Revista Brasileira de Zootecnia

ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.39, n.12, p.2611-2616, 2010

Evaluation of elephant grass silage with the addition of cassava scrapings

Anderson de Moura Zanine[1], Edson Mauro Santos[2], João Ricardo Rebouças Dórea[3], Paulo Alfredo de Santana Dantas[4], Thiago Carvalho da Silva[2], Odilon Gomes Pereira[5]

[1] *Universidade Federal de Mato Grosso.*
[2] *Universidade Federal da Paraíba.*
[3] *Universidade de São Paulo.*
[4] *Universidade Estadual Santa Cruz.*
[5] *Universidade Federal de Viçosa.*

ABSTRACT - The objective of this experiment was to evaluate the effects of adding cassava scrapings on gas and effluent losses, dry matter recovery, pH, contents of N-NH_3, organic acids and volatile fatty acids and the bromatological composition of elephant grass silages. It was used a randomized complete design, with four levels of cassava scrapings (0, 7, 15 or 30% natural matter) each one with four replications per level. The grass was cut at 50 days of regrowth and ensiled in 15-L silos, equipped with a Bunsen valve to allow gas outflow. The gas losses decreased quadratically with the addition of cassava scrapings, whereas effluent losses decreased linearly. Dry matter recovery increased quadratically with the addition of cassava scrapings. Dry matter (DM) concentration increased but crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose (HEM) decreased linearly with the addition of cassava scrapings. The pH value and lactic acid concentration increased quadratically with the addition of cassava scrapings. Contents of N-NH_3 and butyric acid decreased quadratically with the addition of cassava scrapings, whereas acetic acid content decreased linearly. Addition of cassava scrapings reduced gas and effluent losses and improved the fermentation profile of elephant grass silages and the level of 7% already ensures this improvement.

Key Words: crude protein, dry matter, effluent, fermentation, gas

Avaliação da silagem de capim-elefante com adição de raspa de mandioca

RESUMO - Objetivou-se com este experimento avaliar os efeitos da adição de raspa de mandioca na ensilagem sobre as perdas por gases e efluentes, a recuperação da matéria seca, o pH, os teores de N-NH_3, ácidos orgânicos e ácidos graxos voláteis e a composição bromatológica de silagens de capim-elefante. Utilizou-se um delineamento inteiramente casualizado, com quatro níveis de raspa de mandioca (0, 7, 15 ou 30% da matéria natural), cada um com quatro repetições. O capim foi cortado aos 50 dias de rebrota e ensilado em silos de 15 litros de capacidade, com válvula de bunsen para escape dos gases. A adição de raspa de mandioca ocasionou redução quadrática nas perdas por gases e redução linear nas perdas por efluente. A recuperação de matéria seca aumentou de forma quadrática com a adição de raspa de mandioca. O teor de matéria seca aumentou, enquanto os de proteína bruta, fibra em detergente neutro, fibra em detergente ácido (FDA) e hemicelulose diminuíram linearmente com a adição de raspa de mandioca. O valor de pH e o teor de ácido lático aumentaram de forma quadrática com a adição de raspa de mandioca. Os teores de N-NH_3 e de ácido butírico diminuíram de forma quadrática com a adição de raspa de mandioca, enquanto o teor de ácido acético diminuiu linearmente. A inclusão de raspa de mandioca na ensilagem reduz as perdas por gases e efluentes e melhora o perfil fermentativo de silagens de capim-elefante e o nível de 7% da matéria natural é suficiente para assegurar essa melhora.

Palavras-chave: efluente, fermentação, gases, matéria seca, proteína bruta

Introduction

Elephant grass (*Pennisetum purpureum* Schum.) is the most used perennial grass for silage because of its high forage yield (Vilela, 1990; Cândido et al., 2007) and its soluble carbohydrate concentration which favors good fermentation (Machado Filho & Mühlbach, 1986). However, when it is cut young, when it presents a good nutritive value, the low percentage of dry matter, the high buffer power and the low sugar concentration can result in low quality silage. According to Wilkinson (1983), the low dry matter concentration of elephantgrass results in low osmotic pressure, which permits the development of bacteria from the *Clostridium* sp genus that break down sugars, lactic

Received October 15, 2009 and accepted April 29, 2010.
Corresponding author: andersonzanine@ufmt.br

acid, proteins and amino acids into butyric acid, acetic acid, ammonia, carbonic gas and starches which result in significant losses.

