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Mesquite pod meal in elephant grass silages

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ABSTRACT. This study evaluated the chemical composition and *in vitro* dry matter digestibility (IVDMD) of elephant grass silages at different growth stages (70, 90 and 110 days), with the addition (0, 5, 10 and 15%, on a fresh matter basis) of mesquite pod meal. A completely randomized design (CRD) was used in a factorial arrangement with four replications. PVC pipes 100 mm in diameter were used as experimental silos. After 30 days of ensilage, samples were taken from the open silos to determine chemical composition and IVDMD. The inclusion of mesquite pod meal (MPM) increased ($p < 0.01$) the concentrations of DM and CP. No interaction ($p > 0.01$) was detected between MPM concentrations and elephant grass cutting age for DM, CP and NDF contents in the silages. A decrease ($p < 0.01$) was observed in NDF, ADF and MM concentrations with the inclusion of MPM. There was a linear increase ($p < 0.01$) in IVDMD with increasing levels of MPM; and IVDMD decreased ($p < 0.01$) with increasing cutting age of the elephant grass. The inclusion of mesquite pod meal contributed to improve the chemical composition and digestibility of silages.

Keywords: chemical composition, digestibility, ensilage, *Pennisetum purpureum*, Schum., *Prosopis juliflora*.

Farelo da vagem de algaroba como aditivo em silagens de capim-elefante

RESUMO. Objetivou-se avaliar a composição químico-bromatológica e a digestibilidade "in vitro" da matéria seca (DIVMS) de silagens de capim-elefante em diferentes tempos (70; 90 e 110 dias) de crescimento do capim, com inclusão (0, 5, 10 e 15%) do farelo da vagem de algaroba. Foi utilizado um delineamento inteiramente casualizado (DIC), arranjado em um esquema fatorial, com quatro repetições. Como silos experimentais foram utilizados tubos do tipo PVC com 100 mm de diâmetro. Passados 30 dias da ensilagem, os silos foram abertos e retiradas amostras para determinação da composição químico-bromatológica e DIVMS. A inclusão do farelo da vagem de algaroba (FVA) elevou os teores de MS e PB. Não foi observada interação ($p > 0,01$) concentração do FVA × idade de corte do capim-elefante nos teores de MS, PB e FDN das silagens. Foi observada diminuição ($p < 0,01$) nos teores de FDN, FDA e MM com a inclusão do FVA. Houve aumento linear ($p < 0,01$) na DIVMS com o aumento na concentração do FVA e diminuição ($p < 0,01$) na DIVMS com o aumento da idade de corte do capim-elefante. A inclusão do farelo da vagem de algaroba contribui para melhorar a composição química e a digestibilidade das silagens.

Palavras-chave: composição química, digestibilidade, ensilagem, *Pennisetum purpureum*, Schum., *Prosopis juliflora*.

Introduction

The seasonality of feed production has been one of the limiting factors in ruminant production, due to low and irregular rainfall.

Mesquite (*Prosopis juliflora*) is a non-oily legume with wide distribution in Brazil's northeast. It grows up to 10 m tall, produces fruit measuring up to 20 cm in length, with pods that yield 2 to 8 tons per hectare in non-irrigated areas. Ripe mesquite pods contain nearly 84.0% dry matter (SILVA et al., 2001). In addition to nutritional advantages, mesquite has the most intense fruiting period when pastures are low in protein and have high fiber levels – between July and November in northeastern Brazil.

Ensilage is one of the most commonly employed practices to conserve fodder. The advantage of this process is that it preserves the nutritional valued of ensiled materials. Among the species used for silage, elephant grass (*Pennisetum purpureum,* Schum.) has stood out. However, excess moisture, low soluble carbohydrate levels and with high buffering capacity combine to limit the production of high-quality silage. Forage species with 28 to 35% dry matter are ideal for ensiling (MUCK, 1988). Yields increase as vegetative development advances, offset by a reduction in nutritional value. Therefore, a balance is sought between the use of additives and the best cutting age for elephant grass.

Forage plants with low dry matter levels and high buffering capacity are prone to secondary fermentation, high nutrient loss and formation of products that depreciate the nutritional value of silage (McDONALD et al., 1991). The use of additives rich in dry matter and soluble carbohydrates could be an alternative to minimize the limitations of ensiling. In recent years, the number of studies featuring inclusion of additives rich in dry matter for grass ensilage has increased (CARVALHO et al., 2007; MONTEIRO et al., 2011; RÊGO et al., 2010a). Thus, including mesquite pod meal (MPM) at ensiling could be a viable alternative.

The objective of this work was to evaluate the chemical composition and *in vitro* dry matter digestibility of elephant grass silages at different cutting ages with added mesquite pod meal.

Material and methods

The study was carried out at the Animal Science Department of the Federal University of Lavras – DZO/UFLA, in Lavras, Minas Gerais State, Brazil, 21°13'48" S, 44°58'19" W, elevation 928 m. The climate is Cwb (Köppen), with two well-defined seasons: rainy (October to March) and dry (April to September). Annual rainfall averages 1,493.2 mm and the average temperature is 19.3°C, averaging highs of 26.0°C and lows of 14.6°C.

