, especially in the arid or semi-arid regions of the country. Since sorghum culture is highly relevant due to its high resistance to water stress, Brazil is one of the countries with the greatest potentialities in sorghum adaptation and growth.

Climate risk zoning for sorghum culture has been prepared for the state of Pernambuco, Brazil, by the Secretary of Rural Production and Agrarian Reform and by Embrapa Soils. Further, one hundred and twelve municipalities within the "Agreste" and "Sertão" micro-regions with a potentiality for sorghum culture were identified. The Agronomy Institute of Pernambuco (IPA) has made extensive effort for sorghum improvements so that several varieties with high productivity and resistant to the main pests and diseases and adapted to the semi-arid region of north-eastern Brazil could be obtained. IPA's genetic improvement program have selected highly promising forage cultivars IPA SF-25 and IPA 467-4-2 because of their high production of dry matter and resistance to overturning, the grain cultivars IPA 7301011 and IPA 8602564, and the dual purpose cultivar IPA 8602502.

However, sorghum varieties IPA 7301011 and IPA 8602564, IPA 8602502, IPA SF-25 and IPA 467-4-2 were not evaluated in animals. According to Euclides et al. (1998), forage evaluation cannot discard its use in animals. Their use in animals is relevant because results are more representative of production system conditions. In vivo digestibility evaluation may be more adequate than that in vitro to evaluate real nutrition rates by the addition of such factors as voluntary forage intake, degradability in the reticulum-rumen, and absorption of nutrients throughout the whole gastro-intestine tract.

Current analysis evaluates the nutrition rates of five sorghum silages from different cultivars.

Material and methods

The experiment was undertaken in the Department of Animal Science of the Federal Rural University of Pernambuco between February and April 2009. Five crossbreed castrated male lambs, mean weight 26 kg, were employed.

Experimental treatments consisted of silages of five sorghum cultivars: IPA 7301011 (IPA 1011) and IPA 8602564 (IPA 2564) are grain cultivars; IPA 8602502 (IPA 2502) is a dual-purpose cultivar; IPA 467-4-2 (IPA 467) and IPA SF-25 are forage cultivars.

Animals were distributed in an experimental square design 5 x 5, with 5 animals and 5 treatments (silage of different sorghum cultivars) and 5 periods. The experiment was divided into five 15-day periods of which 10 days provided adaptation to diets and five days for data and samples collection.

The animals were set in suspended individual pens (1.10 x 0.55 m) for the study of their metabolism. The pens, furnished with feed, water and salt troughs, had an inclined floor so that feces and urine could be separated in different containers. Water and salt were available throughout the experiment. Prior to the start of the experiment the animals were treated against endo- and ecto-parasites.

Silages were prepared at the Experimental House of the Agronomy Institute of Pernambuco (IPA) in São Bento do Una in the semi-arid region of the state of Pernambuco, Brazil. Collection and silage of material were undertaken when the grain reached the maturity flour stage. The sorghum plant was processed in a foraging machine and cut into approximately 3 cm slices. Silages were conditioned in metal casks and stored in a place protected from direct sun rays and rain. Silages were previously analyzed for dry matter and crude protein rates, while the product was adjusted for an intake of 3% and 12% of body weight per day respectively for dry matter and crude protein.

Animals were weighed at the start and at the end of each collecting period for adjustment of supply. Adjustment of crude protein rate was undertaken by a mixture of urea: ammonium sulfate (9:1). Diets were divided into two daily equal supplies at 8h and at 14h. Silage samples were collected at the start and during the beginning of each collection period. Whereas quantities supplied and remains were daily weighed for intake control, total collection of feces during the last 5 days of each experimental period was also undertaken.