Silage effluent contains a large quantity of organic compounds such as sugars, organic acids and proteins. To decrease effluent losses, techniques such as wilting and the application of moisture absorbent additives can be used. Some additives can be used to increase dry matter concentration of elephant grass silage, and they should also present a known water retention capacity, good palatability and supplement of carbohydrates for fermentation.

Within this reality, the use of additives becomes an interesting option to reduce effluent losses since effluents carry highly digestible nutrients in addition to sugar and organic acids and their losses reduce the nutritive value of the silage (Zanine et al., 2006ab). Cassava scrapings are a byproduct from the flour milling industry and they can be used as an additive in the silage, mainly with the objective of raising the dry matter concentration, in addition to supply carbohydrates to ferment the silage material (Ferrari Jr. & Lavezzo, 2001) at a low cost. Thus, studies aiming at establishing the correct levels of cassava scrapings to allow improvement in fermentation and nutritive value and to reduce gas and effluent losses are necessary.

Accordingly, the objective of the present experiment was to assess the chemical composition, the dry matter recovery and to quantify gas and effluent losses and the organic acids production in elephant grass silage with the addition of cassava scrapings.

Material and Methods

The experiment was carried out in the Departamento de Zootecnia of Universidade Federal de Viçosa (UFV), in the municipality of Viçosa, Minas Gerais, with a average annual precipitation of 1,341 mm, out of which about 86% occur from October to March. The grass used in the experiment was brought from the experimental area of the Setor de Agrostologia, in an established grass field, 50 days after the standardizing cut to 20 cm from the soil.

A complete randomized experimental design was used with four levels of cassava scrapings: elephant grass (0% cassava scrapings); elephant grass + 7% cassava scrapings; elephant grass + 15% cassava scrapings and elephant grass + 30% cassava scrapings, with four replications for each level. The cassava scrapings were obtained from a flour milling industry in the south of Bahia state and the levels were defined based on the natural matter. Elephant grass was mixed by hand with cassava scrapings according to the established levels.

The experimental silos were constructed using 15-L buckets, sealed and fitted with a Bunsen valve in the lid to allow escape of fermentation gases. Four kilograms of sand were placed at the bottom of each silo, separated from the forage by a layer of cotton cloth so that the quantity of retained effluent could be measured.

The elephant grass was cut for ensilage by a stationary forage machine, into a particle size of approximately 1.5 cm and compacted by feet stamping. The silos were opened 40 days after ensilage.

Samples of the pre-ensilage material (approximately 500 g) were collected, pre-dried in a forced air oven at 65°C for 72 hours and ground in a Wiley grinder to later determine the concentrations of dry matter, crude protein, neutral detergent fiber, acid detergent fiber, hemicelullose and soluble carbohydrates. After opening the silos, the silage samples (approximately 500 g) were pre-dried to determine the dry matter, crude protein, neutral detergent fiber, acid detergent fiber and hemicellulose following methodologies described by Silva & Queiroz (2002). The soluble carbohydrates were assessed according to the method reported by Bailey (1967). The principle of this method consists of extracting the carbohydrates with 80% alcohol solution in the reaction with acid solution prepared with anthrone and the reading is performed in a spectrophotometer using glucose solution to prepare the standard curve.

The dry matter losses in the silages in the form of gases were quantified by weight difference. From the equations below, the losses through gases, effluent and dry matter recovery were obtained:

Table 1 - Chemical composition of cassava scrapings and elephant grass in ensilage

	Cassava scrapings	Cassava scrapings level (% natural matter)			
		0	7	15	30
Dry matter (%)	87.00	20.72	25.68	30.09	37.31
Crude protein (DM%)	3.4	8.16	7.10	5.68	4.52
Neutral detergent fiber (DM%)	17.80	67.48	55.04	48.74	43.04
Acid detergent fiber (DM%)	12.20	49.11	39.67	33.11	27.85
Hemicellulose (DM%)	5.60	18.37	15.37	15.63	15.19
Soluble carbohydrates (DM%)	17.54	6.55	8.79	11.79	15.24

Gas losses were calculated according to the equation: G = (PCf – PCa)/(MFf × MSf) × 10000, in which: G = gas losses (%DM); PCf = weight of full silo at sealing (kg); PCa = weight of full bucket at opening (kg); MFf = forage mass at sealing (kg); MSf = forage dry matter concentration at closing (%).

