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# Chemical composition and organic acids profile of high-moisture corn silages inoculated with lactic acid bacteria and rehydrated with water or acid whey

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**Introduction** The fermentation of high-moisture corn (HMC) is often restricted because of its relatively moisture low and fermentable sugar contents, and the accumulation of total acids produced is quite low (Kung Jr. et al., 2007). As result, there is low aerobic stability after opening of the silos. However, this can be minimized using different strategies, as lactic acid bacteria (LAB) application or acid whey application (main sub-product formed in the dairy plants from manufacture of cheese). The acid whey can be not discarded in rivers or ponds because promote serious damages for the environment, increasing the biochemical oxygen demand (Gheri et al., 2003). This product has been used like fertilizer in agricultural systems and in the animal feeding, and has potential to use in the ensiling process. Thus, our aim was to evaluate the chemical composition and organic acids profile of HMC silages inoculated with lactic acid bacteria and rehydrated with water or acid whey.

**Material and Methods** We used the AG-4051 cultivar in this study. The corn was harvested to ensiling when the grains presented 14% of humidity. The following treatments were applied to the corn: control (untreated); inoculated with Maize All® (*Enterococcus faecium* and *L. plantarum*, 1.0 x $10^{10}$ cfu per gram of product, *P. acidilactici*, 1.0 x $10^{9}$ cfu per gram of product, amylolitic and cellulolytic enzymes (1.5%), and proteolytic enzymes (2.0%)); rehydration with water or acid whey until reaches 30; 35 or 40% of humidity. The application rate of the inoculant was determined in accordance with the instructions from the manufacturer. Thus, the experiment was conducted in a completely randomized design, with four replicates in a factorial arrangement 3 (rehydration with three different humidity levels) x 2 (silage inoculated or not) x 2 (liquid used in the rehydration). As experimental silos were used PVC tubes with capacity of 4 L. After 30 days of ensiling, the silos were opened, and the silage was homogenized for chemical characterization. Total nitrogen (TN) was determined following the recommendations of AOAC (1996). The crude protein (CP) was obtained by the product between the TN and the factor 6.25. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were estimated using the techniques described by Van Soest et al. (1991). The pH values and volatile fatty acids (VFA) were analyzed. The VFA were determined by gas chromatograph. Data were subjected to ANOVA by SISVAR program, and the differences between the means were determined using Tukey test. Significant differences were declared at 5%.

**Results and Discussion** Acid whey application in HMC silages increased the acetic and lactic acid concentrations compared with the silages rehydrated with water. Perhaps, this result may be related with higher concentration of nutrients on acid whey (rich in minerals, as nitrogen, potassium and phosphorus). Thus, probably the LAB present in silos used this acid whey as substratum to development. The inoculant used in this study has only homofermentative LAB (produce mainly lactic acid), however, the lactic acid concentration decreased because of the inoculant application, which may be related with the increase in the acetic acid concentration. Lactic acid concentration decreases because of the increase in the rehydration. However, the pH values were not affected by factors evaluated in this study (Table 1). The CP, NDF and ADF contents decreased with the acid whey application, whereas there was not effect of the inoculant application. NDF content was higher with rehydration until 35%, whereas the ADF content was higher with 40% of humidity. However, we expected that the CP content increased because the acid whey has protein in your composition. As in the present work, Schingoethe et al. (1980) found positive responses with application of dried whole whey in sunflower silages, and observed improvement in the *in vitro* dry matter digestibility. Schingoethe et al. (1974) observed decreases of non-protein nitrogen with application of dried whole whey in corn silages.

**Table 1** Chemical composition and organic acids profile (% of DM) of HMC silages inoculated with LAB and rehydrated with water or acid whey.

| Item | Rehydration (%) | | | Liquid | | Inoculant | | P value[1,2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 35 | 40 | Water | AW[3] | No | Yes | R | L | I | Interaction |
| *Fermentation end products, % of DM* | | | | | | | | | | | |
| pH | 4.12 | 4.25 | 4.06 | 4.22 | 4.07 | 4.08 | 4.21 | ns | ns | ns | ns |
| AC | 0.17[b] | 0.18[a] | 0.17[b] | 0.172[b] | 0.179[a] | 0.16[b] | 0.18[a] | ** | * | ** | RxLxI** |
| PA | 0.11 | 0.12 | 0.11 | 0.11 | 0.12 | 0.11[b] | 0.12[a] | ns | ns | ** | RxLxI** |
| LA | 1.41[a] | 1.30[ab] | 1.24[b] | 1.25[b] | 1.38[a] | 1.37[a] | 1.26[b] | * | * | * | ns |
| *Chemical composition, % of DM* | | | | | | | | | | | |
| CP | 9.98 | 9.37 | 10.39 | 10.47[a] | 9.36[b] | 9.85 | 9.98 | ns | * | ns | ns |
| NDF | 13.9[b] | 20.12[a] | 15.2[b] | 18.37[a] | 14.51[b] | 16.66 | 16.22 | ** | ** | ns | RxLxI* |
| ADF | 2.05[b] | 2.72[ab] | 3.49[a] | 3.38[a] | 2.13[b] | 2.69 | 2.82 | ** | ** | ns | RxLxI* |

*Means followed by different letters differ by Tukey test (P<0.05). [1]ns = not significant (P>0.05); *P<0.05; **P<0.01. [2]R = rehydration; L = liquid; I = inoculant; [3]AW = acid whey. AC = acetic acid; PA = propionic acid; LA = lactic acid; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.

**Conclusions** High-moisture corn silages rehydrated with acid whey are more fermented, and have lower fiber content. Application of inoculant in high-moisture corn silage increases the production of acetic and propionic acids.

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# *In vitro* gas production of corn silages produced in different maturity stages and inoculated with lactic acid bacteria

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**Introduction** Silage is a common method of preserving forage and is based on the conversion of carbohydrates into organic acids by the action of lactic acid bacteria (LAB) under anaerobic conditions. As a result, the pH decreases and the forage are preserved against deterioration caused by microorganisms (McDonald et al., 1991). According to Filya (2004), the stage of maturity when the plant is harvested can be considered the main determinant of the nutritional value of silage. Moreover, the knowledge of the real importance of the LAB application in each point of development of plant is important to analyze the impact this strategy on the silage quality. Thus, the technique of *in vitro* gas production is used in the assessment of feed quality. The objective of this study was to evaluate the *in vitro* gas production in corn silages produced in different maturity stages and inoculated with LAB.

**Material and Methods** A corn hybrid BM3061 was harvested in five maturity stages: without milk line (WML), 1/3 of milk line (ML), 1/2 ML, 2/3 ML and black layer (BL), corresponding to 261.3; 290.9; 321.1; 340.2 and 385.8 g of dry matter (DM)/kg fresh matter (FM). When established the ideal harvest (although observing reduction of the milk line in the grain), all plants of the sub-plot corresponding to the stage of maturity for silage were harvested and cut in particles close to 2.0 cm. Each maturity stage was inoculated or not with LAB. The treatments evaluated were: uninoculated (control); forage inoculated with Silobac® (*Lactobacillus plantarum* and *Pediococcus pentosaceus*, 2.5 x $10^{10}$ cfu per gram of product); forage inoculated with Maize All® (*Enterococcus faecium* and *L. plantarum*, 1.0 x $10^{10}$ cfu per gram of product, *P. acidilactici*, 1.0 x $10^{9}$ cfu per gram of product, amylolitic and cellulolytic enzymes (1.5%), and proteolytic enzymes (2.0%)). As experimental silos were used PVC tubes (4 L; specific mass between 540-605 kg FM/$m^3$). After 55 days of ensiling, the silos were opened and samples were taken for characterization of silages and evaluation of gas production. The assay *in vitro* was conducted incubating dry samples (200 mg) in a water bath at 39°C in serum bottles (115 mL) with 30 mL buffered rumen fluid, according to Maurício et al. (1999). Accumulated headspace gas pressure measurements were made using a needle attached to a pressure transducer connected to a visual display (readings after 2, 4, 6, 8, 10, 12, 24, 48, 60 and 72 h post-inoculation). Relative gas production was calculated by dividing the gas production at a given time by the gas production for that bottle at 72 h. Experiment was conducted in a completely randomized design, with four replicates in a factorial arrangement 5 x 3. The test of *in vitro* gas production was conducted as split plot, where the factor of plots was the treatments, and the factor attributed to the sub-plots was the time, with four replicates All data was analyzed as mixed model with repeated measures in the time using MIXED procedure of SAS (v. 9.0). Differences among means were tested using the LSMEANS statement with the PDIFF option, and significance was declared at 5% and tendencies between 5 and 10%.

**Results and Discussion** Gas production and relative gas production were changed by use of inoculant, stage of maturity and interaction between factors ($P<0.0001$). Gas production technique considers the conversion of all the main rich sources of metabolizable energy, such as pectins, starch, cellulose and hemicellulose into gases. Thus, we observed that silages produced with high moisture presented more non-structural carbohydrates (NSC) contents in relation to silages harvested with dry matter content ideal (WML = 250.32; 1/3 ML = 242.22; 1/2 ML = 226.57; 2/3 ML = 221.20 ; BL = 249.10 g/kg of DM). These results help us to explain the higher gas production in corn silages harvested in the stages WML and 1/3 ML. However, in the stages 2/3 ML and BL, the LAB inoculation resulted in higher gas production, and this can be explaining by presence of fibrolytic enzymes in the inoculant Maize All. The relative gas production ranged 7 to 10% of the total gas production (72 h) after 2 h of incubation, whereas after 48 h ranged 86 to 90%.

**Table 1** Gas production (mL/g of organic matter) of corn silages inoculated with lactic acid bacteria in different stages of maturity.

| Stage | Silage | Time of fermentation, h | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 | 6 | 10 | 24 | 48 | 72 |
| WML | Control | 27.40 | 47.20 | 82.20 | 191.02 | 238.08 | 269.12 |
| | Silobac | 26.45 | 50.12 | 74.75 | 175.19 | 250.75 | 282.87 |
| | Maize All | 25.10 | 47.75 | 71.14 | 166.96 | 232.66 | 270.08 |
| 1/3 ML | Control | 25.90 | 53.11 | 82.97 | 201.51 | 265.61 | 299.01 |
| | Silobac | 24.33 | 54.81 | 82.03 | 163.59 | 200.07 | 231.92 |
| | Maize All | 25.40 | 55.68 | 77.36 | 197.15 | 250.56 | 279.88 |
| 1/2 ML | Control | 27.62 | 53.33 | 84.02 | 185.42 | 251.08 | 275.92 |
| | Silobac | 21.69 | 41.32 | 68.03 | 156.18 | 210.81 | 241.42 |
| | Maize All | 23.96 | 47.34 | 69.77 | 179.65 | 236.22 | 265.77 |
| 2/3 ML | Control | 21.91 | 46.51 | 71.36 | 171.13 | 229.65 | 257.27 |
| | Silobac | 23.87 | 56.93 | 86.82 | 207.09 | 271.59 | 300.07 |
| | Maize All | 22.01 | 47.68 | 73.77 | 203.07 | 269.30 | 298.75 |
| BL | Control | 23.84 | 47.00 | 70.64 | 171.40 | 229.27 | 262.63 |
| | Silobac | 24.06 | 48.97 | 75.18 | 163.91 | 206.68 | 234.41 |
| | Maize All | 26.06 | 59.03 | 90.74 | 189.18 | 247.10 | 286.95 |
| SEM | | 0.486 | 0.834 | 0.957 | 1.385 | 1.624 | 2.305 |
| P value | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

*SEM = standard error of the mean.

**Conclusions** Corn silages produced higher *in vitro* gas when the plants are harvested with high moisture. Lactic acid bacteria increase the gas production when applied in silages produced in maturity stages more advanced.

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# Performance of dairy cows fed diets containing corn silage from silos with different sealing strategies

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**Introduction** The horizontal silos have become one of the most attractive options to the storage of forage crops as silage. However, the design of these silos results in large areas of the ensiled material that are exposed to the environment, making the silage prone to spoilage, especially in the upper layer (Borreani et al., 2007) and near the silo walls (McDonell et al., 2007). It has long been known that the practice of sealing horizontal silos with a covering improves silage quality. The traditional method used to cover silos is through the use of polyethylene (PE) films. Borreani et al. (2007) reported that the high $O_2$ permeability of PE films can contribute to the low quality of silage in the top layer of horizontal silos. New plastic films have been developed with the objective of reducing silage deterioration and improving silage quality, for instance, a coextruded oxygen barrier (OB) film composed of polyethylene and polyamide polymers. Recent studies conducted in several countries have shown that the use of these polymers reduced DM losses and top surface spoilage when compared with the use of standard plastic films. The objective of this trial was to evaluate different plastic films to seal horizontal silos on the performance of Holstein cows.

**Material and Methods** Fifteen lactating cows were randomly assigned to 5 replicated 3×3 Latin square design with 21-d periods. Animals were housed in sand-bedded tie-stall barn and individually fed ad libitum to achieve approximately 10% refusals twice daily (06:30 and 17:30 h). Treatments were defined according to silo covering method: BW: 200μm black-on-white polyethylene film, BW+SB: BW plus sugarcane bagasse over the film, and PA: 125μm polyamide/polyethylene coextruded film. Diets were formulated to reach isonitrogen content and contained 53% of corn silage (% DM) to meet the nutrient requirements of a dairy cow producing 35 kg/d of milk (NRC, 2001) (Table 1). The deteriorated inedible silage was discarded every day and only edible silage was used to prepare the total mixed rations (TMR). Dry matter intake (DMI) and milk yield were recorded from d-15 to d-21 in each period, as well as milk composition. Data were analyzed using the Mixed procedure of SAS.