Feces were collected at a 24h-period during the five days of collection. Samples were weighed and a 20% aliquot was retrieved. Feed remains were weighed every day immediately before the 8h supply from which a 20% aliquot was also retrieved. The five samples obtained during the experimental period from each animal were homogenized so that compound samples of feces and remains per period and per animal could be obtained. Urine samples were obtained by collecting excreted material during a 24h-period which was collected in a specific container with an acid solution of sulfuric acid (H_2SO_4) so that nitrogen loss by volatilization could be avoided. Remain samples were preserved in a freezer for later analyses and feces samples were pre-dried in a buffer at 60ºC and stored in plastic bags for a compounded sample.

Rates of dry matter (DM), ethereal extract (EE), ashes, neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP) were determined, coupled to the determination of total nitrogen rate of urine samples (SILVA; QUEIROZ, 2002). Fiber was determined by using nonwoven fabric bags

(TNT) 100 g m^{-2} and autoclave. Nitrogen rate in the waste of silage NDF and ADF was determined and, thus, the rate of insoluble nitrogen in neutral detergent (INND) and in acid detergent (INAD).

Total carbohydrates (CHO) and total digestible nutrients (TDN) were calculated according to Sniffen et al. (1992), CHO = 100 – (%CP + %EE + % Ashes), TDN = (ingested CP – fecal CP) + 2.25 (ingested EE – fecal EE) + (ingested total CHO – fecal total CHO). Silages were also analyzed for pH (SILVA; QUEIROZ, 2002) and ammonia nitrogen (FENNER, 1965) when the silo was opened.

All analyses were undertaken at the Laboratory of Animal Nutrition of the Department of Animal Science of the Federal Rural University of Pernambuco, Brazil.

Non-fiber carbohydrates (NFC) were determined following NRC (2001), NFC = 100 - (%NDF + %CP + %EE + % Ashes). Digestibility coefficients were calculated by: CD = ((ingested nutrient – excreted nutrient)/ingested nutrient) x 100. Nitrogen balance (NB) was calculated by subtracting the excreted nitrogen in feces and urine from total ingested nitrogen (NB = ingested N – feces N – urine N).

Data underwent variance analysis and, when required, Tukey's test for mean comparisons ($p < 0.05$). Statistical analysis was undertaken by software Universidade Federal de Viçosa - UFV - SAEG (1998).

Results and discussion

Table 1 shows sorghum silages with variations regarding bromatological composition, pH and $N\text{-}NH_3$. Grain silage IPA 1011 had lower DM rates than those of the other cultivars under analysis. According to McCullough (1977), ideal fermentation in the silo occurs when ensilaged forage presents a dry matter rate ranging between 28 and 34%.

Low DM rates may positively affect the development of bacteria of the genus Clostridium and may cause nutrient loss through effluents on compaction (McDONALD et al., 1991). On the other hand, high dry matter rates impair the compaction of material and hinder the establishment of anaerobiosis and lowering of pH, with losses in silaged material.

Since crude protein rates were low in cultivar IPA SF-25, it differentiated itself from the other cultivars. CP rates ranged between 5.66% for IPA SF-25 and 7.68% for IPA 1011. The above rates are very close to CP rates in sorghum silages of several cultivars in the literature (MOLINA et al., 2003; PIMENTEL et al., 1998; SOUZA et al., 2003) which is a highly critical rate for full activity of rumen microorganisms with lower digestibility of forage and depression in voluntary intake (OSKOV, 1982). Low CP rates for silages may have been caused by cultivar-inherent factors and by soil conditions in which the grass was cultivated. Aguiar et al. (2006) also reported low CP rates when the bromatological composition of cultivars IPA SF-25 and IPA 467 was evaluated (7.28 and 6.63%, respectively).