Four concentrations of mesquite pod meal were evaluated (0, 5, 10 and 15%, on a fresh matter basis), at three cutting ages of elephant grass (70, 90 and 110 days), in a 4 x 3 factorial design. A completely randomized design (CRD) was used, with four replications.

The mesquite pod meal was obtained from Flores Farm, located in the municipality of Quixeramobim, Ceará state. Prior to being ensiled with elephant grass, the mesquite pods were ground in a hammer mill with 1 cm mesh screens. The elephant grass used to process the silage came from a grass field at the UFLA Animal Science Department. The experimental area was cut uniformly with a shredder, after which the cuttings were made for silage processing at 70, 90 and 110 days of the grass. Each cutting age was ensiled with all four concentrations of mesquite pod meal. The composition of the materials was determined prior to ensiling (Table 1).

The elephant grass was processed in a chopping machine set for 1 cm particle size, then weighed and manually mixed with the mesquite pod meal for later silage processing. PVC pipes were used as experimental silos, 500 mm long and 100 mm in diameter. Approximately 2.4 kg of fresh matter were placed in each silo, amounting to 600 kg m^{-3} density, thus providing good compactness of the ensiled mass.

Thirty days after ensiling, the silos were opened and the collected samples were subjected to pre-drying in a forced air oven at 60°C for 72h, ground in a Thomas Wiley-type mill, with 1 mm mesh screens, for chemical analysis and the *in vitro* digestibility assay. From those samples, the dry matter (DM) at 105°C, crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were obtained, according to the methodology of Van Soest and Winer (1968); mineral matter (MM) and pH, using a potentiometer with fresh samples (SILVA; QUEIROZ, 2002). Buffering capacity was measured using samples of the original material, according to the technique described by Playne and McDonald (1966).

Table 1. Chemical compositions of mesquite pod meal (MPM) and elephant grass.

Parameters (% of DM)	MPM	Elephant grass		
		70 days	90 days	110 days
Dry matter (DM)	89.60	21.33	21.20	24.68
Crude protein[1] (CP)	11.30	8.41	8.64	7.98
Neutral detergent fiber[1] (NDF)	29.89	68.34	68.32	70.45
Acid detergent fiber[1] (ADF)	20.83	43.43	43.98	43.65
Hemicelulose[1] (HCEL)	9.06	24.91	24.34	26.8
Mineral matter[1] (MM)	4.55	8.65	8.87	8.89
Ether extract[1] (EE)	2.70	3.01	2.78	2.76
Total Carbohydrates[1] (TC)	81.45	79.93	79.71	80.4
Non-fiber Carbohydrates[1] (NFC)	50.56	11.00	11.39	9.95
Buffering Capacity[2] (BC)	14.66	20.17	19.41	20.23
In Vitro DM Digestibility[1] (IVDMD)	70.98	63.52	59.60	53.39

[1] % of DM; [2] (ep. mg NaOH 100 g^{-1} DM).

The values of total carbohydrates (TC) were obtained by subtraction, according to the methodology described by Sniffen et al. (1992), in which:

$$TC\% = 100\% - (CP\% + EE\% + MM\%)$$

Non-fiber carbohydrates (NFC) levels were calculated according to the methodology adapted from Hall (2003), in which:

$$NFC\% = 100\% - (NDF\% + CP\% + EE\% + MM\%).$$

In the *in vitro* dry matter digestibility (IVDMD) assay, a non-lactating, non-pregnant Jersey cow was used to donate rumen fluid though a cannula. The cow had been previously adapted to the diet. The *in vitro* digestibility assay was carried out according to the methodology described by Tilley and Terry (1963).

The effect of mesquite pod meal inclusion and cutting age of elephant grass on the nutritional components of the silages was analyzed statistically by analysis of variance and regression, according to the PROC REG procedure of the SAS® statistical package (2002), version 9.1.2.

Results and discussion

A linear increase ($p < 0.01$) was observed in the DM levels of silages as mesquite meal was included (Figure 1). Forage dry matter content is an important factor to obtain silage with good fermentation standards (VAN SOEST, 1994). With 13.5% mesquite pod meal inclusion, the silages showed a minimum limit of dry matter (28.0%), cited by Muck (1988) as the standard for good silage conservation due to the predominance of lactic fermentation (Figure 1).

This increase in DM levels may be justified, as the additive used (MPM) has high levels of DM (89.6%) compared to elephant grass prior to ensilage (Table 1), making it a moisture-absorbing additive. Similar results were obtained by several authors observing DM levels of elephant grass silage with additives characterized as moisture absorbers. The addition of coffee hulls (0, 10, 20, 30 and 40%) is an example of this, in which elephant grass silage raised DM levels by 0.69 percentage points for every 1% of additive inclusion (BERNARDINO et al., 2005).