Effluent losses were calculated by the equation below, based on the difference on weight of the sand and related to the mass of fresh matter (FM) at sealing:

E = [(PVf – Tb) – (PVi – Tb)]/MFi × 100, in which: E = Effluent losses (kg/t FM); PVi = weight empty bucket + sand weight at sealing (kg); PVf = weight empty bucket + sand weight at opening (kg); Tb = weight empty bucket (kg); MFi = forage mass at sealing (kg).

The following equation was used to estimate the dry matter recovery:

RMS = (MFa × MSa)/(MFf ×MSf) × 100, in which: RMS = dry matter recovery rate (%); MFf = forage mass at sealing (kg); MSf = forage dry matter concentration at sealing (%); MFa = forage mass at opening (kg); MSa = forage dry matter concentration at opening (%).

To analyze the pH, it was collected samples of approximately 25 g in which 100 mL water were added and after resting for two hours, the pH was read using a potenciometer. In another 25 g sample, 200 mL H_2SO_4 0.2 N solution were added and after a 48-hour rest, it was filtered through a Whatman 54 filter. This filtrate was stored in a refrigerator for later N-ammoniacal analysis (Bolsen et al. 1992). For organic acid analyses, 10 mL samples were diluted in water, acidified with 50% H_2SO_4 and filtered through Whatman filter paper (Kung Jr. & Ranjit, 2001) and 1 mL 20% metafosforic acid and 0.2 mL 0.1% phenic acid were added to 2 mL of the filtrate which was centrifuged later. The analyses of organic acids (lactic acid, acetic acid and butyric acid) were analyzed by high resolution liquid chromatography.

The data were submitted to analysis of variance and regression, using the SAEG software, 8.0 version (UFV, 1999), which was chosen because of the significance of the regression parameters, tested by t test ($P<0.05$) and the values of the coefficients of determination.

Results and Discussion

Concentration of dry matter linearly ($P<0.05$) increased with the addition of cassava scrapings, while there was a linear decrease ($P<0.05$) in the concentrations of crude protein, neutral detergent fiber, acid detergent fiber and hemicellulose (Table 2). Incresing dry matter concentrations and the reductions in the fiber fraction components occurred because of the cassava scraping composition (Table 1),which has a higher dry matter concentration and lower concentrations of neutral detergent fiber, acid detergent fiber and hemicellulose than the elephantgrass used in the silage. Ferrari Jr. & Lavezzo (2001) also observed an increase in the dry matter concentrations and a reduction in the fiber fraction and in crude protein content of elephantgrass silage with the addition of cassava meal.

In spite of the reduction in the crude protein concentration (Table 2) with the addition of cassava scrapings, which was due to the small concentration of this nutrient in the cassava scrapings, there was a sharp reduction in the crude protein concentration during the ensilage process in the untreated elephantgrass silage with a 30% reduction compared to the material before the ensilage.

This probably happened because of the high proteolysis in the untreated elephantgrass silage, probably due to the development of clostridia and enterobacteria. According to Muck (1996), when material is ensilaged with a small quantity of soluble carbohydrates and reduced dry matter concentration, these microorganisms develop in detriment to lactic acid and produce bacteria resulting in intense

Table 2 - Chemical composition of elephant grass silage with of cassava scrapings levels

	Cassava scrapings level (% natural matter)				
	0	7	15	30	CV (%)
Dry matter (%)	18.1 ± 0.83	24.2 ± 0.63	28.3 ± 0.44	32.6 ± 0.29	11.0
Crude protein (DM%)	5.6 ± 0.30	5.9 ± 0.22	4.9 ± 0.35	4.3 ± 0.43	13.7
Neutral detergent fiber (DM%)	66.2 ± 1.09	54.8 ± 0.89	47.2 ± 0.81	41.4 ± 0.76	7.8
Acid detergent fiber (DM%)	50.5 ± 0.40	39.6 ± 0.59	32.8 ± 0.73	27.4 ± 0.39	8.2
Hemicellulose (DM%)	15.6 ± 1.40	15.2 ± 1.21	14.3 ± 1.54	13.9 ± 1.22	17.9