**Results and Discussion** The responses of cows fed the experimental silages are shown in Table 2. Contrary to previous trials, protecting the BW film with sugarcane bagasse (BW+SB) did not improve milk yield, but unlikely decreased DMI and tended to decrease daily milk protein excretion. On the other hand, the PA sealing strategy showed extra protection resulting in higher dietary energy efficiency (Milk $NE_L$/DMI) due to a tendency for higher fat corrected milk yield and milk energy excretion. In the same way, milk protein excretion was also enhanced for PA treatment.

**Table 1** Ingredient composition (% of DM) of TMR fed to lactating cows.

| Item | Treatments[1] | | |
|---|---|---|---|
| | BW | BW+SB | PA |
| Corn silage | 52.79 | 52.41 | 52.33 |
| Citrus pulp | 11.47 | 11.91 | 11.77 |
| Ground corn | 11.59 | 11.93 | 11.21 |
| Soybean meal | 21.57 | 21.09 | 22.17 |
| Mineral-vitamin mix[2] | 2.58 | 2.66 | 2.61 |

[1]BW: 200µm black-on-white polyethylene film; BW+SB: 200µm black-on-white polyethylene film plus sugarcane bagasse over the film; PA: 125µm polyamide/polyethylene copolymer film.
[2]Mineral-vitamin mix contained (DM basis) 10% Ca, 2% S, 4% P, 5% Mg, 2% K, 2800 ppm of Zn, 490 ppm of Cu, 18 ppm of Se, 1400 ppm of Mn, 14 ppm of Co, 56 ppm of I, 20 ppm of Cr, 400 KIU/kg of vitamin A, 40 KIU/kg of vitamin D, 1200 IU/kg of vitamin E, 80 mg of biotin, and 600 mg of monensin.

**Table 2** Responses of dairy cows fed corn silage stored under different sealing strategies.

| Item | Treatment[1] | | | SE[2] | *P*-contrasts | |
|---|---|---|---|---|---|---|
| | BW | BW+SB | PA | | BW + (BW+SB) vs. PA | BW vs. (BW+SB) |
| DMI, kg/d | 24.34 | 22.98 | 23.37 | 1.19 | 0.47 | 0.03 |
| 3.5% FCM[3], kg/d | 27.63 | 26.84 | 28.10 | 3.39 | 0.09 | 0.18 |
| Fat, % | 3.58 | 3.55 | 3.45 | 0.26 | 0.22 | 0.76 |
| Fat, kg | 0.96 | 0.94 | 0.97 | 0.09 | 0.25 | 0.23 |
| Protein, % | 3.48 | 3.44 | 3.53 | 0.20 | 0.17 | 0.45 |
| Protein, kg | 0.94 | 0.91 | 0.96 | 0.98 | 0.05 | 0.09 |
| Casein, % | 2.73 | 2.69 | 2.75 | 0.16 | 0.21 | 0.38 |
| Lactose, % | 4.53 | 4.52 | 4.45 | 0.07 | 0.27 | 0.90 |
| Urea, mg/dL | 12.24 | 12.21 | 11.40 | 0.93 | 0.23 | 0.97 |
| Milk $NE_L$[4], Mcal/d | 19.08 | 18.49 | 19.43 | 2.16 | 0.07 | 0.14 |
| Milk $NE_L$/DMI, Mcal/kg | 0.77 | 0.79 | 0.82 | 0.06 | 0.02 | 0.46 |

[1]BW: 200µm black-on-white polyethylene film; BW+SB: BW plus sugarcane bagasse over the film; PA: 125µm polyamide/polyethylene copolymer film, [2]SE: standard error of the mean, [3]3.5% Fat corrected milk, [4]Milk energy excretion.

**Conclusion** The oxygen barrier property of PA film was effective on maximizing the animal performance.

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**Nutritional value of Pioneiro grass silages in association with maize as grain or whole plant after aerobic stability**

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**Introduction** The success in ruminant production has been strongly dependent of a regular forage allowance. However, forage production is not constant over the year, especially due to the huge climatic variations along the seasons. Silage making has been an important option to balance these deficits in farm management decisions.

Maize is a well-established forage crop with proved fermentative and nutritional quality, but quite sensitive to climate changes (Farré and Faci, 2006). On the other hand, some forage cultivars of *Pennisetum purpureum*, like Pioneiro grass, can yield up to three times more dry matter than maize plants (Morais et al., 2009) with better tolerance to the Brazilian climatic variations. The association of the yield potential of Pioneiro grass to the nutritional and fermentative quality of maize could be regarded in the silage production to increase the production of high quality silage. The maintenance of silage quality involves its proper management after silo opening. The aerobic stability breakdown is usually related to the reduction in the nutritional value with the silage mass exposure to oxygen. This loss of quality can be minimized depending on the association of feeds used for silage making.

The present study was carried out with the aim to evaluate the nutritional changes in silages of Pioneiro grass associated to maize as grain or whole plant during the aerobic stability.

**Materials and Methods** The research was carried out at the Federal University of Paraná, Palotina Campus, Palotina, Brazil. The materials under study were the Pioneiro grass and Maize. All plants were chopped to 20mm particles and placed into PVC experimental silos under 600 kg of fresh mass/$m^3$.The silos were provided with upper Bunsen valves to escape of gases and bottom valves to effluent drainage. In this study it was used a completely randomized design within a split plot scheme, with ensilage processes as main plots and times of aerobic exposure as subplots, with eight replicates. It were tested four ensilages (Pioneiro grass 100%; Pioneiro grass 90% + Whole plant maize 10%; Pioneiro grass 98% + Maize grain 2%; Whole plant maize 100%) and three periods of aerobic exposure (0, 7 and 14 days after silo opening). The addition of whole plant maize and maize grain to the treatments was set on the fresh mass basis. The nutritional value of the silages were analyzed to crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and dry matter (DM) content.

The statistical analysis was performed using the GLM procedure and multiple comparisons of means (SNK) by the SAS software (version 9.0) at a level of 5% significance.

**Results and Discussion** The association of maize to Pioneiro grass improved ($P<0.05$) the nutritional value of the silages, but the aerobic exposure impaired ($P<0.05$) these values. It was not found significant interaction between time of aerobic exposure and silage types. All silage types presented the same pattern in response to oxygen reducing the dry matter and protein content and increasing the fiber compounds of the silage mass (Table 1).

Although many research points out to the highest carbohydrate substrate to fermentation in maize feeds at the time of ensilage compared to warm season grasses, it was not found difference between silages in other nutritional patterns along the aerobic exposure. An intense consumption of non-structural carbohydrates during this period may explain the relative increase in protein and fiber components. In average, the addition of maize as grain at 2% of the fresh mass allowed better improvement in the nutritional value of the Pioneiro grass silage than the addition of 10% of whole plant maize. The association of maize as grain or whole plant to improve the nutritional value of the silage must still consider the stability of the silage mass and the costs of both maize feeds to reach the same nutritional profiles.

**Conclusion** The addition of maize is effective in improving the nutritional value of the silages. The better nutritional profile of the silage with maize grain must be compared with silages with whole plant maize under other parameters of quality after aerobic stability, like by the temperature changes into the silage mass.

**Table 1** Dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF) and crude protein (CP) levels during silo aerobic exposure of Pioneiro grass and maize silages in mixtures. (P: Pioneiro grass; PWPM: Pioneiro grass with whole plant maize; PMG: Pioneiro grass with maize grain; M: Maize).

| Silage | DM (%) | NDF (%) | ADF (%) | CP (%) |
|---|---|---|---|---|
| P | 23.10D | 70.75A | 46.02A | 5.50C |
| PWMP | 24.24C | 67.11B | 42.22B | 6.11B |
| PMG | 24.89B | 65.23C | 40.34C | 6.27AB |
| M | 32.84A | 45.77D | 22.86D | 6.50A |
| Time of aerobic exposure (days) | DM (%) | NDF (%) | ADF (%) | CP (%) |
| 0 | 26.31A | 60.93B | 36.41B | 5.75B |
| 7 | 26.65A | 62.93A | 38.13A | 6.21A |
| 14 | 25.83B | 62.79A | 39.04A | 6.32A |
| CV (%) | 15.11 | 16.30 | 24.84 | 11.36 |

Means with same letter in columns are not different (P>0.05) by SNK test.

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**Aerobic stability of Pioneiro grass silages with addition of maize grain or whole maize plant**

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**Introduction** Silages have been an important alternative to ruminant nutrition due to the seasonality of pasture growth in different regions. Maize, although regarded as an ideal crop for conservation due to its high quality in silage production (McDonald et al., 1991), is a plant known by its low tolerance to climate changes. To minimize the effects of seasonal climatic variations on forage allowance, some cultivars of *Pennisetum purpureum* have been used due to their perennity, drought tolerance and increased forage yield, sometimes yielding up to three times more dry matter than the maize plant.

One of the challenges found in the silage use is the process of aerobic degradation where the presence of oxygen into the silage mass triggers the growth of undesirable microorganisms causing increased temperature and nutritional losses (Bernardes et al., 2007). To track the changes on silage quality during feed out phase, the temperature variation has been a useful measurement to show the start of silage spoilage. Thus, a trial was carried out with the aim to study the correlation between thermal changes and aerobic stability on pure and mixed silages of Pioneiro grass and maize.

**Materials and Methods** The research was carried out at the Federal University of Paraná, Palotina, Brazil. The materials under study were the Pioneiro grass (*Pennisetum purpureum* Schumach) and Maize (*Zea mays*). All plants were chopped to 20mm particles and placed into experimental silos under 600 kg of fresh mass/m$^3$. It was used a completely randomized design within a split plot scheme, with ensilage processes as main plots and times of aerobic exposure as subplots, with eight replicates. It were tested four ensilages (Pioneiro grass 100%; Pioneiro grass 90% + Whole plant maize 10%; Pioneiro grass 98% + Maize grain 2%; Whole plant maize 100%) and four periods of aerobic exposure (0, 5 10 and 15 days after silo opening). The addition of maize was set on the fresh mass basis. The environmental and silo temperatures were monitored regularly using thermo sensors inserted into the silage mass and connected to data loggers. The aerobic stability was considered as the time elapsed so that the temperature of the silage increased two degrees Celsius when compared to the environment, after the silo was opened. The statistical analysis was performed using the GLM procedure and multiple comparisons of means (SNK) by the SAS software (version 9.0) at a level of 5% significance.

**Results and Discussion** It was observed significant differences in the temperature variations for aerobic exposure and silages, but without effects of interaction between these variables (Table 1). Although the days used in the statistical analysis of aerobic stability have not demonstrated the breakdown of the stability, probably due to the nesting effect of silages at each evaluation date, the exploratory analysis of the daily individual temperature variations until the 15th day allowed the identification of aerobic stability breakdown for maize silage from the 9th day after silo opening (Figure 1).

Despite Pioneiro grass silages had not their aerobic stability impaired by the addition of maize, it is shown that the silage containing maize grain had its thermal oscillation very close to the limit for the breakdown (Figure 1). The association of both plants in a mixture of forages (Pioneiro grass + whole maize plant) resulted in silages with lower temperature variation during the aerobic exposure.

**Conclusion** The addition of maize as grain or whole plant to Pioneiro grass silages is effective in keeping the aerobic stability of the silage mass. These mixtures can be used to produce higher yield of more stable silages, but the choice of maize grain to Pioneiro grass mixed silage still has the advantage to release more field space to increase the total silage yield at farm scale.

**Table 1** Temperature changes between silages and times during aerobic exposure. (P: Pioneiro grass; PWPM: Pioneiro grass + whole plant maize; PMG: Pioneiro grass + maize grain; M: Maize).

| | Silage | | | |
|---|---|---|---|---|
| | P | PWPM | PMG | M |
| Temperature ($^oC$) | 0.62b | 0.54b | 0.89ab | 1.54a |
| | Time of aerobic exposure (days) | | | |
| | 0 | 5 | 10 | 15 |
| | -0.07b | 1.03a | 1.17a | 1.47a |

Means with same small letters in the rows are not different (P>0.05) by SNK test.

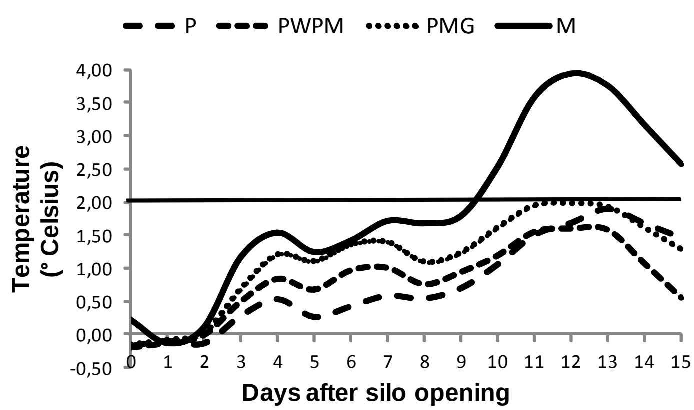


**Figure 1** Temperature variations during aerobic stability of Pioneiro grass and maize as pure and mixed silages. (P: Pioneiro grass; PWPM: Pioneiro grass + whole plant maize; PMG: Pioneiro grass + maize grain; M: Maize). Ambient temperature set as the control.