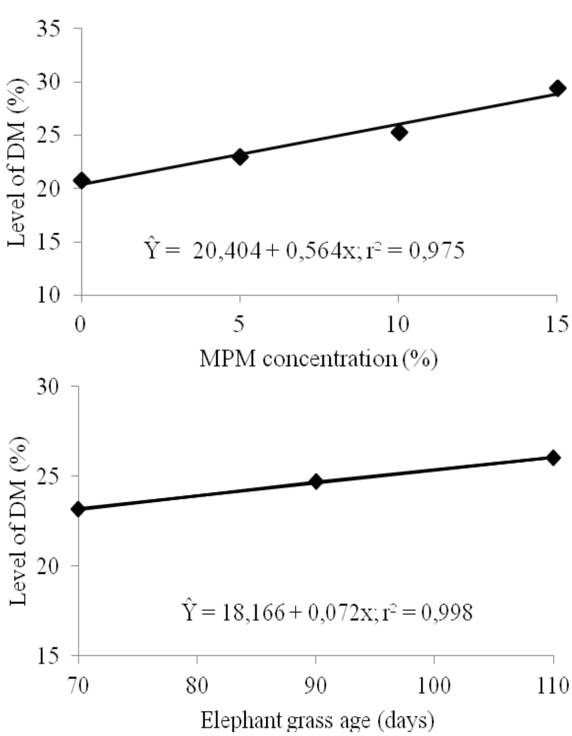

Figure 1. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the level of DM in elephant grass silages.

A linear increase ($p < 0.01$) was observed in the DM levels of silages as the cutting age of elephant grass increased. A rise of 0.072 percentage points was observed in the DM levels of silages for each additional day of age of the grass at the time of cutting. This was already expected, given that as a C_4 tropical grass, elephant grass is highly capable of assimilating solar energy and therefore accumulating dry matter throughout its vegetative development (LAETSCH, 1974). No interaction ($p = 0.61$) was observed between mesquite pod meal concentration and cutting age of elephant grass on the dry matter levels of silages.

With regard to crude protein levels, a linear increase ($p < 0.01$) was observed when mesquite pod meal was included in the ensiling of elephant grass. For every 1% addition of mesquite pod meal, an increase of 0.169 percentage points was seen on the level of CP of the silages (Figure 2). The percentage of crude protein in mesquite pod meal (11.3%) caused silages to reach 9.5% of crude protein with the highest concentration of MPM (15%), which is 2.53 percentage points higher than the witness treatment (0% mesquite pod meal).

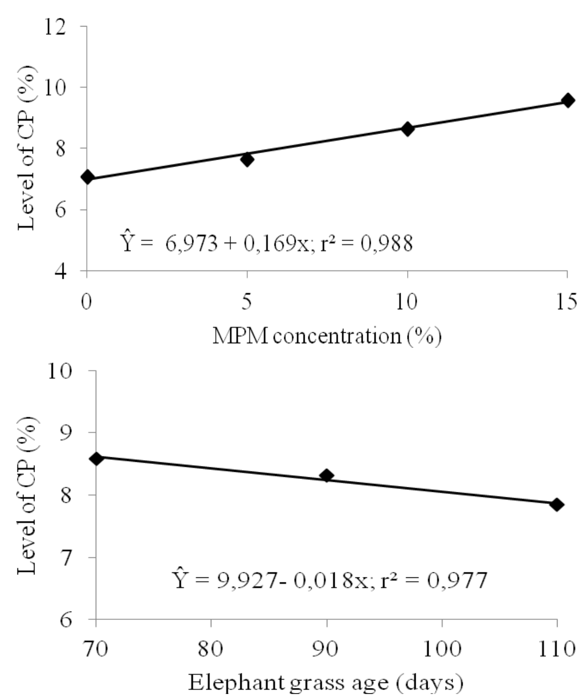

Figure 2. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the level of CP in elephant grass silages.

A linear decrease ($p = 0.02$) was observed in the crude protein levels of silages as the cutting age of elephant grass increased. It was observed that the mean level of CP decreased 0.018 percentage points for each additional day of age of the elephant grass at the time of cutting (Figure 2). This variation is due to changes that take place as tissues age and the growth period of the plant (AKIN; BURDICK, 1981). No interaction was observed ($p = 0.90$) between mesquite pod meal concentration and cutting age of elephant grass on the crude protein levels of silages.

A linear decrease ($p < 0.01$) was observed in the levels of NDF with the addition of mesquite pod meal (Figure 3). The reduction in NDF levels with the addition of mesquite pod meal is explained by the low levels of NDF found in the additive (29.9%) when compared to elephant grass. For every 1% of additive inclusion, a decrease of 0.508 percentage points was observed in NDF levels. This caused NDF levels to go from 72.0% in silages containing exclusively elephant grass to 64.3% in the treatment with the highest concentration of mesquite pod meal – a 7.62% reduction. Rêgo et al. (2010b) observed a linear reduction of 0.71% in the level of NDF in elephant grass silages containing dried cashew apple (0, 4, 8, 12 and 16%).