When compared to other cultivars, IPA 2564 and IPA 467 had higher INND rates expressed in percentage of total nitrogen (INND/TN). INAD also had a higher rate in IPA 2564. Whereas INND is the nitrogenated fraction linked to the cell walls, albeit potentially degradable, INAD is the indigestible nitrogenated fraction linked to lignin, tannins and heat-damaged proteins (SANTOS, 2006). Valadares Filho et al. (2006) supplied the composition of silages which were separated according to their panicle participation level in total mass, or rather, 13.05% INND/TN for forage sorghum; 11.08% INND/TN for dual-purpose sorghum; between 10.10 and 11.13% INND/TN for grain sorghum. Results in current analysis are close to those registered by the above researchers, with the exception of cultivar IPA 2564 with high INND and INAD (16.37%) levels. INND and INAD rates in current analysis are below those reported by Rodrigues et al. (2002), Oliveira et al. (2009) and Pereira et al. (2007).

Total carbohydrate rates did not differ among themselves and were similar in all cultivars, ranging between 85.78% (IPA 1011) and 89.07% (IPA SF-25). Grain and dual-purpose cultivars (respectively IPA 1011, IPA 2564 and IPA 2502) had higher non-fiber carbohydrate rates (NFC) when compared to those in forager cultivars. Results had the lowest rates in NDF and ADF for grain (IPA 1011 and IPA 2564) and dual-purpose (IPA 2502) cultivars when compared to forage ones (IPA SF-25 and IPA 467). This event was probably due to a proportional increase of grains in silages.

Further, there was no significant statistical difference in pH rates in silages, with ranges between 3.3 and 3.8. Excepting silage of cultivar IPA 2502, the other rates were slightly below those registered by McDonald et al. (1991) who reported that pH of silages with well-preserved non pre-dried material should range between 3.7 and 4.0. Stabilization of pH in silage was due to the interactivity between concentrations of soluble carbohydrates and of lactate coupled to environmental anaerobiosis conditions (HAIGH, 1990; HENDERSON, 1993; MOISIO; KEIKONEN, 1994).

N-NH_3 rates in % of total N at the opening of the silos were higher for cultivars IPA 1011, IPA SF-25, IPA 467 when compared to those for IPA 2564 and 2502, with variations ranging between 1.02 and 2.13. According to AFRC (1993) and Henderson (1993), N-NH_3 rates of total nitrogen below 11% revealed decreased proteolysis. Consequently, rates in the material under investigation did not indicate high proteolysis of the material under analysis. They also showed that they underwent less deterioration in the fermentation and stabilization process of the silage, without any liabilities in silage quality.

N-NH_3 rates in current analysis were lower than those reported by several authors who researched sorghum silage (MOLINA et al., 2003; OLIVEIRA et al., 2007; OLIVEIRA et al., 2009; RODRIGUES et al., 2002).

N-NH_3 and pH rates showed that silaged material presented a fast decrease in pH to levels that impaired the proliferation of undesired microorganisms which intake protein, especially bacteria of the genus *Clostridium*. According to McDonald et al. (1991), pH 4.2 was low enough to avoid the growth of bacteria of the genus *Clostridium*.

Grain sorghum cultivar IPA 2564 provided a higher intake of dry matter (g day^{-1}, %PC and g kg^{-1} $PV^{0.75}$) similar to that in cultivars IPA 1011 and IPA 2502 (Table 2), perhaps due to a lower percentage of fiber fraction. McDonald et al. (1991) reported that forage intake was related to the removal rate of forage particles from the reticulum-rumen, which was related to forage chemical composition, digestion rate of digestible factors and reduction rate of indigestible items. Mizubuti et al (2002) registered lower results for dry matter intake (DMI) than those in current analysis (48.06 g kg^{-1} $PV^{-0.75}$) when they provided forage sorghum silage to lambs.

CP intake followed DMI since isoprotein diets were provided with higher intakes for cultivars IPA 2564 and IPA 2502 than for the others. Intake of NDF was higher for animals fed on cultivar IPA SF-25 (419.57 g day^{-1}) and similar to the other cultivars. This was due to the fact that it had the highest rate of the component (Table 1).

Table 1. Bromatological composition, pH and N-NH3 of silages from different sorghum cultivars.