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## Aspects of sugarcane laboratory ensiling and analysis techniques

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**Introduction** Fermentation in sugarcane silages is dominated by yeasts, resulting in high ethanol content in the forage and high dry matter (DM) losses. Usually, aspects of silage fermentation are evaluated in laboratory silos but studies on the effects of differences in laboratory silos on silage fermentation are scarce. Analysis of fermentation products is normally carried out in water extracts produced in a blender or stomacher and, less frequently, in silage juices produce by means of a hydraulic press. A direct comparison of these methods could not be found on the literature. The aim of this trial was to test the hypothesis that fermentation in sugarcane silages is not affected by the type of laboratory silo but, the recovery of ethanol and other fermentation products may be affected by the presence of valves in the silos and the method used to produce silage extracts.

**Materials and Methods** Sugarcane was ensiled in three different types of laboratory silos: 9.7 x 30 cm PVC tubes with tight lids fitted with rubber O-rings (seal rings), equipped or not with Bunsen valves, and 20 L plastic buckets with tight lids and Bunsen valves. The minisilos (five replicates) were weighed and the forage sampled on day 0 and 139 days after ensiling. Gas losses (GL) were estimated by difference between the weight of the minisilos immediately after sealing and at the end of the ensiling period, after removal of the adhesive tapes. Total DM loss (TDML) was calculated by DM weight loss in the silages. Three methods were used to produce silage extracts: a hydraulic press, a stomacher or a blender. Dry matter, CP, NDF, ash, GL and TDML data were analyzed as a complete randomized design and ethanol, acetic acid, lactic acid and pH as a complete randomized design on a 3 x 3 factorial design, with six treatments (three types of minisilos and three methods of silage extract preparation) and five replicates. All data were subjected to ANOVA by the GLM procedure of SAS (SAS, 2003). Differences among means were tested using LSMEANS and the *t* test ($P<0.05$).

**Results and Discussion** The type of laboratory silo did not affect DM, CP, NDF, ash and TDML in the silages but affected GL (Table 1). Gas losses corresponded to about 50% of TDML in the three types of silos and did not differ between PVC tubes with valves and plastic buckets with valves. Gas losses in the PVC tubes without valves were equal to buckets with valves and smaller than in PVC tubes with valves, indicating that the rubber O-rings did not prevent gases from escaping after the adhesive tapes were removed, at the time the silos were weighed with lids on. No interaction between silo type and method of silage extract production was observed for ethanol and organic acids contents in the silages but it was detected for pH. The type of silo affected ethanol content but did not affect the concentration of lactic and acetic acids in the silages (Table 1). Considering the similar composition and TDML of silages produced in the three types of silos, it may be inferred that fermentation was not affected by silo type and that ethanol production was the same in the different silos. Therefore, the variation in ethanol but not in lactic and acetic acids contents among silages might be explained by differences in the volatility of these components and in the ratio between the silage top surface area and the silage mass in the different silos (TSA:SM). The PVC silos with valves had a higher TSA:SM what may have allowed more ethanol to escape through the valves relatively to the amount of DM in the silos, reducing its concentration compared to the silages in the buckets.

**Table 1** Chemical composition (g/kg DM; except when otherwise stated) and losses of sugarcane silages produced in different types of laboratory silos.

| | PVC with valve | PVC without valve | Bucket with valve | *SE* |
|---|---|---|---|---|
| DM (g/kg FF) | 262 | 262 | 255 | *7.2* |
| CP | 33.4 | 32.4 | 31.2 | *2.44* |
| NDF | 622 | 598 | 604 | *34.8* |
| Ash | 29.6 | 29.2 | 28.2 | *1.80* |
| Gas losses | 133a | 118b | 124ab | *9.6* |
| TDML | 225 | 223 | 244 | *22.8* |

a, b, c, d - Means within a row with different letters differ by *t* test (P<0.05); FF: fresh forage

The method used to produce silage extracts affected the recovery of all fermentation products in the silages (Table 2). Recovery of ethanol and acetic acid was higher in silage extracts produced using a blender, compared to recovery in extracts produced using a stomacher or a hydraulic press. For lactic acid recovery, the hydraulic press method was superior to the other two methods. In an overall view, the recovery of fermentation products was more effective with the blender, intermediate with the hydraulic press and lower with the stomacher.

**Table 2** Fermentation parameters (g/kg DM) in sugarcane silages as affected by different types of laboratory silos and methods of silage extract production.

| | Ethanol | Acetic acid | Lactic acid |
|---|---|---|---|
| | | (g/kg DM) | |
| PVC with valve | 81.3B | 38.2A | 30.8A |
| PVC without valve | 106.8A | 34.2A | 31.9A |
| Bucket with valve | 116.3A | 35.8A | 33.2A |
| Blender | 128.7a | 43.3a | 33.0b |
| Stomacher | 75.1c | 30.3b | 18.9c |
| Hydraulic press | 105.3b | 34.5b | 44.1a |
| *SE* | *16.5* | *6.5* | *5.5* |

A, B, C ; a, b, c - Means within a column with different letters differ by the *t* test (P<0.05): capital letters within silo type and lowercase letters within type of silage extract.

All silages presented adequate pH but values were lower (P<0.05) in juices produced with the hydraulic press (3.36), compared to blender (3.57) and stomacher (3.61) for the three types of silos. The more efficient extraction of lactic acid may have led to a lower pH in these extracts compared to the other two methods. Among silos, pH was lower for silage produced in buckets, in extracts produced with a blender or a stomacher but not with a hydraulic press. This result cannot be explained since there was no difference in the concentration of acids among silos.

**Conclusion** It may be concluded that fermentation was not affected by type of silo but both type of silo and method of silage extract production influenced the recovery of fermentation products in the silages. Therefore, caution must be taken when comparing inter-experimental results and efforts should be made aiming the standardization of experimental procedures.

**Relation among loss, physical and chemical characteristics of corn silage**

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**Introduction** The production of silage of high nutritional quality with minimum possible losses is of interest to producers because it allows increased animal productivity and cost reduction. Thus, this study was carried out to evaluate the physical and nutritional characteristics of corn silages in relation to effluent losses, deteriorated layer and silage disposal.

**Materials and Methods** From March to July, 2011, 95 properties from eight cities in the region of Campos Gerais, Paraná were visited and 108 silos used in animal feeding were evaluated. The density (DEN) of the silage was determined according to the methodology proposed by D'Amours and Savoie (2005). At the time of sampling, the temperature of the silage was measured with a pen shape digital thermometer, at 0-15 cm in depth, and at five points in the silo panel. To assess the aerobic stability, silage samples were collected and placed in 20 liters buckets at 25 °C ± 2 °C for 120 hours. Aerobic stability was broken when the temperature of the silage increased by 2 °C compared to ambient temperature (Moran, 1996). For all silages, the content of dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), relative nutritional value (RNV), in vitro dry matter digestibility (IVDMD), starch, hydrogen potential (pH), zearalenone mycotoxin, distribution (sieves 1, 2, 3 and 4) and average particle size (APS) were determined using Penn State sieves. For data analysis the Pearson correlation test was performed between the three variable responses and the physical and chemical characteristics of the silage. The statistical program used was the SAS 9.3, through the Proc Corr procedure.

**Results and Discussion** The dry matter density, aerobic stability, CP, ADF, NDF, TDN, starch, sieves (1, 2 and 4), RNV, IVDMD and zearalenone variables were not associated with the losses. The DM and pH variables had a negative correlation with the effluent losses, that is, the greater the losses, the lower the DM content and the pH of the silage (Table 1). According to (Schmidt et al., 2011), the effluent volume is influenced by the DM content, particle size, degree of compression, type of silo and characteristics of the plant itself. Silages with higher effluent losses were more acid (lower pH). This is due to premature harvest of the plants with higher levels of sugar and water, thereby facilitating the development of bacteria responsible for producing lactic acid which lowers the pH.

None of the assessed variables was related to the deteriorated layer. This might have occurred because the analysis was made on samples taken in the silo panel, below this layer. However, in many situations the length of the deteriorated layer may be associated with poorly fermented silages, impairing the quality due to infiltration or the presence of oxygen (Borreani et al. 2007).

Losses due to the disposal of the silage had a negative correlation with the density of the silage (NMDE) and the retained extract in sieve 3 (PennState 1.18 to 8.0 mm), and a positive correlation with the temperature of the silage in the silo and the particles average size (PAS). The density of the silage was favored by the smaller average particle size and a greater amount of them retained in sieve 3. The higher compaction results in increased silage density, reducing the porosity (Holmes, 2009) and the development of undesirable micro-organisms, which cause the temperature rise and the decomposition of the silage (Bolsen et al. 1993).

**Table 1** Correlation between losses agents and the quality of the silage.

| Variable | Effluent | | Deteriorated Layer | | Silage Disposal | |
|---|---|---|---|---|---|---|
| | r | p > f | r | p > f | r | p > f |
| NMDE | 0.0932 | 0.3376 | 0.0612 | 0.5294 | **-0.2055** | **0.0329** |
| T0 | 0.1199 | 0.2163 | 0.1718 | 0.0755 | **0.3096** | **0.0011** |
| DM | **-0.2233** | **0.0202** | -0.0669 | 0.4917 | 0.0508 | 0.6019 |
| pH | **-0.2472** | **0.0099** | -0.0875 | 0.3679 | -0.0004 | 0.9967 |
| Sieve 3 | -0.0677 | 0.4865 | -0.1296 | 0.1814 | **-0.2161** | **0.0247** |
| PAV | 0.0189 | 0.8462 | 0.1609 | 0.0963 | **0.2196** | **0.0224** |

NMDE: natural matter density; T0: temperature of the silo panel; DM: dry matter; pH: potential hydrogen; Sieve 3, 1.18 to 8 mm; PAV: particles average size.

**Conclusion** The effluent losses are higher when the DM content and silage pH are lower. The losses due to silage disposal are higher when the particle size is bigger and the density of the natural material is lower, which results in higher temperature in the silo panel. The physical and chemical characteristics of the silo panel have no relation to the losses through the deteriorated layer below the tarp.

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**Relation between losses and corn silage technologies**

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**Introduction** Corn cultivation for silage is one of the most productive in terms of digestible energy per area due to its high mass production and nutritional quality. A frequent concern of producers and technicians are the losses in quantity and quality during the usage of the silage. The losses, in turn, depend on the decisions made towards management and practices before, during and after ensiling. This study was carried out with the aim of identifying the main factors related to the ensiling process that affect physical losses in corn silages.

**Materials and Methods** From March to July 2011, 95 properties from eight cities in the region of Campos Gerais, Paraná were visited and 108 silos used in animal feeding were evaluated. During the visits, the following data were collected: the kind of silo (trench or surface), the color of the tarp used to cover the silo (black, white, black and white, black and gray), the tarp cover (dirt, no cover, others) and the form of removing the silage (manually with fork, tractor with scoop, silage extractor with milling cutter, silage block cutter).
Regarding the silage, information related to the harvesting (own or outsourced), forage type (self-propelled or by tractor) were collected.
The evaluations concerning the silages were: presence of effluents, deteriorated layer below the tarp and silage disposal. The assessments on the silage mass losses were made visually, with four reference points (absent, low, medium, high). The specific mass (EM) of the silage was determined according to the methodology proposed by D'Amours and Savoie (2005).

**Results and Discussion** The losses were most frequent on the silage disposal (97%), followed by the deteriorated layer (33%) and effluent (27%). Silage disposal was affected by the type of machine used in the harvest (Table 1). The deteriorated layer beneath the tarp was affected by the type of silo, tarp cover and form of removing the silage (Table 2). On the other hand effluent losses were not affected by the ensiling technology.

**Table 1** Losses by silage disposal depending on the type of machine used in harvesting.

| Variable | Absent | Low | Medium | High |
|---|---|---|---|---|
| | | % Silos | | |
| | | Type of Machine | | |
| Self-propelled | 3.4 | 33.9 | 42.4 | 20.3 |
| By Tractor | 2.0 | 55.1 | 38.8 | 4.1 |

Considering silage disposal, the self-propelled harvesting had high losses, five times higher than by tractor. This might have occurred because self-propelled machines produce large volume of mass collected per hour, exceeding the capacity of compression, favoring deterioration caused by microorganisms in some parts of the silo, increasing losses by disposal, as noted by D'amous and Savoie (2005).

**Table 2** Losses through deteriorated layer below the tarp depending on the type of silo, tarp cover and silage removal.

| Variable | Absent | Low | Medium | High |
|---|---|---|---|---|
| | | % Silos | | |
| | | Type of Silo | | |
| Trench | 70.37 | 18.52 | 9.88 | 1.23 |
| Surface | 55.56 | 18.52 | 11.11 | 14.81 |
| | | Tarp Covers | | |
| Dirt | 71.74 | 16.3 | 9.78 | 2.17 |
| Others | 12.5 | 50 | 25 | 12.5 |
| No Cover | 62.5 | 12.5 | 0 | 25 |
| | | Silage Removal | | |
| Block | 0 | 100 | 0 | 0 |
| Silage extractor | 60 | 26.67 | 13.33 | 0 |
| Fork | 70.15 | 19.4 | 7.46 | 2.99 |
| Scoop | 66.67 | 4.17 | 16.67 | 12.5 |

The trench type silos were 14 times lower in losses through deteriorated layer classified as "high" in relation to surface silos. The highest losses in the surface silos are connected to the lower specific mass compared to the trench silos (Bolsen et al. 2,012) which in this study were of 659 to 695 kg/m$^3$, respectively. The tarp cover with dirt reduced the occurrence of such losses. The results obtained in this study corroborate with Amaral et al. (2012), who observed lower losses when using dirt or sugarcane bagasse on the top of the tarp. The removal of the silage with the tractor scoop increased frequency of silos with high losses through the deteriorated layer. The irregular revolving of the silage in the panel of the silo caused by the scoop allows oxygen to penetrate deep into the silage, facilitating deterioration (Holmes, 2009).