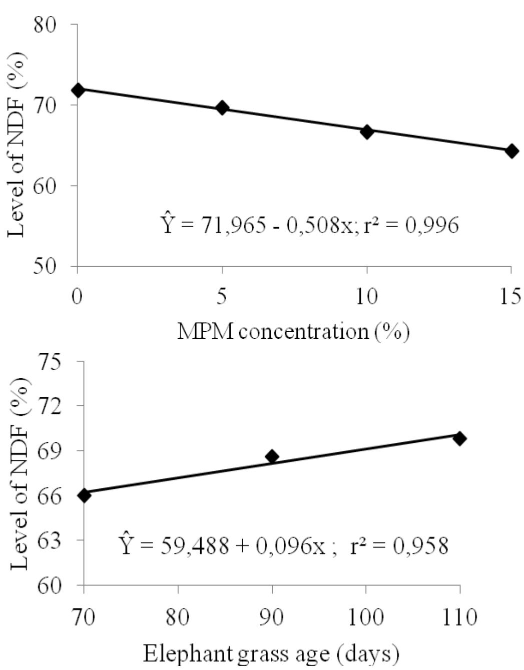

Figure 3. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the level of NDF in elephant grass silages.

A linear increase ($p < 0.01$) was observed in the NDF of silages as the cutting age of elephant grass increased. An increase of 0.096 percentage points was observed in the level of NDF of the silages for each additional day of age of the grass, ranging from 59.5% for the silage of grass cut at 70 days to 70.0% for the silage of grass at 110 days (Figure 3). This increase in NDF levels is evidenced by thickening of the plant cell wall and by a reduction in lumen and cell content as cutting age increases (WILSON; HATIFIELD, 1997). No interaction ($p = 0.12$) between mesquite pod meal concentration and cutting age of elephant grass was observed for the NDF levels of the silages.

There was an interaction ($p = 0.04$) between mesquite pod meal concentration and cutting age of elephant grass for ADF. There was a linear decrease ($p < 0.01$) in ADF levels for silages processed with elephant grass cut at 70, 90 and 110 days of age as mesquite pod meal was included. For every 1% of mesquite pod meal inclusion there was a reduction of 0.54, 0.44 and 0.42% in ADF for the silages, for their respective cutting ages (Figure 4). This decrease in ADF levels can be explained by the lower ADF content of mesquite pod meal (20.8%) compared to elephant grass (43.7%).

The obtained values are in accordance with those observed by Gonçalves et al. (2004), who while working with inclusion of acerola residue in elephant grass ensilage, observed a decrease in ADF levels of 0.32 percentage points for every 1% of residue inclusion. Rezende et al. (2007) worked with inclusion of meal from discarded potatoes to Napier grass, observing a linear decrease (0.64%), in ADF levels.

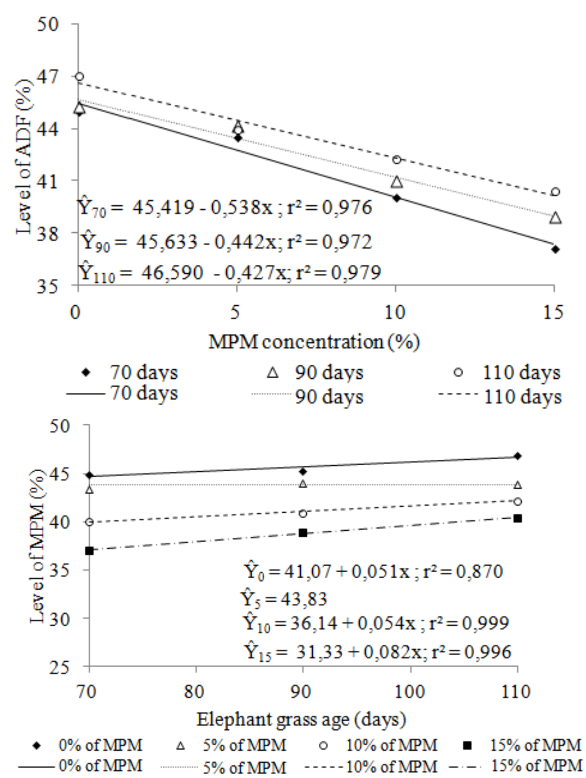

Figure 4. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the level of ADF in elephant grass silages.

A linear increase ($p < 0.01$) was observed in the ADF of silages as the cutting age of elephant grass increased, at 0, 10 and 15% MPM concentrations. At

5% concentration there was no difference ($p = 0.41$) between the tested ages. For every 1% of mesquite pod meal inclusion there was an increase of 0.051, 0.054 and 0.082 percentage points on the ADF levels of the silages, at 0, 10 and 15% MPM concentrations, respectively (Figure 4). This increase in ADF as cutting age increase is due to thickening of the plant cell wall as the vegetative stage of grass advances. ADF analysis presents an estimate of cellulose and lignin levels of the sample; higher ADF values indicate greater lignin concentration in the cell wall, and consequently lower digestibility (VAN SOEST, 1994).