	Regression equation	
Dry matter (%)	$\hat{Y} = 19.821 + 0.463X$	$r^2 = 93.19\%$
Crude protein (DM%)	$\hat{Y} = 5.881 - 0.0506X$	$r^2 = 84.15\%$
Neutral detergent fiber (DM%)	$\hat{Y} = 62.649 - 0.785X$	$r^2 = 89.40\%$
Acid detergent fiber (DM%)	$\hat{Y} = 47.114 - 0.728X$	$r^2 = 88.74\%$
Hemicellulose (DM%)	$\hat{Y} = 15.537 - 0.056X$	$r^2 = 91.64\%$

proteolysis with a consequently reduction in the crude protein concentration in the silage.

Gas and effluent losses decreased ($P<0.05$) quadratically and linearly, respectively, as the cassava scraping level was increased, and dry matter recovery increased quadratically ($P<0.05$) with the inclusion of this additive (Table 3). Gas losses in silage result from secondary fermentation by enterobacteria, clostridium bacteria and aerobic microorganisms. Usually, these microorganisms grow in poorly fermented silage, because well fermented silage, with the predominance of lactic fermentation, results in minimal nutrient losses, and it has to be taken into account that this fermentation consists of the production of two moles of lactic acid from 1 mol glucose, without CO_2 production or another secondary metabolite (McDonald, 1981; Muck, 1996).

The reason for the increase in losses starting in 30% cassava scrapings inclusion may have been because of the development of microorganisms adapted to acid media high in carbohydrates, as it is the case of the yeasts, considering that at this level of inclusion, carbohydrate concentration of 15% was much higher than that considered to be optimal by McDonald et al. (1991), which was around 10%. When the quantity of sugars is very high, yeast development results in alcohol fermentation, with gas losses in the form of ethanol.

The reduction in the effluent losses was the result of the increase in the dry matter concentration in the silage in function of the addition of cassava scrapings and it should be remembered that reduction in effluent losses represents minimization of the nutrient losses through percolation together with the effluent produced by the silage. Furthermore, the value of 24.2% is close to the recommended by McDonald et al. (1991) (25% dry matter) to control effluent production in silage. It can be considered that silage effluent carry away nitrogen compounds, sugars, organic acids and mineral salts (McDonald, 1981).

The dry matter recovery was not different among the three treatments with the additive, and it was concluded that reduction in gas and effluent losses was accompanied by increase in dry matter recovery. According to McCullough (1977) the potential of elephant grass for silage depends on the original moisture concentration that should be close to 70% because, otherwise, fermentation by bacteria from the *Clostridium* genus would be significant. Perhaps because of this, differences were not observed in dry matter recovery among the silages with cassava scrapings, suggesting that the addition of low levels of cassava scrapings might be sufficient to minimize secondary fermentations.

Table 3 - Losses and dry matter recovery of elephant grass in function of levels of cassava scrapings inclusion

	Cassava scrapings level (%)				
	0	7	15	30	CV (%)
Gas losses (%DM)	4.83 ± 0.56	2.5 ± 0.34	2.8 ± 0.47	3.7 ± 0.39	17.8
Effluent losses (kg/t)	42.2 ± 1.13	33.7 ± 0.93	16.1 ± 0.80	5.3 ± 0.69	19.9
Dry matter recovery (%)	86.8 ± 0.76	93.7 ± 0.66	93.4 ± 0.57	93.5 ± 0.45	9.8
	Regression equations				
Gas losses (%DM)	$\hat{Y} = 4.593 - 0.2615X + 0.007X^2$				$r^2 = 80.81\%$
Effluent losses (kg/t)	$\hat{Y} = 40.782 - 1.262X$				$r^2 = 94.82\%$
Dry matter recovery (%)	$\hat{Y} = 87.34 + 0.962X - 0.033X^2$				$r^2 = 93.98\%$