**Conclusion** There were physical losses of silage in all silos evaluated, more frequently to silage disposal, followed by deteriorated layer and effluent. Silage collected with self-propelled machines had higher rate of losses through silage disposal. Surface silos without tarp cover with silage removed with a scoop showed higher incidences of losses through deteriorated layer.

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# Range in grain and silage corn productivity under seed treatment with plant hormone extract

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**Introduction** The animal production, in general aspects, have essential premises to present evolution in its system, being probably the intensification the most important of them, showing up directly proportional to the profitability, if tried in the correct way. In the beef cattle, specifically in the finishing step, the confinement is maybe the most adapted system in this case, overcoming in number of animals per area the grazing finishing and, as Ueno, 2012, even the profitability per area by the corn grain sale. This research work aimed to enquire the range of grain and biomass in the silage corn culture, with harvest point in R4, under the influence of seed treatment with plant hormone extract (HAF PLUS).

**Materials and methods** The research was conducted in the Animal production center (NUPRAN) of the ambiental and agrarian sector of the Universidade Estadual do Centro-Oeste (UNICENTRO), at Guarapuava, PR. The climate of Guarapuava, PR, is the Cfb (subtropical humid mesothermal), without a dry season, with warm summers and moderate winters as the Köppen classification, in altitude of nearly 1100 m, mean annual precipitation of 1944mm, mean annual minimal temperature of 12.7°C, mean annual higher temperature of 23.5°C and air relative humidity of 77.9%. It was utilized the corn hybrid SG 6030Y, planted in November/2012 with between lines spacing of 0.4m, 4cm of depth and seed per meter distribution aiming a final population of 80,000 plants.ha$^{-1}$, in a total area of 6400 m$^2$. The base fertilization constituted by 500 kg .ha$^{-1}$ of NPK in the formulation 08-30-20 (N-$P_2O_5$-$K_2O$). After 30 days of plantation 160 kg.ha$^{-1}$ of N, as urea (45-00-00) was also applied. The corn crop management, until 30 days after the plants emergence involved practices for weed control utilizing herbicide based in *Atrazina* and *Simazina* (Siptran: 7,5 L. ha$^{-1}$) and the insecticide based in *Lambdacyhalothrin* (Karate: 150 ml.ha$^{-1}$) for the control of *Spodoptera frugiperda.*

The evaluation occurred by collecting plants while was being made the silage. The area was divided in 2 blocks, one without hormonal seed treatment and the other with the addition of HAF PLUS, where each block was divided in 3 plots, being thereby collected 3 subsamples in each plot, randomly. In the act of collecting, it was measured 10 meters, in order to choose 3 median plants of the sample and realize the count of the plants, to estimate the total population. Of the nine plants per plot resulting from sampling, all of them were weighted and had leaves measured to calculate the leaf area index, as the methodology of Guimarães et al. (2002), and, just after, were chosen 3 median plants, from which two were fragmented in stem, leaves, bracts and cobs and grains, and one was completely fragmented. This material was weighted and forwarded to the oven, in order to obtain dry matter. The obtained data was submitted to analysis of variance with comparison of means at 5% of significance, by the statistical program SAS (1993).

**Results and Discussion** Significant ranges in fresh biomass, dry biomass and grains, verifiable in table 1, demonstrated that is really effective the action of stimulate the growing searched with the seed treatment utilizing the additional of plant hormonal extract HAF PLUS, these data that shown to be similar to the founded by (Santana, 2012), that reports corn plant biometric indices increase provided by the same product, as number of grain rows per ear, number of grains per ear and mass of 100 grains in g.

The importance of defining the leaf area of a plant is given by the existence of a straight relationship between it and the transpiration and photosynthesis rates, since affects the capacity of realizing gas exchange and intercepting the sun radiation, thus implying in an important way to estimate the productive capacity of the cultivation (Guimarães et al., 2002).

**Table 1** Estimates production of fresh biomass per ha (PMV, kg $ha^{-1}$), dry biomass per ha (PMS, kg $ha^{-1}$), grain production per ha (PG, kg $ha^{-1}$), leaf area index (IAF, m²), plant stature, ear height, plants population and plant weight, of corn destined for silage, with harvest point in R4, under the influence of seed treatment with plant extract (HAF PLUS).

| Parameter | Plant hormonal extract | | Mean | CV | P>F |
|---|---|---|---|---|---|
| | With | Without | | | |
| PMV, kg $ha^{-1}$ | 84451.00 $^{a}$ | 70082.00 $^{b}$ | 77266.67 | 10.14 | 0.05 |
| PMS, kg $ha^{-1}$ | 28147.00 $^{a}$ | 24501.00 $^{b}$ | 26324.33 | 12.22 | 0.04 |
| PG, kg $ha^{-1}$ | 11198.00 $^{a}$ | 9926.00 $^{b}$ | 10562.33 | 9.56 | 0.05 |
| IAF, m² | 0.72 $^{a}$ | 0.59 $^{b}$ | 0.65 | 10.35 | 0.04 |
| Plant stature, m | 2.51 $^{a}$ | 2.45 $^{a}$ | 2.48 | 2.85 | 0.36 |
| Ear height, m | 1.49 $^{a}$ | 1.41 $^{a}$ | 1.44 | 3.14 | 0.18 |
| Plants population, $ha^{-1}$ | 72944.00 $^{a}$ | 76111.00 $^{a}$ | 74527.00 | 3.52 | 0.27 |
| Plant weight, kg | 1.16 $^{a}$ | 0.92 $^{b}$ | 1.04 | 5.80 | 0.04 |

Means within a row followed by different superscripts differ by the test F as 5%.

**Conclusion** The results found in this research, where was observed variation in the plant weight followed by a considerable increase in the productivity, lead to believe that was, probably, provided by the superior leaf area index.

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**Aerobic stability of maize silages inoculated with homo and heterofermentative lactic acid bacteria**

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**Introduction** Forage conservation process as silage is predisposed to dry matter losses during fermentation and after silo opening. When exposed to air, silages are susceptible to yeasts spoilage. These microorganisms utilize the lactic acid as substrates and consequently cause pH rises. It leads to a propitious environment for development of aerobic microorganisms. Aerobic degradation increases silage temperature and decreases its nutritive value. High temperatures are usually associated with intense microbial degradation. The use of microbial inoculants, mostly heterolactic bacteria, may reduce silage degradation after oxygen exposure. However, research papers have found inconsistent results. This work aimed to evaluate aerobic stability and dry matter losses of maize silages inoculated with homo and heterofermentative lactic acid bacteria.

**Material and Methods** The trial was carried out at Universidade Federal do Parana, Brazil. The maize hybrid 30R50H (Pioneer, New Zealand) was harvested at 356 g $kg^{-1}$ of dry matter (DM) content in Castro, Parana, on March 2013. Maize was harvested by a self propelled chopper set to 22-mm particle size. The treatments applied were: TA – control (no additives); TB - *L. plantarum, E. faecium* and *P. acidilactici* (homolactic bacteria combination) plus *L. buchneri*; TC – homolactic bacteria combination plus high dosage of *L. buchneri*; TD – homolactic bacteria combination plus high dosage of *L. brevis*; TE – homolactic bacteria combination plus *L. brevis*. Proportions of each strain are confidential. All treatments were applied at $10^5$ CFU $g^{-1}$ of fresh matter. Inoculants were dissolved in distillated water and sprayed over the forage. Forage was compacted at a bulk density of 600 kg $m^{-3}$ in experimental silos made of 20-liter buckets provided with a valve for gases production measurement and a device for gravimetric determination of losses, as described by Jobim et el. (2007). Experimental silos were sealed and stored for 60 days. After opening, aerobic stability was assessed according to the methodology described by Kung Jr. et al. (2000). Samples of 4 kg were placed in open recipients with no compression, and kept for ten days in a closed room where mean temperature was 20.1±1.85 $^{o}$C. Silage and room temperatures were measured every four hours by bulb thermometers inserted in the geometric center of the forage. The assessed variables were: aerobic stability (AS, as the number of hours for silage temperature raising 2°C above room temperature), Maximum temperature reached by the silage (maxT, °C), time to reach maximum temperature (HTmax, hours), accumulated temperature above room temperature (accT, °C), dry matter losses during aerobic exposure (DML). Experimental design was completely randomized with five replicates, considering each silo as an experimental unit. Data were analyzed by ANOVA and means of treatments were compared by Tukey test at probability of 0.05.

**Results and Discussion** Aerobic stability results are presented in Table 1. The control silage showed the lowest maxT, which was statistically lower than silages added with *L. brevis* (TD and TE). This strain might not have been efficient in inhibiting spoiling microorganisms, leading to a greater heat production. Silage pH, HTmax and AS were not affected by inoculation. Danner et al. (2008) tested homo and heterolactic bacteria added to silages and verified that *L. rhamnosus* and *P. pentosaceus* inoculation promoted lower aerobic stabilities when compared to control silages. Accumulated temperature was higher in TE than it was in TA, that showed lower accT. This indicates that TE silages have lost more energy as heat than TA during 10 days of aerobic exposure of silages. Dry matter losses, however, were not influenced by inoculation. The bacteria added to maize silages in this trial might not have been effective in avoiding aerobic degradation.

**Table 1** Aerobic stability variables of maize silages inoculated with homo and heterofermentative lactic acid bacteria

| | Treatment[1] | | | | | |
|---|---|---|---|---|---|---|
| Variable[2] | TA | TB | TC | TD | TE | SEM[3] |
| maxT, °C | 24.3[a] | 26.7[abc] | 25.3[ab] | 28.1[bc] | 29.7[c] | 0.52 |
| HTmax, hours | 176.0 | 176.8 | 178.4 | 161.6 | 187.2 | 3.23 |
| AS, hours | 155.2 | 132.0 | 151.2 | 116.0 | 117.6 | 5.12 |
| accT, °C | 75.4[a] | 114.2[ab] | 96.0[ab] | 148.7[ab] | 191.7[b] | 13.19 |
| DML, g kg $^{-1}$ | 44.0 | 58.7 | 42.0 | 52.9 | 60.6 | 0.69 |
| pH | 4.0 | 4.1 | 4.0 | 4.1 | 4.1. | 0.01 |

[1] TA – control, no additives; TB - *L. plantarum, E. faecium* and *P. acidilactici* (homolactic bacteria combination) plus *L. buchneri*; TC – homolactic bacteria combination plus high dosage of *L. buchneri*; TD – homolactic bacteria combination plus high dosage of *L. brevis*; TE – homolactic bacteria combination plus *L. brevis*.

[2] maxT - maximum temperature reached by the silage; HTMax - time to reach maximum temperature; accT - accumulated temperature above room temperature; AS - time for raising 2 $^{o}$C above the room temperature; DML - dry matter losses during aerobic exposure.

[3] Standard error of the mean.

Means in the same line, followed by different letters are different (P<0.05) by the Tukey test.

**Conclusions** The homo and heterofermentative bacteria added to maize silages were not effective for improving aerobic stability or reduce dry matter losses during aerobic exposure.

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**Evaluation of a propionic acid based additive to avoid aerobic degradation of maize silage**

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**Introduction** Maize silage is one of the most common preserved forages for livestock. It is important to reduce visible and invisible losses through the ensiling process and during the use of the silage. After silo opening, aerobic degradation phase takes place, in which aerobic microorganisms such as yeasts and bacteria play a major role. Propionic acid is known to reduce yeast population due to its antifungal proprieties, thus delaying aerobic deterioration (Kung Jr. et al., 1998). Spreading a propionic acid based additive at exposed face of the silo might control aerobic degradation by inhibition of yeasts and molds populations. It would reflect in better chemical compositions and lower mycotoxins contents of silages. The objective of this study was to assess aerobic stability of corn silages from the exposed face of the silo, when treated with a propionic acid based preservative (PA).

**Materials and Methods** Bunker silos of eight farms located in Castro (Paraná, Brazil) were evaluated. Two squares of 1 m² were marked on the exposed face of the silo, and treated with PA (30 mL $m^{-2}$) or control treatment (30 mL $m^{-2}$ distillated water). Assessments were made 24 hours after applications. This process was repeated for four consecutive days in each silo. Room temperature (rT) and silage internal temperature (sT) were measured by bulb thermometers. For sT assessment, four thermometers were placed at 5 cm depth in each square. Every day, silage was sampled for pH evaluation. Dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), ether extract (EE), ashes, aflatoxins (AFB1, AFB2, AFG1 and AFG2), zearalenone (ZEA), deoxynivalenol (DON) and fumonisins (FB1 and FB2) contents were quantified in samples taken on the last day of the trial. The means of chemical composition and temperature were compared by analysis of variance (ANOVA) at the significance level of 0.05, in a randomized block design, considering the farm as a block.

**Results and Discussion** No treatment effect was found. Means and coefficients of variation for all variables are shown in Table 1. No detectable concentrations of aflatoxins, DON or fumonisin B2 were found. Zearalenone was detected in 87.5% of the samples. The absence of treatment effect might be partially explained by the utilized dosage. The same dosage of 1 mL $kg^{-1}$ fresh matter was tested by Kleinschmit et al. (2005), who did not observe any differences in fermentation pattern, dry matter recovery or aerobic stability. High concentrations of propionic acid (12 to 17 g $kg^{-1}$) added to high dry matter corn silages were tested by Huber and Soejono (1976), who noted decrease of temperature during fermentation and feeding, lower yeasts count at air exposed silages, increase of intake and milk yield. Another explanation for undetected differences is the insufficient time for silage to be spoiled when adequate management conditions are adopted. The 24 hour period was not enough for silage heating, thus avoiding possible PA effects to be noted.