An interaction ($p < 0.01$) was observed between mesquite pod meal concentration and cutting age of elephant grass for variable MM. A linear decrease ($p < 0.01$) was observed for mineral matter levels of silages processed with elephant grass cut at different ages as mesquite pod meal was included. For every 1% of mesquite pod meal inclusion there was a decrease of 0.101, 0.109 and 0.159 percentage points on the mineral matter levels of the silages, for cutting ages of 70, 90 and 110 days, respectively (Figure 5).

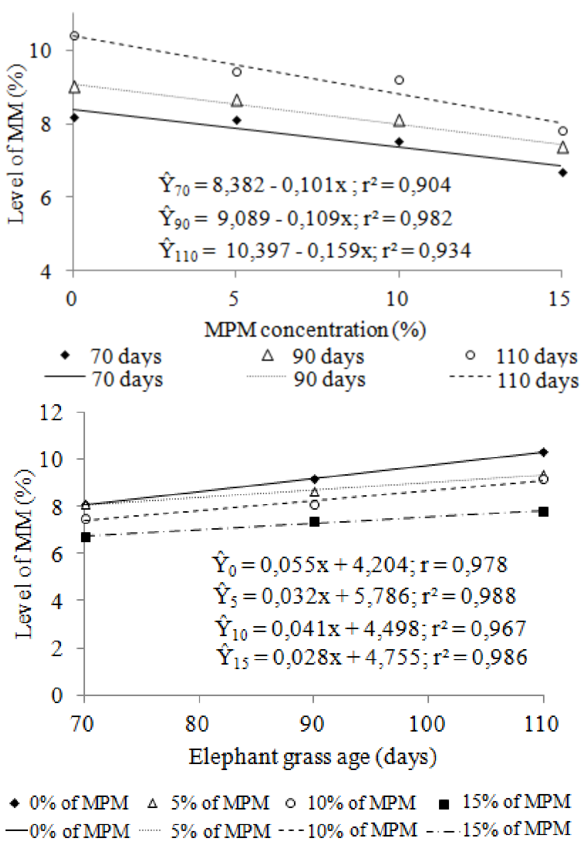

Figure 5. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the level of MM in elephant grass silages.

A linear increase ($p < 0.01$) was observed in the MM level of silages as the cutting age of elephant grass increased, in all concentrations of mesquite pod meal. For every 1% of mesquite pod meal inclusion there was an increase of 0.055, 0.032, 0.041 and 0.028 percentage points in the levels of MM in the silages, at concentrations of 0, 5, 10 and 15% inclusion of mesquite pod meal, respectively (Figure 5).

An interaction ($p < 0.01$) was observed between mesquite pod meal concentration and cutting age of elephant grass for variable pH. It was detected in all evaluated silages that pH values were lower than the minimum limit described by the literature (4.2). There was a quadratic effect ($p < 0.01$) on pH values, for all silages, regardless of cutting age of elephant grass (Figure 6). The pH of the silages in this study is considered adequate for good fermentation. Normally, this pH reduction process is due to the formation of organic acids, such as lactic acid, from the fermentation of soluble carbohydrates by lactic bacteria found naturally in the culture or added to the ensiled mass. These acids increase the concentration of hydrogen ion at a level in which undesirable microorganisms are inhibited (McDONALD et al., 1991).

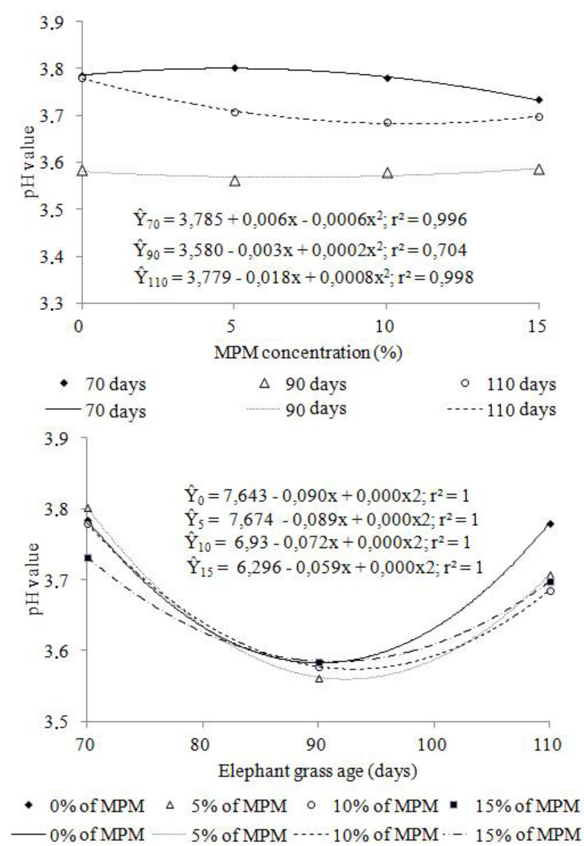

Figure 6. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the pH value of elephant grass silages.