Nutrients	Cultivars				
	Grain				Grain
	IPA 1011		IPA 1011		IPA 1011
DM (%)	31.23b ± 1.16	DM (%)	31.23b ± 1.16	DM (%)	31.23b ± 1.16
OM[1]	96.03a ± 0.20	OM[1]	96.03a ± 0.20	OM[1]	96.03a ± 0.20
Ashes[1]	3.97a ± 0.20	Ashes[1]	3.97a ± 0.20	Ashes[1]	3.97a ± 0.20
CP[1]	7.68a ± 0.34	CP[1]	7.68a ± 0.34	CP[1]	7.68a ± 0.34
INND[2]	9.62b ± 0.04	INND[2]	9.62b ± 0.04	INND[2]	9.62b ± 0.04
INAD[2]	9.51b ± 0.17	INAD[2]	9.51b ± 0.17	INAD[2]	9.51b ± 0.17
CHOT[1]	85.78a ± 0.51	CHOT[1]	85.78a ± 0.51	CHOT[1]	85.78a ± 0.51
NCHO[1]	39.46a ± 4.71	NCHO[1]	39.46a ± 4.71	NCHO[1]	39.46a ± 4.71
NDF[1]	46.32b ± 0.29	NDF[1]	46.32b ± 0.29	NDF[1]	46.32b ± 0.29
NDF_p[1]	45.81b ± 0.04	NDF_p[1]	45.81b ± 0.04	NDF_p[1]	45.81b ± 0.04
ADF[1]	30.08b ± 0.15	ADF[1]	30.08b ± 0.15	ADF[1]	30.08b ± 0.15
LIGNIN[1]	6.48b ± 1.34	LIGNIN[1]	6.48b ± 1.34	LIGNIN[1]	6.48b ± 1.34
EE[1]	2.57a ± 0.48	EE[1]	2.57a ± 0.48	EE[1]	2.57a ± 0.48
pH	3.4a ± 0.00	pH	3.4a ± 0.00	pH	3.4a ± 0.00
N-NH_3[2]	2.13a ± 0.28	N-NH_3[2]	2.13a ± 0.28	N-NH_3[2]	2.13a ± 0.28

Means following the same letter within the line do not differ ($p < 0.05$) by Tukey's test; DM = dry matter; OM = organic matter; CP = crude protein; INND = insoluble nitrogen in neutral detergent; INAD = insoluble nitrogen in acid detergent; CHOT = total carbohydrates; CNF = non-fibrous carbohydrates; NDF = neutral detergent fiber; NDFp = protein-free neutral detergent fiber; ADF = acid detergent fiber; EE = ethereal extract; TDN = total digestible nutrients N-NH3 = ammonia nitrogen. 1 % dry matter, 2 % total nitrogen.

Table 2. Nutrient intake.

Item	Cultivars					
	Grain			Grain		
	IPA 1011		IPA 1011		IPA 1011	
DMI (g day^{-1})	707.05ab	DMI (g day^{-1})	707.05ab	DMI (g day^{-1})	707.05ab	DMI (g day^{-1})
DMI (%BW)	2.66ab	DMI (%BW)	2.66ab	DMI (%BW)	2.66ab	DMI (%BW)
DMI (g kg^{-1} $LW^{0.75}$)	60.32ab	DMI (g kg^{-1} $LW^{0.75}$)	60.32ab	DMI (g kg^{-1} $LW^{0.75}$)	60.32ab	DMI (g kg^{-1} $LW^{0.75}$)
OMI (g day^{-1})	666.58ab	OMI (g day^{-1})	666.58ab	OMI (g day^{-1})	666.58ab	OMI (g day^{-1})
CPI (g day^{-1})	86.57b	CPI (g day^{-1})	86.57b	CPI (g day^{-1})	86.57b	CPI (g day^{-1})
INDF (g day^{-1})	317.61b	INDF (g day^{-1})	317.61b	INDF (g day^{-1})	317.61b	INDF (g day^{-1})
INDF %BW	1.20b	INDF %BW	1.20b	INDF %BW	1.20b	INDF %BW
IADF (g day^{-1})	207.05c	IADF (g day^{-1})	207.05c	IADF (g day^{-1})	207.05c	IADF (g day^{-1})
ITDN (g day^{-1})	461.52[a]	ITDN (g day^{-1})	461.52[a]	ITDN (g day^{-1})	461.52[a]	ITDN (g day^{-1})