**Table 1** Means[1] and coefficient of variation of maize silages treated with or without propionic acid, for the variables pH, silage temperature, chemical composition and mycotoxins contents

| Variable[2] | Treatment | | Mean | CV (%) |
|---|---|---|---|---|
| | Control | Propionic Acid | | |
| pH | 3.83 | 3.83 | 3.83 | 3.6 |
| rT, °C | 23.6 | 23.6 | 23.6 | 24.9 |
| sT,°C | 21.5 | 21.4 | 21.4 | 9.5 |
| DM, g $kg^{-1}$ | 371.4 | 361.1 | 366.3 | 14.4 |
| NDF, g $kg^{-1}$ DM | 401.5 | 400.0 | 400.8 | 11.0 |
| ADF, g $kg^{-}$1 DM | 212.9 | 218.5 | 215.7 | 11.7 |
| CP, g $kg^{-}$1 DM | 71.6 | 74.5 | 73.1 | 5.6 |
| EE, g $kg^{-}$1 DM | 36.7 | 34.1 | 35.4 | 12.4 |
| Ashes, g $kg^{-}$1 DM | 30.9 | 33.3 | 32.1 | 17.2 |
| ZEA, µg $kg^{-1}$ | 139 | 124 | 132 | 49.2 |
| FB1, µg $kg^{-1}$ | - | 139 | 139 | 13.7 |

[1]No significant difference was found between treatments for any analyzed variable (P>0.05).
[2] rT – Room temperature; sT – silage temperature.

**Conclusions** Spreading a propionic acid based additive on the exposed face of the silo did not influence maize silage temperature, pH, chemical composition or mycotoxins contents when evaluated 24 hours after application.

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## Chemical composition and digestibility of corn silage inoculated with *Lactobacillus buchneri* CNCM I-4323

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**Introduction** After opening silos, there is intense bacteria, moulds and yeasts activity that cause spoilage of the silages and reduce the feed quality. In this sense, the heterofermentative lactic acid bacteria, as *Lactobacillus buchneri*, are applied because reduce spoilage during aerobic exposure, and some strains of this microorganism may produce the ferulic acid esterase enzyme (Nsereko et al., 2008) that act on the fiber content (reduce or alter the structure) and improve the silage quality. Thus, our aim was to evaluate the influence of *L. buchneri* application on chemical composition and digestibility of corn silages.

**Material and Methods** A corn hybrid Impacto Víptera (Syngenta) was harvested at 279 g/kg of dry matter (DM), and chopped to achieve a theoretical length averaging 10 mm. It was evaluated forage ensiled without (control) or with $1x10^5$ cfu of *L. buchneri* CNCM I-4323 per gram of fresh matter. Inoculant was dissolved in water (0.7 L/t) and then applied with spray mounted on the fresh forage under constant mixing. The similar amount of water was applied in control silage. Eight silos were filled with 350 kg of corn forage each. Inoculation and packing was completed on the same day. After 229 days of ensiling, the silos were opened and samples were taken for characterization of silages. DM, mineral matter (MM), organic matter (OM), total nitrogen (TN) and ether extract (EE) was determined following the recommendations of AOAC (1996). The crude protein (CP) was obtained by the product between the TN and the factor 6.25. Neutral detergent fiber (aNDF) and acid detergent fiber (ADF) contents were estimated using the techniques described by Van Soest et al. (1991). Residual N (NDIN and ADIN) was analyzed. Lignin was determined after solubilization the cellulose in 72% sulfuric acid (Van Soest and Robertson, 1985). The total carbohydrates (CHO) and non-structural carbohydrates (NSC) were calculated according to Sniffen et al. (1992). *In vitro* apparent OM digestibility (IVDOM) was estimated by the gas production, as described by Mauricio et al. (1999). The IVDOM was estimated as described below:

$$IVDOM\ (g/kg) = 14.88 + ((0.889*gas24) + (0.045*CP) + (0.065*Ash))$$

where: gas24 equals the gas production in 24 h (mL 0.2 $g^{-1}$ of DM) and the CP and ash contents are expressed in g/kg of DM.

The trial was conducted in a completely randomized design, with 16 replicates. Data were subjected to ANOVA by mixed model using the MIXED procedure of SAS (v. 9.0). Differences between the means were determined using DIFF. Significant differences were declared at 5% and tendencies between 5% and 10%.

**Results and Discussion** Silage inoculated with *L. buchneri* presented higher DM, ash and NSC contents and lower OM, EE, CP and NDF contents than control silage (Table 1). According to Nsereko et al. (2008), some *L. buchneri* strains can produce the ferulate esterase on silage. This might be the case of the strain used in this study, although we did not directly investigate it. Ferulic acid esterase releases ferulic acid from cell-wall arabinoxylans (Kang et al., 2009) and directly decreases fiber content, a mechanism that can account for the observed reduction of NDF and the consequent increase in NSC. There was higher IVDOM when used the inoculant probably due to the lower NDF content and higher NSC. Gas production technique considers the conversion of all the main rich sources of metabolizable energy, such as pectins, starch, cellulose and hemicellulose into gases. Therefore, the higher NSC content produces more gas and allows obtaining higher IVDOM.

**Table 1** Chemical composition and digestibility (g/kg of DM) of corn silages inoculated with *Lactobacillus buchneri* (LB).

| Item | Control | LB | P value | SEM[1] |
|---|---|---|---|---|
| DM | 242 | 257 | 0.09 | 0.596 |
| Ash | 34 | 38 | 0.04 | 0.114 |
| OM | 966 | 962 | 0.04 | 0.114 |
| EE | 40 | 37 | 0.01 | 0.090 |
| CP | 89 | 84 | 0.02 | 0.169 |
| aNDF | 312 | 284 | 0.08 | 1.090 |
| apNDF[2] | 284 | 261 | 0.12 | 1.040 |
| ADF | 179 | 167 | 0.20 | 0.644 |
| Lignin (sa) | 38 | 46 | 0.13 | 0.384 |
| NDIN/TN | 221 | 213 | 0.48 | 0.811 |
| ADIN/TN | 167 | 151 | 0.25 | 0.941 |
| CHO | 837 | 840 | 0.13 | 0.184 |
| NSC | 552 | 586 | 0.04 | 1.142 |
| IVDOM | 634 | 659 | 0.02 | 0.488 |

*Means followed by different letters differ by F test ($P<0.05$). [1]SEM = standard error mean; [2]apNDF = NDF corrected for residual ash and protein.

**Conclusions** Application of *Lactobacillus buchneri* reduced the fiber contents and improved the in vitro digestibility of organic matter.

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**Carcass traits of Nellore young bulls fed corn silage inoculated with *Lactobacillus buchneri* 40788 associated at two concentrate levels**

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**Introduction** According to Millen et al. (2009), corn silage is among the main sources of fiber used in finishing of beef cattle in feedlot in Brazil, justifying the *Lactobacillus buchneri* application because the aerobic deterioration. However, there are few studies that evaluate the lactic acid bacteria application on carcass traits of young bulls. Lower roughage: concentrate ratios is important to reduce slaughter time of animals, because the use diets with more concentrate increase the average daily gain and modified protein and fat deposition in carcass (Missio et al., 2010). The aim of this trial was to evaluate *L. buchneri* inoculation in corn silage and their effect on the carcass traits of Nellore young bulls fed in feedlot with two concentrate levels in the diet.

**Material and Methods** A corn hybrid 2B688Hx (Dow AgroSciences) was harvested at 312 g/kg DM. Forages were chopped to achieve a theoretical length of 10 mm and ensiled without inoculant (control) or with $1x10^5$ cfu of *Lactobacillus buchneri* NCIMB 40788 per gram of fresh forage. Inoculant was dissolved in water (0.7 L/t) and then applied with spray above on the fresh forage under constant mixing. Similar amount of water was applied in control silage. Bunker silos (60 t of corn forage each) remained closed for 70 d. Twenty eight Nellore young bulls with average initial body weight (BWi) of 322.7±10.2 kg were kept in feedlot. Initially, cattle were weighed, identified and housed in individual pen (8 $m^2$) with feeders and automatic drinkers. Cattle were submitted to 18 days of adaptation to experimental installations and diets. The treatments were two silages (uninoculated and inoculated with *L. buchneri*) associated with two concentrate levels (60:40 and 40:60). All diets were balanced according nutrient requirement of beef cattle for daily gain of 1.3 kg (NRC, 2000). Animals were fed *ad libitum* (orts of 10%) once daily (7:00 am). Daily weights and samplings were performed for the diet quantities provided and orts from each animal. After 116 days of feedlot after adaptation, animals were slaughtered when they reached 503 kg of body weight. The beginning of the trial all the animals were weighed after a 16 h solid fast before the first feeding in the morning. Average daily gain (ADG) was obtained by weighing the animal at the beginning and the end of the experiment, always after a 16 h solid fast. The feed efficiency (G:F) was determined dividing ADG (g/d) by DM intake (g/d). The animals were slaughtered with an average shrunk BW of 503.0 ± 23.9 kg and all carcasses were chilled at 0°C for approximately 24 h. After slaughter, the hot carcass weight (HCW), dressing percentage (DP) in relation the HCW and pelvic, kidney and heart fat (KPH, %) in relation the HCW were recorded. *Longissimus muscle* area (LMA) and cover rib fat thickness (RFT) was estimated as from the left side of the carcass by exposing the *L. muscle* at the region between the 12$^{th}$ and 13$^{th}$ rib. *L. muscle* areas were traced on transparencies and measured later with a planimeter and RFT measurements were taken ¾ the length ventrally over the *L. muscle* by using a digital paquimeter (Greiner et al., 2003). The pH values of the carcass were taken after 24 hours of chilling (final pH), using pH meter with electrode penetration, measured at approximately 4 cm deep, made the *L. muscle* in left carcass. Data were analyzed by ANOVA using MIXED procedure of SAS as a completely randomized design in a 2 x 2 factorial arrangement (with seven replicates). Effect of treatment was considered fixed and animal considered random effect. Differences between the means were determined using DIFF. Significant differences were declared at $P < 0.05$ and tendencies at $P \geq 0.05 < 0.10$.

**Results and Discussion** The ADG was improved when the young bulls consumed inoculated silage associated with a greater amount of concentrate in the diet (S x F:C ratio interaction). The association of inoculated silage with 40% of concentrate resulted in lower LM area in the young bulls fed with this diet (Table 1). No observed effect of inoculant on the DP, KPH, RFT and pH values (Table 1). However, all treatments have allowed the animals end up with more than 3 mm of RFT, which is required by the packing plants. The results of this study support the findings of Fugita et al. (2012), in which the authors evaluated the use of a commercial product containing strains of lactic acid bacteria on carcass traits of crossbreed steers (Nellore x Angus), and did not observe any effect of the inoculant on the variables studied.

**Table 1** Effect of *Lactobacillus buchneri* inoculation in corn silage associated with concentrate levels on performance and carcass traits of Nellore young bulls.

| Item | Control | | *L. buchneri* | | SEM | P-value* | | |
|---|---|---|---|---|---|---|---|---|
| | 60:40 | 40:60 | 60:40 | 40:60 | | S | R:C | S × R:C |
| BWi, kg | 347 | 339 | 343 | 349 | 3.702 | 0.436 | 0.863 | 0.073 |
| BWf, kg | 511 | 506 | 498 | 520 | 7.426 | 0.939 | 0.259 | 0.096 |
| ADG, kg/dia | 1.46 | 1.44 | 1.36 | 1.58 | 0.051 | 0.737 | 0.065 | 0.029 |
| G:F | 0.17 | 0.17 | 0.17 | 0.16 | 0.003 | 0.742 | 0.124 | 0.329 |
| DP, % | 54.96 | 55.66 | 54.80 | 55.34 | 0.369 | 0.645 | 0.231 | 0.881 |
| KPH, % | 1.66 | 1.79 | 2.01 | 2.13 | 0.164 | 0.147 | 0.595 | 0.987 |
| RFT, mm | 5.65 | 4.34 | 5.84 | 3.57 | 0.623 | 0.746 | 0.530 | 0.590 |
| pH | 6.08 | 6.14 | 6.01 | 6.18 | 0.096 | 0.881 | 0.373 | 0.679 |
| LMA, $cm^2$ | 68.53 | 64.54 | 63.24 | 69.94 | 1.827 | 0.976 | 0.463 | 0.007 |

*S = silage (inoculated vs. control); R:C = roughage: concentrate ratio (60:40 vs. 40:60); S x R:C = silage x R:C ratio interaction.

**Conclusions** Nellore young bulls fed corn silage inoculated with *Lactobacillus buchneri* associated at high concentrate level presents higher ADG. However, only LMA was higher in these animals, with no effect on the others traits.

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# Chemical composition and aerobic stability across the storage period of corn silages

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**Introduction** Although the silage pH quickly reduce and stabilize for about three to seven days after harvest (Bolsen et al. 1992), a period of 21 to 30 days has been widely recommended as adequate for silage fermentation and stabilization. However, some studies have reported alterations in silage quality throughout storage period (Hallada et al., 2008; Der Bedrosian et al., 2012). Thus, the objective of this study was to evaluate the influence of storage period and microbial inoculants on chemical composition, microbiology, and aerobic stability of corn silages.