With regard to the vegetative stage of elephant grass, a quadratic effect ($p < 0.01$) was observed for pH value in all silages (0, 5, 10 and 15%) containing mesquite pod meal (Figure 6). Braga et al. (2001), while evaluating the chemical composition of silages from elephant grass cv. Cameron, at five cutting ages, concluded that the pH value was affected by cutting age, equaling 4.0 (112 days), 4.2 (70 days), 4.3 (56 days), 4.3 (98 days) and 4.5 (84 days).

The levels of total carbohydrates of elephant grass silages decreased ($p < 0.01$) with inclusion of mesquite pod meal (Figure 7). In tropical grasses, carbohydrates represent the largest share of DM of plants, and any changes in this ratio interfere directly on energy availability for ruminants. It is possible that the reduction in the TC level of silages with mesquite meal was caused by the high rate of inclusion, as according to Sniffen et al. (1992), the more CP and EE, the lower the rate of carbohydrates when estimating TC levels. No interaction ($p = 0.50$) was observed between mesquite pod meal concentration and cutting age of elephant grass in the TC levels of silages.

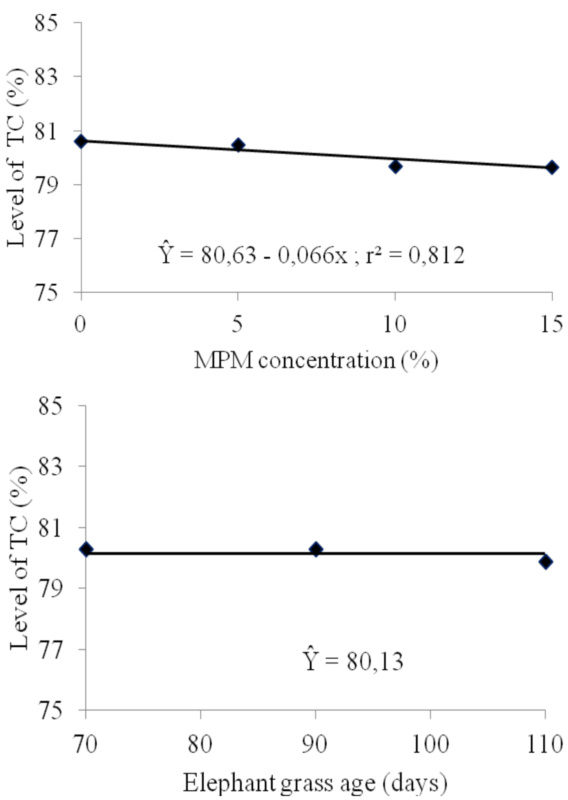

Figure 7. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the TC level of elephant grass silages.

A 0.442% increase was observed in the NFC level of silages for every 1% of added MPM, ranging from 8.67% in the silage with 0% MPM inclusion to 15.30% in the silage with 15% MPM (Figure 8). According to Van Soest (1994), NFCs serve as substrates for *Lactobacillus* bacteria, improving silage quality and increasing nutritional value. They also contribute to increase the energy value of silage and are considered highly digestible carbohydrates. A linear decrease ($p < 0.01$) was observed in the NFC levels of silages as the cutting age of elephant grass increased. A 0.107% reduction was observed in the NFC levels of silages for each additional day of age of the grass at the time of cutting, ranging from 14.11% in the silage of grass cut at 70 days to 9.83% in the silage of grass cut at 110 days (Figure 8). No interaction ($p = 0.44$) was observed was observed between mesquite pod meal concentration and cutting age of elephant grass in the NFC levels of silages.

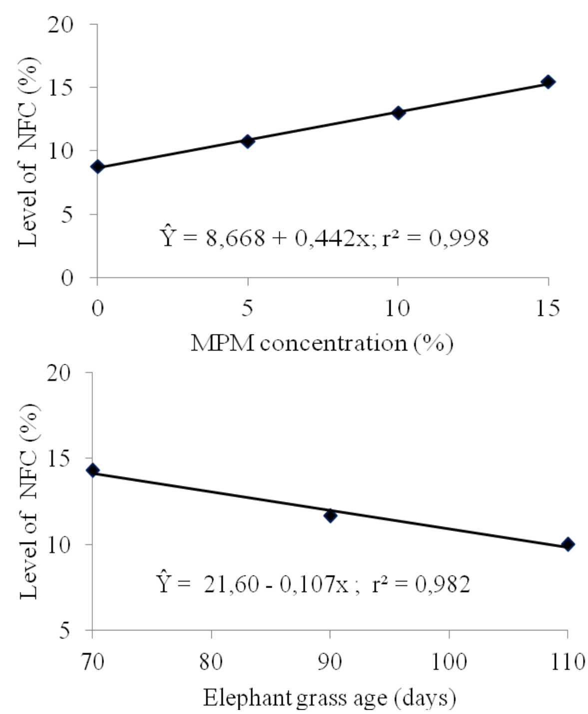

Figure 8. Effect of mesquite pod meal (MPM) concentration and elephant grass age on the NFC level of elephant grass silages.