Means followed by the same letter do not differ ($p < 0.05$) by Tukey's test; DMI = Dry Matter Intake; CMI = Organic Matter Intake; CPI = Crude Protein Intake; INDF = Intake of Neutral Detergent Fiber; IADF = Intake of Acid detergent fiber; ITDN = Intake of Total Digestible Nutrients; BW = Body Weight; LW = Live Weight.

Highest INDF presented by animals which were fed on forager sorghum silage IPA SF-25 may have restricted their DMI due to the NDF rate of the variety, coupled to the diet's low NFC. According to Mertens (1994), when animals are fed on tasty diets, high in volume and low in energy concentration, intake is limited by restrictions in the digestive tract capacity.

Whereas animals fed on grain sorghum silage had the highest ITDN (IPA 1011 = 461.52 g day^{-1} and IPA 2564 = 464.20 g day^{-1}), treatments with forage sorghum provided the lowest intake. Dual-purpose treatment had an intermediary intake rate, very similar to rates with grain and forage sorghum silage (Table 2).

Grain sorghum silage IPA 1011 showed coefficients of apparent digestibility of dry matter which were higher than those of sorghum silage of the forager cultivar IPA SF-25. Above results coincided with those by McDonald et al. (1991) who stated that the decrease of forage digestibility was related to an increase in fiber fraction, specifically with ADF. The cultivar with the highest ADF rate (Table 1) had the lowest coefficient of dry matter apparent digestibility (Table 3).

Table 3. Coefficient of apparent digestibility of different nutrients.

Item	Cultivars					
	Grain			Grain		
	IPA 1011		IPA 1011		IPA 1011	
CDMAD	65.45a	CDMAD	65.45a	CDMAD	65.45a	CDMAD
COMAD	66.67a	COMAD	66.67a	COMAD	66.67a	COMAD
CCPAD	63.41ab	CCPAD	63.41ab	CCPAD	63.41ab	CCPAD
CNDADF	53.20ab	CNDADF	53.20ab	CNDADF	53.20ab	CNDADF
TDN(%MS)	65.28a	TDN(%MS)	65.28a	TDN(%MS)	65.28a	TDN(%MS)

Means followed by the same letter do not differ ($p < 0.05$) by Tukey's test; CDMAD = Coefficient of dry matter apparent digestibility; COMAD = Coefficient of organic matter apparent digestibility; CCPAD = Coefficient of crude protein apparent digestibility; CNDADF = Coefficient of neutral detergent fiber apparent digestibility; TDN = total digestible nutrients; DM = dry matter.

Apparent digestibility results in current analysis were similar to those reported by Miron et al. (2007), who compared sorghum cultivar FS-5 with commercial sorghum cultivar BMR-101 with regard to dry matter and crude protein. However, results were only slightly higher in the case of NDF. When control treatments exclusively with sorghum silage undertaken by Al-Rokayan et al. (1998) and Rodrigues et al. (2002) were compared, treatments in current analysis had higher apparent digestibility rates in the case of dry matter (49.60%, 53.24%) and crude protein (49.60%, 36.21%) respectively. Difference in the rate of crude protein apparent digestibility may have been due to the addition of urea which is a source of non-protein nitrogen characterized by fast digestibility which occurred in current experiment and in the experiment by Miron et al. (2007). Lowest coefficients of crude protein digestibility for cultivars IPA 2564, IPA SF-25 and IPA 467 may be related to a higher percentage of crude protein linked to ADF (Table 1).