**Materials and Methods** Whole corn plants were harvested at 40% dry matter (DM), chopped, and packed in lab-scale silos. Microbial inoculants were applied as follows: Control – no additives, LB – *Lactobacillus buchneri* (application rate of $1×10^5$ cfu/g fresh forage), and LP+EF – *Lactobacillus plantarum* + *Enterococcus faecium* (application rate of $1×10^5$ cfu/g of fresh forage). Silos were stored for 3, 7, 15, 30, 60, 210, 390, 480, and 570 d. At opening, silages were evaluated for chemical composition, fermentation end-products, lactic acid bacteria and yeasts counts, and aerobic stability. The experimental design was completely randomized with factorial arrangement (3x9) and three replicates per treatment. Data were analyzed using the Mixed procedure of SAS version 9.3.

**Results and Discussion** Due to the lack of responses to additives, only the fact of storage length will be discussed. Contents of neutral detergent fiber (45.5%), acid detergent fiber (23.0%), lignin (2.1%), and ash (3.8%) were not significantly altered across the storage period ($P$>0.05). Crude protein (CP) fluctuated among opening dates (6.2 to 7.1%; $P$<0.01), but without biological significance. The proportion of nitrogen as ammonia ($N\text{-}NH_3/N$) increased with the storage length ($P$<0.01), from 1.3% at d-3 to 4.4% at d-570 (Figure 1). According to Kung Jr. (2001), $NH_3\text{-}N/N$ contents ranging from 5 to 7% are acceptable for corn silage, and increased values are likely due to the long storage periods (Der Bedrosian et al., 2012). In the same way, DM losses increased with prolonged storage time (Figure 1) and periods exceeding one year further enlarged nutrient losses ($P$<0.01). As expected, soluble carbohydrates were metabolized during the fermentation and decreased from 1.8% at d-3 to 0.9% at d-570 ($P$<0.01). Lactic acid bacteria and yeast counts decayed exponentially ($P$<0.01) over the corn silage storage (Figure 2). Seven days after ensiling, silage pH stabilized at 3.9.

Accordingly, lactic acid accumulated until d-7 and reached 5.3% DM. On the other hand, acetic acid reached the maximum value of 3.1% DM at d-60. Because of yeast counts decreased and acetic acid content increased over time, aerobic stability was greatly improved (Driehuis et al., 1999), especially for corn silages stored for more than 60 d. Likewise, thermal accumulation during 5 d and 10 d after silage exposure to the air were also decreased ($P$<0.01), indicating lower nutrient oxidation at air exposure for silages stored for more than 60 d.

**Conclusions** The nutritional value of corn silage increases along the storage period, whereas the main changes occur during the first 60 d. Nonetheless, periods exceeding one year would increase the risk of increased DM losses and reduction of nutritional value.

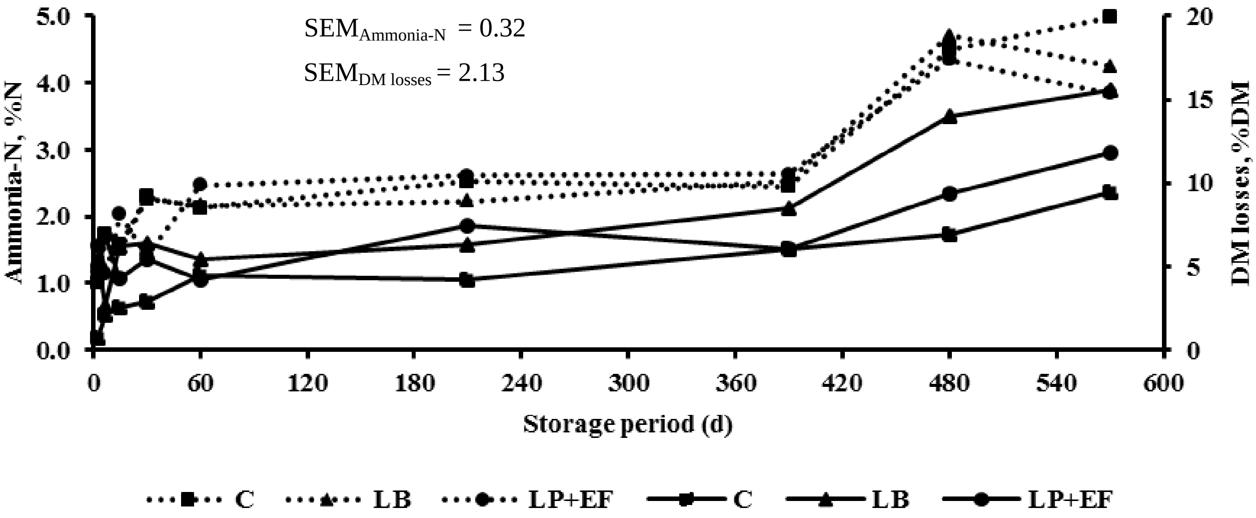


**Figure 1** Content of N-$NH_3$ (···) and DM losses (−) in corn silages across the storage period.

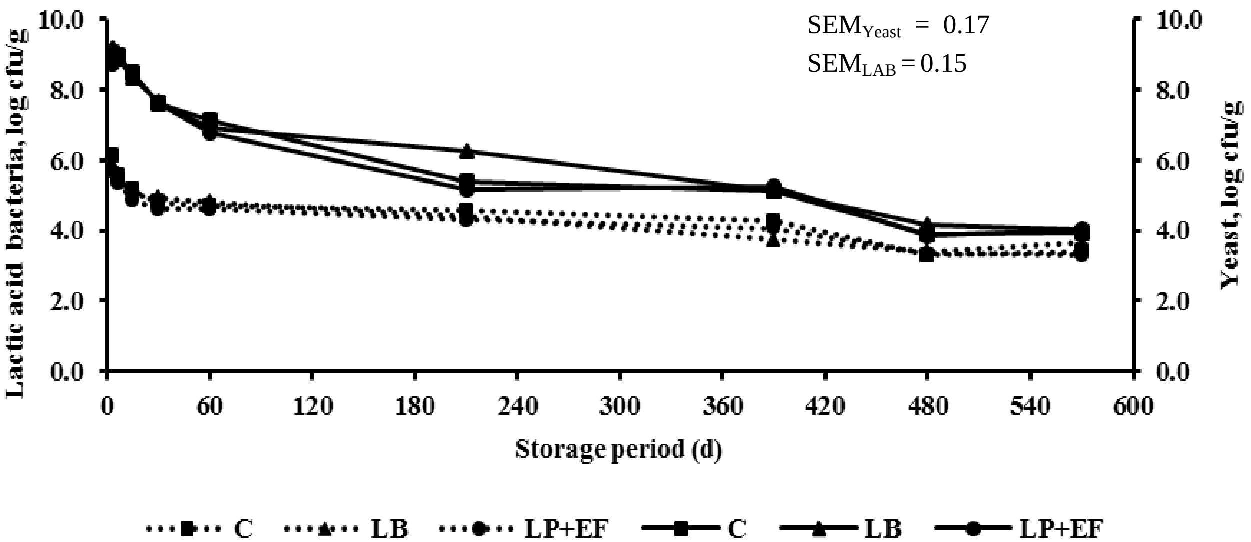


**Figure 2** Lactic acid bacteria (−) and yeast (···) counts in corn silages across the storage period.

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# Intake and ruminal kinetics of sugarcane as affected by fiber digestibility and conservation methods

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**Introduction** Sugarcane has low fiber digestibility, one of the main factors limiting beef cattle performance. Sugarcane attains maturity and is available for daily harvest during the dry season; however, ensiling is an effective option for reducing labor costs. Effects of sugarcane fiber digestibility (NDFD) and method of conservation on intake and rumen kinetics were evaluated.

**Materials and Methods** Eight ruminally cannulated Nellore steers were used in a duplicated 4x4 Latin square design. Two sugarcane genotypes with differing stalk NDFD were used: IAC2480 with higher NDFD, and SP1049 with lower NDFD. Treatment diets contained 40% sugarcane as roughage source given as freshly-chopped or as silage. Animals were housed individually with free access to water and fed *ad libitum*. Periods lasted for 14d, being 10d for adaptation and 4d for sample collection. Dry matter intake was determined on days 10, 11 and 12, and ruminal contents were evacuated manually at 1100 h (2 h after feeding) on d 12 and at 0700 h (2 h before feeding) on d 13 of each period. Total ruminal content mass and volume were determined. Aliquots were squeezed through a nylon screen to separate into solid and liquid phases. Samples were taken from both phases for determination of nutrient pool size. Main effects of sugarcane genotype (CANE), method of conservation (CONS), and their interaction were tested by ANOVA.

**Results and Discussion** Dry matter and NDF intake were greater for steers consuming diets with higher sugarcane NDFD, however the interaction CANE x CONS was significant. The effect of greater NDFD on intake was only significant when feeding sugarcane as silage, having no effect on intake when sugarcane was offered as freshly-cut. Ruminal NDF passage rate was faster for steers fed silage, but only for the genotype with greater in vitro NDF digestibility. Ruminal NDF digestion rate was also faster for steers fed silage, and for steers consuming IAC2480, with no significant interaction. Total ruminal NDF digestibility was greater for steers receiving sugarcane as silage, with no effect of genotype.

**Conclusions** Increased in vitro NDFD improved intake and passage rate, but only when given as silage. Feeding sugarcane as silage increased intake and fiber passage and digestion rates.

**Table 1** Intake and ruminal kinetics of steers fed with sugarcane fresh or ensiled and with higher or lower fiber digestibility.

| Item | Treatments[1] | | | | SEM | P-values | | |
|---|---|---|---|---|---|---|---|---|
| | Fresh | | Ensiled | | | | | |
| | IAC2480 | IAC1049 | IAC2480 | IAC1049 | | Cane | Cons | Cane×Cons |
| DMI (kg/d) | 5,27 | 5,22 | 5,89[A] | 4,68[B] | 0,50 | <0,01 | 0,86 | 0,02 |
| NDFI (kg/d) | 1,07[b] | 1,13[b] | 1,40[A,a] | 1,16[B,a] | 0,12 | 0,02 | <0,01 | 0,02 |
| DMI (%BW) | 1,84 | 1,82 | 2,07[A] | 1,65[B] | 0,09 | <0,01 | 0,99 | 0,02 |
| NDFI (%BW) | 0,38[b] | 0,40 | 0,49[A,a] | 0,40[B] | 0,02 | 0,01 | <0,01 | 0,02 |
| NDF pool (kg) | 1,42 | 1,60 | 1,33 | 1,50 | 0,18 | 0,05 | 0,36 | 0,91 |
| NDF Turnover (%/h) | 3,16[b] | 3,04[b] | 4,39[A,a] | 3,36[B,a] | 0,21 | <0,01 | <0,01 | 0,01 |
| NDF, $k_p$ | 2,88[b] | 3,01 | 3,92[A,a] | 3,05[B] | 0,22 | <0,01 | <0,01 | <0,01 |
| NDF, $k_d$ | 0,77 | 0,11 | 1,20 | 0,97 | 0,43 | 0,03 | <0,01 | 0,17 |
| DNDF, % | 42 | 42 | 57 | 55 | 11 | 0,77 | <0,01 | 0,66 |

[1]Treatments: Sugarcane fresh or ensiled and with higher (IAC2480) or lower (SP1049) NDFD. Means within a row with different superscripts differ (P<0.05).

[A,B] effect of genotype within conservation method.

[a,b] effect of conservation method within genotype.

**Botanic composition of corn hybrids cultivated in two regions of Guarapuava-PR**

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**Introduction** In Brazil, corn presents good adaptability, high dry matter yield and facility of fermentation, a high nutritional value and acceptability by animals, because of this is the material most used for silage yield (Oliveira et al., 2007). This study aimed to evaluate the agronomic characteristic of different corn hybrids for silage cultivated in two different locations.

**Materials and Methods** The experiment was conducted by the Center for Animal Production (NUPRAN), Department of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO) in Guarapuava, PR. We evaluated the percentage of stems, leaves, cob more straw and grain structure of the plant. Six corn hybrids simple (P1630H, P2530, AS1555PRO, 30R50H, 30F53H and X40B143H) associated with two cultivation sites (Location A: located latitude S25°34'513" longitude W51°41'576" and Location B: located at latitude S25°42'480" longitude W51°56'795"). The planting of the experimental fields was in no-tillage, sowing in plots consisting of 4 planting rows with 7 linear meters each, being used as a useful area for evaluations 5 linear meters of each plot. The experimental fields of property A and B were deployed on September 30, 2012, with spacing of 0.55 and 0.45 cm between rows, respectively. Corn plants were harvested at 20 cm in the reproductive stage of hard grain (R5), to evaluate the dry matter content of the plant in order to produce the whole plant silage. All plants contained in the area of each plot were individually weighed to determine the percentage share of stem, leaves, cob more straw and grains per unit area (kg $ha^{-1}$). Homogenous and representative samples of each component of each treatment were obtained and weighed and pre-dried in a forced air oven at 55 ° C. After 72 hours of oven drying, they were weighed again to determine the dry matter content (DM), according to AOAC (1984). The experiment was a completely randomized design with four replications, in a 6 x 2 factorial, consisting of 12 treatments. The data collected for each parameter were subjected to analysis of variance with comparison of means at the significance level of 5% by Tukey test.

**Results and Discussion** Table 1 presents the data of percentage share of stem, leaves, cob more straw and grain structure of different corn hybrids cultivated in two locations at the time of silage production. The percentage of stems and bracts more cob (dry matter basis) had no statistically significant difference ($P > 0.05$) among the hybrids evaluated. The corn hybrid 30R50H leaves showed higher mean (24.0% DM) compared to other hybrids. The percentage of grain had higher averages in hybrid AS1555PRO, 30R50H and X40B143H, with mean values of 41.6, 40.9, 42.7, respectively. The percentage share of stem showed no statistical difference ($p > 0.05$), in agreement with the work of Neumann (2008) compared the two regions evaluated in the study. When assessing the percentage of leaves, it was observed that the site A had the highest average, 24.4% of DM, compared to region B. For the percentage of bracts more cob, region A presented the highest average, 23.8% in DM compared to region B. The percentage share of grain dry matter showed higher average in region B, with a value of 43.3% in DM.