There was a linear increase ($p < 0.01$) in *in vitro* dry matter digestibility as mesquite pod meal concentration increased (Figure 9). This may be explained by the reduction in the levels of NDF and ADF of the silages; that is, they showed a positive linear relationship between the variables.

The results are in agreement with Rezende et al. (2008), who observed a growing linear response (58.2, 62.2, 66.2, 70.2 and 74.2%) for IVDMD compared to addition of potato scrapings (0, 7, 14, 21 and 28%) to elephant grass silage. Rodrigues et al. (2007) observed a growing linear increase in *in vitro* dry matter digestibility with growing concentrations (0, 3, 6 and 9%) of citrus pulp. There was a decrease ($p < 0.01$) in dry matter digestibility as the cutting age of elephant grass increased (Figure 9), given that the digestibility of grass is markedly reduced as their vegetative stage advances, due to accumulation of fiber and lignification of the plant cell wall, in addition to lower CP levels (DESCHAMPS, 1999).

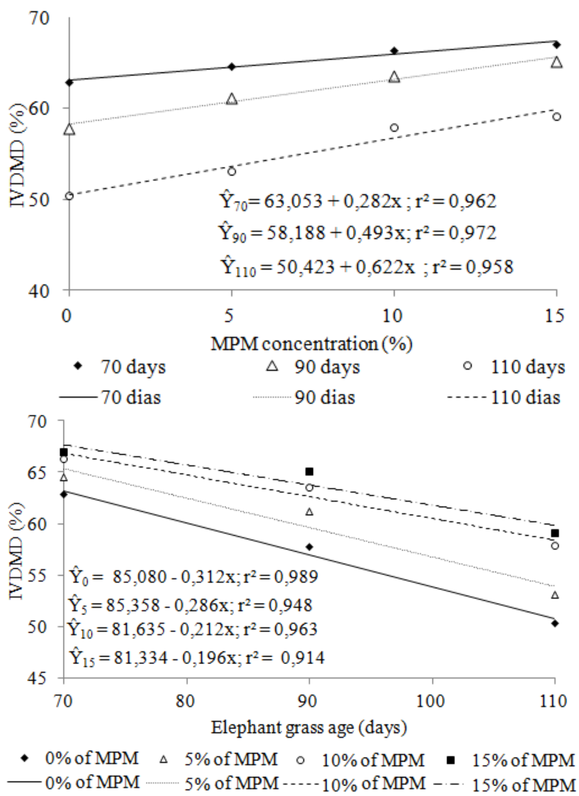

Figure 9. Effect of mesquite pod meal (MPM) concentrations and elephant grass age on the IVDMD of elephant grass silages.

As the vegetative stage of elephant grass advances, the rate of highly digestible components tends to decrease, while fibers tend to accumulate. The area occupied by lignified tissue increased as plants grew, in the leaves and stem alike; therefore, tissue degradation in the different structures decreased as plants aged (BRITO et al., 1999).

Conclusion

Mesquite pod meal can be used as a moisture absorbing additive in elephant grass silages regardless of the growth stage of the grass, as it favors fermentation, improves chemical composition of silages and enhances *in vitro* dry matter digestibility. There are no restrictions to its use within the concentrations tested in the present work.

References

AKIN, D. E.; BURDICK, D. Relationship of different histochemical types of lignified cell wall to forage digestibility. **Crop Science**, v. 21, n. 4, p. 577-581, 1981.

BERNARDINO, F. S.; GARCIA, R.; ROCHA, F. C.; SOUZA, A. L.; PEREIRA, O. G. Produção e características do efluente e composição da silagem de capim-elefante contendo diferentes níveis de casca de café. **Revista Brasileira de Zootecnia**, v. 34, n. 6, p. 2185-2291, 2005.

BRAGA, A. P.; RIBEIRO, H. U.; BARRA, S. B.; BARRA, S. B.; VASCONSELOS, S. H. L.; BRAGA, Z. C. A. C. Composição químico-bromatológica das silagens de capim-elefante cv. Cameron, em cinco idades de corte. **Caatinga**, v. 14, n. 1/2, p. 17-23, 2001.

BRITO, C. J. F. A.; RODELLA, R. A.; DESCHAMPS, F. C.; ALQUINI, Y. Anatomia quantitativa e degradação *in vitro* de tecidos em cultivares de capim-elefante (*Pennisetum purpureum* Schumach.). **Revista Brasileira de Zootecnia**, v. 28, n. 2, p. 223-229, 1999.

CARVALHO, G. G. P.; GARCIA, R.; PIRES, A. J. V.; PEREIRA, O. G.; AZEVÊDO, J. A. G.; CARVALHO, B. M. A.; CAVALI, J. Valor nutritivo de silagens de capim-elefante emurchecido ou com adição de farelo de cacau. **Revista Brasileira de Zootecnia**, v. 36, n. 5, p. 1495-1501, 2007.