Cultivars IPA 1011, IPA 2564, IPA SF-25 and IPA 467 provided the highest coefficients of apparent digestibility of NDF, namely, 53.20, 48.12, 53.73 and 58.23%. Cultivar IPA 2502 had the lowest rate (42.06%) albeit equal to cultivars IPA 1011 and IPA 2564. Cultivars with highest apparent digestibility coefficients of NDF were probably due to a greater retention digesting period, since these cultivars provided lowest intake and greatest time for microbial activity.

Highest TDN rates occurred in the grain sorghum cultivar IPA 1011 which were similar to the grain cultivar IPA 467 since these rates or cultivars had similar results for apparent digestibility coefficients of dry matter (Table 3). This was probably due to a higher proportion of grains in grain sorghum silage and to high coefficient of NDF digestibility of the forage cultivar IPA 467.

Treatments IPA 2564 and IPA 2502 provided higher nitrogen intake than those of the others. This fact was expected since they were iso-protein diets and had the highest intakes of dry matter (Table 4).

Table 4. Nitrogen balance in sorghum silage cultivars.

Item	Cultivars					CV (%)
	Grain		Dual-purpose	Foragers		
	IPA 1011	IPA 2564	IPA 2502	IPA SF-25	IPA 467	
Ingested N (g day^{-1})	13.85b	15.07a	15.01a	13.40b	13.00b	3.94
Fecal N (g day^{-1})	5.06b	6.49a	5.11b	5.57b	5.72ab	7.83
Urine N (g day^{-1})	4.63a	4.07a	4.66[a]	4.79a	3.90a	15.94
N balance (g day^{-1})	4.16ab	4.50ab	5.24[a]	3.03b	3.39ab	25.48
N $BW^{0.75}$ balance (g kg^{-1} $BW^{0.75}$)	0.36a	0.38a	0.43[a]	0.26a	0.29a	25.40

Means followed by the same letter do not differ ($p < 0.05$) by Tukey's test. N = Nitrogen; BW = Body Weight.

Animals that received treatments IPA 2564 and IPA 467 had a higher secretion of fecal nitrogen which comprises microbial protein, protein and amino-acids from the diet and which escaped from digestion, and losses by tissue de-scaling (NRC, 2001). The others were statistically similar to IPA 467 and lower than IPA 2564.

Treatments IPA 2564 and IPA 467 had higher rates for insoluble nitrogen in neutral detergent (INND) (Table 1), with slow rumen degradation. Further, IPA 2564 had a high percentage of insoluble nitrogen in acid detergent (INAD), which was highly unavailable to rumen degradation. This was corroborated by low coefficients of digestibility of crude protein for treatments IPA 2564 and IPA 467.

Nitrogen excretion through urine did not differ statistically among treatments and varied between 3.90 and 4.79 g day^{-1}. Nitrogen excretion through urine was related to high urea concentrations in the blood when the organism was incapable of metabolizing it.

Since all treatments provided positive rates for retained nitrogen, this fact showed that all had nitrogen gain. The highest retained nitrogen rate was found in treatment IPA 2502, even though it was statistically similar to treatments with sorghum cultivars IPA 1011, IPA 2564 and IPA 467. Animals which ingested more dry matter retained more nitrogen. Such difference did not exist when retained nitrogen was given in g kg^{-1} of metabolic live weight. All treatments were equal and positive, ranging between 0.26 and 0.43 g kg^{-1} $BW^{0.75}$.

Sorghum cultivar silages analyzed may be used in the feed of ruminants. In fact, they are a possible alternative for food production in conditions existing in northeastern Brazil. Grain cultivars had a higher nutrition rate than that of forage cultivars. Dual-purpose cultivars had a lower nutrition rate than grain cultivar and higher than forage ones. Choice of cultivar depends on seed availability, production in the region and the producer's aim.

Conclusion

Silages of grain cultivars IPA 1011 and IPA 2564 had higher nutrition rates with regard to intake rates and nutrient digestibility.