**Table 1** Percentage share of stem, leaves, cob more straw and grain structure of the plant different corn hybrids cultivated in different locations at the time of silage production (Crop 2012/2013, Region of Guarapuava-PR).

| Local cultivation | Hybrids | | | | | | Average |
|---|---|---|---|---|---|---|---|
| | P1630H | P2530 | AS1555PRO | 30R50H | 30F53H | X40B143H | |
| | | | stem, % of DM | | | | |
| A | 16.5 | 16.7 | 14.5 | 11.5 | 15.4 | 13.7 | 14.7 a |
| B | 13.6 | 15.2 | 12.5 | 11.8 | 23.2 | 12.0 | 14.7 a |
| Average | 15.1A | 16.0A | 13.5[a] | 11.7A | 19.3A | 12.9A | |
| | | | leaves, % of DM | | | | |
| A | 24.3 | 23.1 | 20.5 | 28.7 | 21.4 | 28.4 | 24.4 a |
| B | 18.5 | 22.4 | 20.1 | 19.3 | 14.5 | 15.1 | 18.3 b |
| Average | 21.4ABC | 22.8AB | 20.3BC | 24.0A | 18.0C | 21.8AB | |
| | | | cob more straw, % of DM | | | | |
| A | 22.8 | 22.9 | 25.1 | 23.8 | 25.0 | 23.0 | 23.8 a |
| B | 19.6 | 21.3 | 24.2 | 23.0 | 21.7 | 22.3 | 22.0 b |
| Average | 21.2A | 22.1A | 24.7[a] | 23.4A | 23.4A | 22.7A | |
| | | | grains, % of DM | | | | |
| A | 36.3 | 37.3 | 39.9 | 35.9 | 38.1 | 34.8 | 37.1 b |
| B | 38.2 | 41.1 | 43.2 | 45.9 | 40.5 | 50.6 | 43.3 a |
| Average | 37.3B | 39.2AB | 41.6[a] | 40.9A | 39.3AB | 42.7A | |

Means, followed by lower case letters in the column differ by F test at 5%.
Means, followed by capital letters in the row differ by Tukey test at 5%.

**Conclusion** The hybrids showed good adaptability to the region with average share percentage of stem, leaves, bracts more cobs and grains satisfactory.

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**Yield of different corn hybrids cultivated in two regions of Guarapuava-PR**

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**Introduction** The adoption of silage as forage became a very developed technique between terminators beef cattle feedlot (ROSA et al., 2010). This study aimed to evaluate the agronomic characteristics in different corn hybrids for silage, cultivated in two different locations.

**Materials and Methods** The experiment was conducted by the Center for Animal Production (NUPRAN), Department of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO) in Guarapuava, PR. It was evaluated the production of dry biomass, green biomass and grain of six corn simple hybrids (P1630H, P2530, AS1555PRO, 30R50H, 30F53H and X40B143H) associated with two cultivation sites (Location A: located at latitude S25°34'513" longitude W51°41'576" and Location B: located at latitude S25°42'480" longitude W51°56'795"). The planting of the experimental fields was in no-tillage, sowing in plots consisting of 4 planting rows with 7 linear meters each, being used as a useful area for evaluations 5 linear meters of each plot. The experimental fields of property A and B were planted on September 30, 2012, with spacing of 0.55 and 0.45 cm between rows, respectively. Corn plants were harvested at 20 cm in the reproductive stage of hard grain (R5), to evaluate the dry matter content of the plant in order to produce the whole plant silage. All plants contained in the area of each plot were individually weighed to determine the production of green biomass, dry biomass and grain yield per unit area (kg $ha^{-1}$). The whole plant samples from each treatment were obtained in a homogenous and representative; weighed and pre-dried in a forced air oven at 55 ° C. After 72 hours of oven drying, they were weighed again to determine the dry matter content (DM), according to AOAC (1984). The experiment was a completely randomized design with four replications, in a 6 x 2 factorial, consisting of 12 treatments, obtained by the association of six hybrids (P1630H, P2530, AS1555PRO, 30R50H, 30F53H and X40B143H) and two cultivation sites. The data collected for each parameter were subjected to analysis of variance with comparison of means at the significance level of 5% by Tukey test.

**Results and Discussion** Table 1 presents the data for the production of green biomass, dry biomass and grains yield of different corn hybrids cultivated in two locations at the time of silage production. For the green biomass yield the average of 85,270 kg $ha^{-1}$ for hybrid X40B143H was significantly different from other hybrids. The work of Gralak, 2011, using various corn hybrids showed lower means on the production of green biomass. In regards to the dry biomass yield, hybrids P2530, 30R50H, 30F53H had higher values than the other hybrids evaluated, averaging 30,919, 30,991 and 30,088 kg $ha^{-1}$, respectively. Grain yield showed no statistical difference among hybrids ($P > 0.05$). The green biomass yield was higher in region B when compared to region A with values of 82,041 kg $ha^{-1}$. Dry biomass from region A showed better average when compared to region B, with a value of 30,621 kg ha$^{-1}$.With respect to grain production region B showed better average when compared to the region A with an average of 12,979 kg ha$^{-1}$.

**Table 1** Production of green biomass, dry biomass and grain yield of different corn hybrids cultivated in different locations at the time of silage production (Crop 2012/2013, Region of Guarapuava-PR).

| Local | Hybrids | | | | | | Average |
|---|---|---|---|---|---|---|---|
| cultivation | P1630H | P2530 | AS1555PRO | 30R50H | 30F53H | X40B143H | |
| | | | Green biomass, kg ha$^{-1}$ | | | | |
| A | 70,708 | 77,670 | 76,056 | 69,478 | 75,968 | 74,600 | 74,080 b |
| B | 77,304 | 76,704 | 72,520 | 85,040 | 84,740 | 95,940 | 82,041 a |
| Average | 74,006B | 77,187AB | 74,288B | 77,259AB | 80,354AB | 85,270A | |
| | | | Dry biomass, kg ha$^{-1}$ | | | | |
| A | 30,587 | 31,668 | 27,228 | 32,346 | 31,116 | 30,783 | 30,621 a |
| B | 29,305 | 30,169 | 26,374 | 29,635 | 29,059 | 28,795 | 28,890 b |
| Average | 29,946AB | 30,919A | 26,801B | 30,991A | 30,088A | 29,789AB | |
| | | | Grain yield, kg ha$^{-1}$ | | | | |
| A | 11,103 | 11,809 | 10,882 | 11,629 | 11,869 | 10,719 | 11,335 b |
| B | 14,119 | 12,410 | 11,393 | 13,593 | 11,792 | 14,566 | 12,979 a |
| Average | 12,611A | 12,110A | 11,138A | 12,611A | 11,831A | 12,643A | |

Averages, followed by lower case letters in the column differ by F test at 5%.
Averages, followed by capital letters in the row differ by Tukey test at 5%.

**Conclusion** The hybrids had shown good adaptability to the region with average production of green biomass, dry biomass and yield satisfactory.

**References**


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# Prediction of individual variation in enteric methane production in lactating dairy cows

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**Introduction** There is increasing interest to identify ways to lower enteric methane ($CH_4$) emissions from ruminant livestock as part of an overall strategy to decrease greenhouse gases and global warming. Enteric $CH_4$ formation represents a loss of dietary energy with high $CH_4$ production reflecting a low efficiency of energy utilization from ingested feeds. Several dietary and animal factors are known to influence $CH_4$ emissions from cattle. Early pioneering studies reported that rumen fermentation pattern influences the amount of $CH_4$ produced in ruminants (Wolin, 1960). There is also evidence from studies involving respiration chambers of between-animal variation (CV 7-8%) in rumen $CH_4$ production (Blaxter and Clapperton, 1965). Changes in rumen microbial ecology can alter the stoichiometry of volatile fatty acid (VFA) production, and consequently the rate and extent of variation in $CH_4$ production between individual animals. The aims of the present study were to compare individual (cow) variance components of a set of animal variables and to establish relationships between more repeatable variables for the prediction of enteric $CH_4$ production estimated by stoichiometry.

**Material and Methods** A meta-analysis was conducted in order to evaluate between-animal differences in enteric $CH_4$ production in lactating dairy cows. The dataset used was derived from 35 experiments conducted in Finland (30 trials, 116 diets) and Sweden (5 trials, 15 diets) involving 126 individual cows and comprised 567 cow/period observations. Observations for individual cows were considered as an experimental unit. All studies were conducted according to change-over designs. Diets comprised principally grass silage and cereal grain concentrates with a mean forage: concentrate ratio (on a DM basis) of 60:40. Both enteric $CH_4$ and $CO_2$ production were calculated based on volatile fatty acid (VFA) stoichiometry ($CH_4$VFA) according to Wolin (1960): $CH_4$VFA (mol/ mol VFA) = 0.5 × acetate – 0.25 × propionate + 0.5 × butyrate. The MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) was used for variance component analysis and for estimating relationships between variables. Repeatability (R) was calculated as: $\delta^2_{Animal} / (\delta^2_{Animal} + \delta^2_{Residual})$.

**Results and Discussion** Intake and milk yield were more repeatable (>0.70) than rumen fermentation, nutrient outflow, diet digestibility or $CH_4$ production (Table 1). Overall, the coefficient of variation between cows within study ranged from 1.0% ($CH_4$VFA) to 14.8% (milk yield (Table 1). All animal (exp) variance components were significant. In previous investigations, variation in rumen fermentation patterns did not explain between-animal variability in $CH_4$ production measured in respiration chambers. Predictions of enteric $CH_4$ production based on between-animal variance components are presented in Table 2. As expected, increased total DM intake was associated with lowered digestibility and $CH_4$ which together with improved energetic efficiency of microbial nitrogen synthesis (EMNS) could explain the decrease in $CH_4$ emissions per unit of intake with increases in feeding level. However, improvements in organic matter (OM) digestibility can increase $CH_4$ emissions both by providing more fermentable substrate and altering fermentation pattern. Emissions of $CH_4$ per unit of VFA were positively related with pdNDF digestion. Digestibility of OM was more strongly related to passage rate than the rate of pdNDF digestion. It appears that variability in OMD and EMNS makes a larger contribution to between-animal variability in $CH_4$ emissions compared with rumen fermentation pattern.

**Conclusion** Results suggest that selecting animals for low $CH_4$ emissions may lead to lowered digestion capacity. Our in vivo measurements with lactating dairy cows using the GreenFeed system (C-Lock Inc, Rapid City, South Dakota, USA) have indicated a high repeatability (>0.70) and moderate between-cow variation (8-9% CV) in $CH_4$ per kg dry matter intake, which suggests that in addition to variance in rumen fermentation pattern, diet digestibility and EMNS, other factors also contribute to between animal variability in $CH_4$ emissions.

**Table 1** Summary of the analyzed dataset and description of individual (cow) variance components

| | Overall | | | | Cow variance component | | | |
|---|---|---|---|---|---|---|---|---|
| Item | n | Mean | SD | CV[1] | SD | P-value | CV | Rep[2] |
| DMI[3], kg/d | 561 | 19.4 | 2.72 | 14.0 | 1.69 | <0.01 | 8.67 | 0.71 |
| Milk, kg/d | 561 | 26.9 | 6.86 | 25.5 | 3.97 | <0.01 | 14.8 | 0.79 |
| pH | 537 | 6.36 | 0.28 | 4.46 | 0.14 | <0.01 | 2.17 | 0.48 |
| Total VFA,mmol/L | 560 | 115 | 15.4 | 13.3 | 5.90 | <0.01 | 5.13 | 0.49 |
| Acetate, mmol/mol VFA | 560 | 678 | 23.6 | 3.48 | 8.22 | <0.01 | 1.21 | 0.41 |
| Prop. mmol/mol VFA | 560 | 190 | 20.6 | 10.8 | 4.97 | <0.01 | 2.62 | 0.13 |
| Butyrate, mmol/mol VFA | 560 | 132 | 18.8 | 14.3 | 6.48 | <0.01 | 4.91 | 0.30 |
| Microbial N, g/d | 234 | 320 | 73.0 | 22.7 | 30.0 | <0.01 | 8.96 | 0.50 |
| EMNS[4], g/kg DOM | 230 | 23.9 | 4.32 | 18.1 | 1.50 | <0.01 | 6.30 | 0.39 |
| pdNDF-kd[5], 1/h | 96 | 0.049 | 0.023 | 47.3 | 0.007 | <0.01 | 14.6 | 0.61 |
| pdNDF-kp[6], 1/h | 96 | 0.017 | 0.004 | 26.6 | 0.002 | 0.02 | 9.19 | 0.31 |
| iNDFkp[7], 1/h | 96 | 0.023 | 0.005 | 21.9 | 0.002 | 0.02 | 8.78 | 0.42 |
| OMD[8], g/kg | 479 | 736 | 33.9 | 4.60 | 10.8 | <0.01 | 1.47 | 0.36 |
| NDFD[9], g/kg | 463 | 643 | 69.8 | 10.8 | 14.0 | <0.01 | 2.17 | 0.24 |
| $CH_4$VFA[10], mmol/mol | 562 | 358 | 14.4 | 4.02 | 3.73 | 0.01 | 1.04 | 0.12 |

[1]CV = coefficient of variation, %, [2]Rep = repeatability, [3]DMI = Dry matter intake, [4]EMNS = Energetic efficiency of microbial nitrogen synthesis, [5]pdNDF-kd = degradation rate of pdNDF fraction, [6]pdNDF-kp = passage rate of pdNDF fraction, [7]iNDF-kp = passage rate of indigestible NDF fraction, [8]OMD = organic matter digestibility, [9]NDFD = NDF digestibility, [10]$CH_4$VFA = calculated $CH_4$ production by stoichiometry.