DESCHAMPS, F. C. Implicações do período de crescimento na composição química e digestão dos tecidos de cultivares de capim-elefante (*Pennisetum purpureum* Schumach.). **Revista Brasileira de Zootecnia**, v. 28, n. 6, p. 1358-1369, 1999.

GONÇALVES, J. S.; NEIVA, J. N. M.; VIEIRA, N. F.; OLIVEIRA FILHO, G, S.; LÔBO, R. N. B. Valor nutritivo de silagens de capim-elefante (Pennisetum purpureum Schum.) com adição de diferentes níveis dos subprodutos do processamento de acerola (*Malpighia glabra* L.) e de goiaba (*Psidium guajava* L.). **Revista Ciência Agronômica**, v. 35, n. 1, p. 131-137, 2004.

HALL, M. B. Challenges with nonfiber carbohydrate methods. **Journal of Animal Science**, v. 81, n. 12, p. 3226-3232, 2003.

LAETSCH, W. M. The C_4 syndrome: a structural analysis. **Annual Review of Plant Physiology**, v. 25, n. 1, p. 27-52, 1974.

McDONALD, P.; HENDERSON, N.; HERON, S. **The biochemistry of silage**. 2nd ed. Marlow: Chalcombe, 1991.

MONTEIRO, I. J. G. M.; ABREU, J. G.; CABRAL, L. S.; RIBEIRO, M. D.; REIS, R. H. P. Silagem de capim-elefante aditivada com produtos alternativos. **Acta Scientiarum. Animal Sciences**, v. 33, n. 4, p. 347-352, 2011.

MUCK, R. E. Factors influencing silage quality and their implications for management. **Journal of Dairy Science**, v. 71, n. 11, p. 2992-3002, 1988.

PLAYNE, M. J.; McDONALD, P. The buffering constituints of herbage and silage. **Journal of the Science of Food and Agricultural**, v. 17, n. 6, p. 262-268, 1966.

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

RÊGO, M. M. T.; NEIVA, J. M. N.; RÊGO, A. C.; CÂNDIDO, M. J. D.; CARNEIRO, M. S. S.; LÔBO, R. N. B. Chemical and bromatological characteristics of elephant grass silages with the addition of dried cashew stalk. **Revista Brasileira de Zootecnia**, v. 39, n. 2, p. 255-261, 2010b.

REZENDE, A. V.; RODRIGUES, R.; BARCELOS, A. F.; CASALI, A. O.; VALERIANO, A. R.; MEDEIROS, L. T. Qualidade bromatológica das silagens de capim-elefante aditivadas com raspa de batata. **Ciência e Agrotecnologia**, v. 32, n. 2, p. 604-610, 2008.

REZENDE, V. M.; PAIVA, P. C. A.; BARCELOS, A. F.; TEIXEIRA, J. C.; NOGUEIRA, D. A. Degradabilidade ruminal das silagens de capim-napier produzidas com diferentes níveis de farelo de "batata diversa". **Ciência e Agrotecnologia**, v. 31, n. 2, p. 485-491, 2007.

RODRIGUES, P. H. M.; LOBO, J. R.; SILVA, E. J. A.; BORGES, L. F. O.; MEYER, P. M.; DEMARCHI, J. J. A. A. Efeito da inclusão de polpa cítrica peletizada na confecção de silagem de capim-elefante (*Pennisetum purpureum*, Schum.). **Revista Brasileira de Zootecnia**, v. 36, n. 6, p. 1751-1760, 2007.

SILVA, D. J.; QUEIROZ, A. C. **Análise de alimentos**: métodos químicos e biológicos. 2nd ed. Viçosa: UFV, 2002.

SILVA, S. A.; SOUZA, A. G.; CONCEIÇÃO, M. M.; ALENCAR, A. L. S.; PRASAD, S.; CAVALHEIRO, J. M. O. Estudo termogravimétrico e calorimétricoda algaroba. **Revista Química Nova**, v. 24, n. 4, p. 460-464, 2001.

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.

SAS Institute. **SAS user's guide**. Statistics, version 9.00 Edition. Cary: SAS Institute, 2002.

TILLEY, J. M. A.; TERRY, R. A. A two-stage technique for the *in vitro* digestion of forage crops. **Journal British Grassland Society**, v. 18, n. 2, p. 104-111, 1963.

VAN SOEST, P. J. **Nutritional ecology of the ruminant**. 2nd ed. Ithaca: Cornell University, 1994.

VAN SOEST, P. J.; WINER, R. H. Determination of lignin and cellulose in acid detergent fiber with permanganate. **Journal Association Official Agronomy Chemistry**, v. 51, n. 4, p. 780-785, 1968.

WILSON, J. R.; HATIFIELD, R. D. Structural and chemical changes of cell wall types during stem development: consequences for fibre degradation by rumen microflora. **Australian Journal of Agricultural Research**, v. 48, n. 2, p. 165-180, 1997.

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