References

AGUIAR, E. M.; LIMA, G. F. C.; SANTOS, M. V. F.; CARVALHO, F. F. R.; GUIM, A.; MEDEIROS, H. R. M.; BORGES, A. Q. Rendimento e composição químico-bromatológico de fenos triturados de gramíneas tropicais. **Revista Brasileira de Zootecnia**, v. 35, n. 6, p. 2226-2233, 2006.

AFRC-Agricultural and Food Research Council. **Energy and Protein Requeriments of Ruminants**. An advisory manual prepared by the AFRC Technical Committee on Responses to Nutrients. Wallingford: CAB Internacional, 1993.

AL-ROKAYAN, S. A.; NASEER, Z.; CHAUDHRY, S. M. Nutritional quality and digestibility of sorghum-broiler litter silages. **Animal Feed Science and Technology**, v. 75, n. 1, p. 65-73, 1998.

EUCLIDES, V. P. B.; EUCLIDES FILHO, K.; ARRUDA, Z. J.; FIGUEIREDO, G. R. Desempenho de novilhos em pastagens de *Brachiaria decumbens* submetidos a diferentes regimes alimentares. **Revista Brasileira de Zootecnia**, v. 27, n. 2, p. 246-254, 1998.

FENNER, H. Method for determining total volatile bases in rumen fluid by steam destilation. **Journal of Dairy Science**, v. 48, n. 4, p. 249-251, 1965.

FERREIRA, M. A.; SILVA, F. M.; BISPO, S. V.; AZEVEDO, M. Estratégias na suplementação de vacas leiteiras no semi-árido do Brasil. **Revista Brasileira de Zootecnia**, v. 38, p. 322-329, 2009. (Suplemento especial).

HAIGH, P. M. Effect of herbage water soluble carbohydrate content and weather conditions at ensilage on the fermentation of grass silages made on commercial farms. **Grass Forage Science**, v. 45, n. 3, p. 263-271, 1990.

HENDERSON, N. Silage additives. Animal Feed **Science and Technology**, v. 45, n. 1, p. 35-56, 1993.

McCULLOUGH, M. E. Silage and silage fermentation. **Feedstuffs**, v. 48, n. 13, p. 49-50, 1977.

McDONALD, P.; HENDERSON, A. R.; HERON, S. J. E. **The Biochemistry of silage**. Marlow: Chalcombe Publications, 1991.

MERTENS, D. R. Regulation of forage intake. In: FAHEY JR., G. C. (Ed.). **Forage quality, evaluation and utilization**. Winsconsin: American Society of Agronomy, 1994. p. 450-493.

MIRON, J.; ZUCKERMAN, E.; ADIN G.; NIKBACHAT, M.; YOSEF, E.; ZENOU, A.; WEINBERG, ZWI, G.; SOLOMON, R.; BEN-GHEDALIA, D. Field yield, ensiling properties and digestibility by sheep of silages from two forage sorghum varieties. **Animal Feed Science and Technology**, v. 136, n. 3-4, p. 203-215, 2007.

MIZUBUTI, I. Y.; RIBEIRO, E. L. A.; ROCHA, M. A.; SILVA, L. D. F.; PINTO, A. P.; FERNANDES, W. C.; ROLIM, M. A. Consumo e digestibilidade aparente das silagens de milho (*Zea mays* L.), sorgo (*Sorghum bicolor* L. Moench.) e girassol (*Helianthus annuus* L.). **Revista Brasileira de Zootecnia**, v. 31, n. 1, p. 267-272, 2002.

MOISIO, T.; HEIKONEN, M. Lactic acid fermentation in silage preserved with formic acid. **Animal Feed Science and Technology**, v. 47, n. 1/2, p. 107-124, 1994.