Table 4 - Fermentation characteristics of elephant grass silage in function of the levels of cassava scrapings levels

	Cassava scrapings level (% natural matter)				
	0	7	15	30	CV (%)
pH	4.44 ± 0.15	3.80 ± 0.12	3.72 ± 0.16	3.84 ± 0.20	7.6
$N\text{-}NH_3$ (% N total)	21.88 ± 0.36	15.94 ± 0.31	14.60 ± 0.22	15.72 ± 0.37	6.6
Latic acid (DM%)	4.23 ± 0.22	5.83 ± 0.11	4.88 ± 0.32	3.17 ± 0.43	8.3
Acetic acid (DM%)	0.94 ± 0.05	0.62 ± 0.03	0.40 ± 0.01	0.37 ± 0.04	6.8
Butyric acid (DM%)	0.03	0.01	0.01	0.01	8.8
	Regression equations				
pH	$\hat{Y} = 4.395 - 0.083X + 0.002X^2$				$r^2 = 93.15\%$
$N\text{-}NH_3$ (% N total)	$\hat{Y} = 20.838 - 0.061X + 0.001X^2$				$r^2 = 88.94\%$
Latic acid (DM%)	$\hat{Y} = 4.472 + 0.157X + 0.006X^2$				$r^2 = 84.16\%$
Acetic acid (DM%)	$\hat{Y} = 0.6961 - 0.006X$				$r^2 = 82.48\%$
Butyric acid (DM%)	$\hat{Y} = 0.025 - 0.001X + 0.004X^2$				$r^2 = 80.06\%$

The pH values decreased ($P<0.05$) quadratically in function of the cassava scraping levels (Table 4) due to the effect of the soluble carbohydrates and the high dry matter concentration (Table 1). According to McDonald et al. (1991), the pH range considered to be the ideal is from 3.8 to 4.2, thus the pH values detected in the treatments with the addition of cassava scrapings were within the ideal range. Unlike the observations for the pH, the $N\text{-}NH_3$ values decreased ($P<0.05$) quadratically with the levels of added cassava scrapings. According to Muck (1996), in silage with low pH, proteolytic bacteria are inhibited and thus proteolysis is reduced and consequently, ammoniacal nitrogen production. This may explain decrease in the amounts of nitrogen observed in this study.

The lactic acid concentrations quadratically increased ($P<0.05$) with the addition of cassava scrapings; this fact was due to the increase in the soluble carbohydrate concentration and high dry matter concentration of this additive. The lowest addition of cassava scraping supplied sufficient soluble carbohydrates and dry matter concentration to ensure lactic fermentation (McDonald et al., 1991). Similar result was obtained by Rêgo et al. (2010) who observed linear increase for latic acid concentration in elephant grass silages with dehydrated mango by-product addition.

Contrary to the observations for lactic acid, the acetic acid and butyric acid concentrations quadratically decreased ($P<0.05$) with the addition of cassava scrapings, for butyric acid and they linearly ($P<0.05$) decreased for acetic acid. The reduction in the pH of the medium may have inhibited the development of enterobacteria and clostridia bacteria that produce these acids, reducing their concentration in the silage. Pires et al. (2009) observed values of 0.61 and 0.10% of dry matter for acetic and butyric acids respectively, with the addition of 15% of cassava to the elephant grass silage with 80 days of regrowth.

The obtained results suggest that the use of cassava scrapings as an additive in elephant grass silage should be made at intermediate levels, because this additive has high concentrations of dry matter and soluble carbohydrate, which favors lactic fermentation because of the inhibiting action on enterobacteria and clostridium bacteria development, resulting in lower values of pH, $N\text{-}NH_3$, acetic acid and butyric acid and greater values of lactic acid, which resulted in silage with a better fermentation profile.

Conclusions

Cassava scrapings reduce losses and increase dry matter recovery, thus improving the nutritional value of the elephant grass silage. The level of 7% of cassava scrapings in elephant grass silage is enough to improve fermentation profile.

References

BAILEY, R.W. Quantitative studies of ruminant digestion of ingested plant carbohydrates in the reticulo-rumen. **New Zealand Journal of Agricultural Research**, v.10, n.l, p.15-32, 1967.