MOLINA, L. R.; RODRIGUEZ N. M.; SOUSA B. M.; GONÇALVES L. C.; BORGES I. Parâmetros de Degradabilidade Potencial da Matéria Seca e da Proteína Bruta das Silagens de Seis Genótipos de Sorgo (*Sorghum bicolor* (L.) Moench) com e sem Tanino no grão, avaliados pela técnica *in Situ*. **Revista Brasileira de Zootecmia**, v. 32, n. 1, p. 222-228, 2003.

NRC-National Research Council. **Nutrient Requirements of Dairy Cattle**. 7th ed. Washington, D.C.: National Academy of Sciences, 2001.

OLIVEIRA, G.; BERCHIELLI, T. T.; REIS, R. A.; VECHETINI, M. E.; PEDREIRA, M. S. Fermentative characteristics and aerobic stability of sorghum silages containing different tannin levels. **Animal Feed Science and Technology**, v. 154, n. 1/2, p. 1-8, 2009.

OLIVEIRA, S. G.; BERCHIELLI, T. T.; PEDREIRA, M. S.; PRIMAVESI, O.; FRIGHETTO, R.; LIMAE, M. A. Effect of tannin levels in sorghum silage and concentrate supplementation on apparent digestibility and methane emission in beef cattle. **Animal Feed Science and Technology**, v. 135, n. 3/4, p. 236-248, 2007.

ORSKOV, R. E. **Protein nutrition in ruminants**. London: Academic Press Inc, 1982.

PEREIRA, D. H.; PEREIRA, O. G.; SILVA, B. C.; LEÃO M I.; VALADARES FILHO, S. C.; CHIZZOTTI, F. H. M.; GARCIA, R. Intake and total and partial digestibility of nutrients, ruminal pH and ammonia concentration and microbial efficiency in beef cattle fed with diets containing sorghum (*Sorghum bicolor* (L.) Moench) silage and concentrate in different ratios. **Livestock Science**, v. 107, n. 1, p. 53-61, 2007.

PIMENTEL, J. J. O.; SILVA, J. J. C.; VALADARES FILHO, S. C.; CECON P. R.; SANTOS, P. S. Efeito da suplementação protéica no valor nutritivo de silagens de milho e sorgo. **Revista Brasileira Zootecnia**, v. 27, n. 5, p. 1042-1049, 1998.

RODRIGUES, P. H. M.; SENATORE, A. L.; LUCCI, C. S.; ANDRADE, S. J. T.; LIMA, FELIX, R.; MELOTTI, L. Valor nutritivo da silagem de sorgo tratada com inoculantes enzimo-microbianos. **Acta Scientiarum. Animal Sciences**, v. 24, n. 4, p. 1141-1145, 2002.

SAEG-Sistemas para Análises Estatísticas. **Sistema de análise estatística e genética**, versão 8.0. Viçosa: UFV, 1998.

SANTOS, A. P. Metabolismo das proteínas. In: BERCHIELLI, T. T.; PIREZ, A. V.; OLIVEIRA, S. G. (Ed.). **Nutrição de ruminantes**. Jaboticabal: Funep, 2006. p. 255-284.

SILVA, D. J.; QUEIROZ, A. C. **Análise de alimentos (métodos químicos e biológicos)**. Viçosa: UFV, 2002.

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

SOUZA, V. G.; PEREIRA, O. G.; MORAES, S. A.; GARCIA, R.; VALADARES FILHO, S. C.; ZAGO, C. P.; FREITAS, E. V. V. Valor Nutritivo de Silagens de Sorgo. **Revista Brasileira de Zootecnia**, v. 32, n. 3, p. 753-759, 2003.

VALADARES FILHO, S. C.; MAGALHÃES, K. A.; ROCHA JÚNIOR, V. R. R.; CAPELLE, E. R. **Tabelas Brasileiras de composição de alimentos para bovinos**. 2. ed. Viçosa: Suprema Gráfica Ltda. - UFV, 2006.

Received on March 20, 2011.
Accepted on June 20, 2011.