BOLSEN, K.K.; LIN C.; BRENT, B.E. et al. Effect of silage additives on the microbial succession and fermentation process of alfalfa and corn silages. **Journal of Dairy Science**, v.75, n.11, p.3066-3083, 1992.

CÂNDIDO, M.J.D.; NEIVA, J.N.M.; RODRIGUEZ, N.M. et al. Características fermentativas e composição química de silagens de capim-elefante contendo subproduto desidratado do maracujá. **Revista Brasileira de Zootecnia**, v.36, n.5, p.1489-1494, 2007.

FERRARI JR., E.; LAVEZZO W. Qualidade da silagem de capim-elefante (*Pennisetum purpureum* Schum.) emurchecido ou acrescido de farelo de mandioca. **Revista Brasileira de Zootecnia**, v.30, n.5, p.1424-1431, 2001.

KUNG JR., L.; RANJIT, N.K. The effect of *Lactobacillus buchneri* and other additives on the fermentation and aerobic stability of barley silage. **Journal of Dairy Science**, v.84, p.1149-1155, 2001.

MACHADO FILHO, L.C.P.; MÜHLBACH, P.R.F. Efeito do emurchecimento na qualidade das silagens de capim-elefante cv. Cameroon (*Pennisetum purpureum*, Schum.) e de milheto (*Pennisetum americanum* (L.) Leeke), avaliadas quimicamente. **Revista Brasileira de Zootecnia**, v.15, n.3, p.224-233, 1986.

McCULLOUGH, M.E. Silage and silage fermentation. **Feedstuffs**, v.49, p.49-52, 1997.

McDONALD, P. **The biochemistry of silage**. Chichester: John Wiley & Sons, 1981. 218p.

McDONALD, P.; HENDERSON, A.R.; HERON, S.J.E. **The biochemistry of silage**. s.l.: Scholium International, 1991. v.15, p.155.

MUCK, R. Inoculant of silage and its effects on silage quality. In: INFORMATIONAL CONFERENCE WITH DAIRY AND FORAGE INDUSTRIES, 1996, Madison. **Proceedings...** Madison: US Dairy Forage Research, 1996. p.43-52.

PIRES, A.J.V.; CARVALHO, G.J.P.; GARCIA, R. et al. Capim-elefante ensilado com casca de café, farelo de cacau ou farelo de mandioca. **Revista Brasileira de Zootecnia**, v.38, n.l, p.34-39, 2009.

RÊGO, M.M.T.; NEIVA, J.N.M.; RÊGO, A.C. et al. Chemical and bromatological characteristics of elephant grass silages containing a mango by-product. **Revista Brasileira de Zootecnia**, v.39, n.1, p.81-87, 2010

SILVA, D.J.; QUEIROZ, A.C. **Análise de alimentos**: métodos químicos e biológicos. Viçosa, MG: UFV, 2002. 235p.

UNIVERSIDADE FEDERAL DE VIÇOSA- UFV. SAEG. **Sistema de análises estatísticas e genéticas**. Versão 8.0. Viçosa, MG, 1999. 138p. (Manual do usuário).

VILELA, D. Utilização do capim-elefante na forma de forragem conservada. In: SIMPÓSIO SOBRE CAPIM-ELEFANTE, 1990, Coronel Pacheco. **Anais...** Coronel Pacheco: EMBRAPA - Centro Nacional de Pesquisa de Gado de Leite. 1990. p.89-131.

WILKINSON, J.M. Silages made from tropical and temperate crops. 1. The ensiling process and its influence on feed value. **World Animal Review**, v.45, n.45, p.36-42, 1983.

ZANINE, A.M.; SANTOS, E.M. FERREIRA, D.J. et al. Avaliação da silagem de capim-elefante com adição de farelo de trigo. **Archivos de Zootecnia**, v.55, n.209, p.75-84, 2006a.

ZANINE, A.M.; SANTOS, E.M. FERREIRA, D.J. et al. Efeito do farelo de trigo sobre as perdas, recuperação da matéria seca e composição bromatológica da silagem de capim-mombaça. **Brazilian Journal Veterinary Research Animal Science**, v.43, n.6, p.73-81, 2006b.