**Table 2** Best models for predicting enteric methane production based on the repeatability of individual (cow) variance components

| Item | X | Intercept | SE | Slope | SE | P-value | RSD[1] |
|---|---|---|---|---|---|---|---|
| $CH_4$VFA | OMD | 272 | 25.1 | 0.099 | 0.032 | 0.003 | 9.80 |
| $CH_4$VFA | DMI | 365 | 7.9 | -0.89 | 0.329 | 0.01 | 9.48 |
| $CH_4$VFA | pdNDF-kd | 359 | 6.1 | 232 | 95 | 0.02 | 7.10 |
| $CH_4$VFA | pdNDF-kp | 381 | 9.4 | -562 | 363 | 0.14 | 6.82 |
| EMNS | OMD | 74 | 7.2 | -0.075 | 0.011 | <0.001 | 1.75 |
| EMNS | DMI | 18.9 | 2.68 | 0.236 | 0.128 | 0.07 | 1.93 |
| OMD | DMI | 820 | 14.1 | -2.5 | 0.59 | <0.001 | 14.2 |

[1]Residual standard deviation = square root of residual variance.

# Case study of agricultural production: cost effective operating of sugarcane plantation (*Saccharum officinarum*) CB 47-355 variety to animal feeding in Porto Velho, Northern Brazil

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**Introduction** Nowadays, Brazil is the largest sugarcane producer, contributing with 40% of the world production (700 MT in 2009), occupying about 9.7 million hectares with the culture of sugar cane. Furthermore, the country is a worldwide reference concerning to technologies for production of sugarcane *Saccharum officinarum*, especially used to table sugar, ethanol and in smaller scale, spirits such as rum and "cachaça" (fermentation and distillation of the stem juice) (Oliveira *et al.*, 2012; Scortecci *et al.*, 2012). Those researches and national technologies have been allowing to lengthen the useful life of the sugarcane plantation, as well as to use more efficiently the inputs and labor, increasing the competitiveness and sustainability of the system. On small farms in Northern Brazil, the chopped sugarcane stalks are widely used as cattle feed during dry season when pastures are not available for grazing, because a mixture of sugarcane, urea and sulfur constitutes a source of energy and protein. Differently from other tropical grasses, sugar cane increase the energy content with advancing age (Caione et al, 2012). The maturation of sugarcane in Southeastern Brazil occurs naturally at beginning of May, peaking from September-October (Deuber, 1988; Galdiano, 2008), yet lack information on soil and climatic conditions of Northern Brazil. Although the average productivity of sugarcane Brazilian oscillates 80-90 t fresh matter per hectare, adopting an appropriate management an fertilizing can be achieved yields higher than 150 t of fresh matter/ha (Oliveira et al, 2012). However, technological innovations are dynamic and there is a need to quantify the efficiency and cost of production, to detect bottlenecks to ensure feasibility for the dairy farmer. The aim of this study was to evaluate costs of sugarcane plantation of CB 47-355 variety, in plant-cane crop, under conditions of Northern Brazil, in Porto Velho.

**Materials and Methods** The costs of sugarcane production were evaluated in an experimental area of Embrapa Rondonia, Porto Velho city, located in Amazonia, State of Rondonia, Brazil. The sugarcane variety CB 47-355 was planted in November 2012 in the area of 0.43 ha allocated to livestock feed with use of termiticide (tiametoxam 141 g/kg) and fungicide (azoxistrobine 200 g/L+ciproconazol 80 g/L). After plantation, it was fertilized in February and March, desiccated pre (Paraquat dichloride 276 g/L+ Oxyfluorfem 240 g/L) and post emergence (Tebuthiurom 500 g/L). The fertilizer doses were chosen based on soil sample analysis (20 cm depth) to reach saturation of 60% of total bases. The rate of 93-180-166 kg/ha of formulate ($N$-$P_2O_5$-$K_2O$), based on the yield of 120-150/ha of fresh matter, in according to the tables of IAC. The Operating Cost Effective (COE) provides adequate financial return in relation to outlay (Moreira and Bonizio, 2012) and was calculated about the costs of sugarcane plantation until early 2013 year. The costs were collected through exploratory research, and the procedures and data collection defined as a case study (Oliveira et al, 2012).

**Results and Discussion** During plantation of sugarcane, the items that were more costly included chemical fertilizers (N-P-K+FTE), expenses with plowing and harrowing, application of limestone, sugarcane seedlings (cut on own farm), furrowing for planting and limestone and totalized 75% of CEO (Figure 1). The cost was divided by two mainly categories: services and operations (labor in unity of days-worked, d/h; mechanization in unity of hour-tractor or hour-machine, h/m) equivalent to 50.28% of the COE, already spending on agricultural supplies were of 49.72%. The activities itemized as: soil preparation/treatment; plantation of sugar cane; chemical treatment of soil and plants (herbicide, termiticide, fungicide); fertilization, fertilizer (phosphate triple, urea, potassium chlorate, FTE-micronutrients mix), limestone, etc.

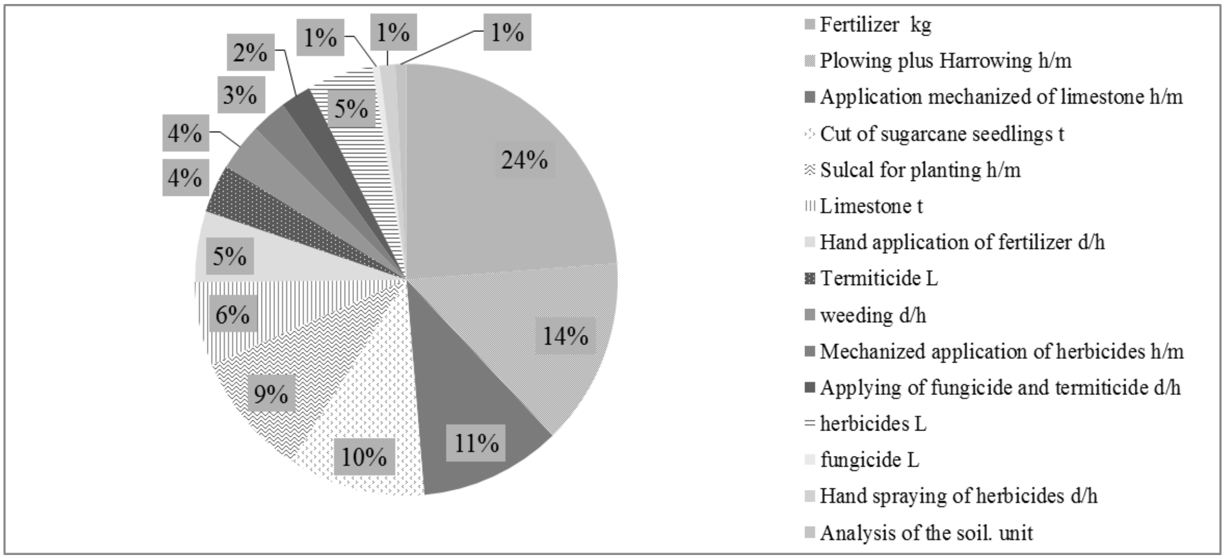


**Figure 1** Percentual cost effective operating of implantation of sugarcane plantation in 0.43ha

Because this case study refers to small area, similar to the small milk producer, the COE this study (R$ 6,852.06/ha) were similar to those found by Moreira and Bonizio (2013) for other regions, of R$ 6,333.00/ha, three times higher for small farmers, because the large area has lower costs due to economies of scale. One point that can be improved is the regulation of herbicide application, once were applied as 135% of the recommended dose, one can saved the equivalent of 35%. The training of workforce had so much impact on costs of operations and the increasing scale of production can also optimize costs, since dilute the time used in mechanized operations (tractor).

**Conclusion** Therefore, it is concluded that the production scale, technical management and training of the workforce are aspects that can improve the results of small crops of sugar cane in Porto Velho.

## *In vitro* degradability and gas production of corn silage ensiled with fibrolytic enzymes

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**Introduction** Fibrolytic enzymes have been added to forage at ensiling with the goal to improve fermentation. Furthermore, enzymes can improve cell wall degradation, decreasing fiber content and enhancing the animal performance. An additional advantage could be that, by degrading the cell walls of the forage, the rate and extent of digestion of silage in the rumen may be increased (Bolsen et al., 1995). The objectives of this study were to evaluate *in vitro* degradability and gas production of corn silage ensiled with fibrolytic enzymes.

**Materials and Methods** Fibrolytic enzymes were produced by submersed fermentation (FSbm) of *Aspergillus niger* in a liquid medium (SR) containing 1% of wheat bran as substrate in stove 30ºC per 168 hours. Enzymatic extract contained 20.59 U $mL^{-1}$ and 1.04 U $mL^{-1}$ of xylanases and cellulases, respectively. Enzymatic extract was sprayed on the corn plant to manufacture the following treatments: Control - without enzymes; E1 – ensiling with 5.0 mL of enzymatic extract kg of fresh $forage^{-1}$; E2 - ensiling with 10.0 mL of enzymatic extract kg of fresh $forage^{-1}$; E3 - ensiling with 15.0 mL of enzymatic extract kg of fresh $forage^{-1}$. The forage was treated and ensiled into plastic buckets (5 L). The experimental silos were opened after 60 days of ensiling and all samples were dried, ground to pass through a 1-mm screen and weighed (0.5g) into filter bags (F57, ANKON). Then the bags were heat-sealed, placed into 115 ml vials and incubated with 60 ml of anaerobic buffer medium and ruminal fluid mixture (Goering and Van Soest, 1970). The diet of animals was composed of 60% of silage and 40% of concentrate (ingredients: corn meal, soybean meal, urea and mineral supplement) and ruminal fluid was colected 3 hours after feeding. The vials were sealed and incubated at 39°C in a water bath for 48 h. Head space gas production (GP) resultant of substrate fermentation was measured at 3, 6, 9, 12, 24 and 48 h post inoculation. At 24 and 48 h, vials were removed from the water bath, placed on ice and the bags were washed under cold tap water until excess water ran clear. Bags were dried at 55 °C for 48 h, and dry matter degradability (DMD) was determined following the procedures outlined by Van Soest et al. (1991) using thermostable α-amylase but without sodium sulfite in the Ankom 2000 Fiber Analyzer (Ankom Tecnologies, Macedon, NY, USA. After each analysis, bags were dried as described for DMD determination. All the statistical analyses were conducted using the MIXED procedure of SAS (SAS System, version 9.1, 2002). Orthogonal polynomial contrasts were performed to determine linear and quadratic effects of enzymatic level.

**Results and Discussion** Gas production was not significantly increased by enzymatic treatment (Table 1, $p>0.05$). According Nadeau et al. (2000), the most consistent effect of cell wall degrading enzymes such as cellulases and hemicellulases, is the reduction of structural carbohydrate concentration of silages. This decrease in fiber content could increase the degradability of feed, however, when the rapidly fermentable NDF is degraded, this extensive fermentation of forage before feeding can decrease the digestibility of remaining NDF (Van

Vuuren, 1995). In this research, the addition of different levels of enzymes in ensiling of corn plant not improved the degradability of DM and NDF after 24 or 48 hours. Colombatto et al. (2003) found which silages treated with commercial enzymes produced less gas and were degraded more slowly than control silage. Several factors contribute to the effectiveness of fiber degrading enzymes such as, for example, the activity of the enzymes used, the pH of the medium where the enzyme must act, as well as temperature and moisture content.

**Table 1** Cumulative gas production (mL $gDM^{-1}$) of corn silage ensiled with different level of fibrolytics enzymes.

| | Incubation time (hour) | | | | | |
|---|---|---|---|---|---|---|
| Treatment[1] | 3 | 6 | 9 | 12 | 24 | 48 |
| Control | 62.41 | 99.11 | 130.10 | 153.36 | 183.54 | 235.17 |
| E1 | 60.18 | 97.58 | 124.76 | 148.03 | 181.37 | 232.18 |
| E2 | 61.71 | 100.38 | 129.39 | 151.85 | 182.17 | 226.83 |
| E3 | 62.80 | 100.26 | 130.09 | 153.34 | 182.16 | 227.28 |
| Mean | 61.78 | 99.33 | 128.59 | 151.65 | 182.31 | 230.36 |
| SEM | 0.58 | 0.65 | 1.29 | 1.50 | 0.45 | 2.01 |
| Significance | Ns | ns | ns | ns | ns | ns |

[1]Control: without enzymes; E1: ensiling with 5.0 mL of enzymatic extract kg of fresh forage$^{-1}$; E2: ensiling with 10.0 mL of enzymatic extract kg of fresh forage$^{-1}$; E3: ensiling with 15.0 mL of enzymatic extract kg of fresh forage$^{-1}$.

**Table 2** Apparent degradability (g $kg^{-1}$) of DM and NDF, from corn silage ensiled with fibrolytic enzymes after 12 and 48 h of incubation with ruminal fluid.

| | Degradability | | | |
|---|---|---|---|---|
| Treatment | 24 hours | | 48 hours | |
| | DM | NDF | DM | NDF |
| Control | 35.43 | 17.08 | 43.92 | 40.08 |
| E1 | 35.11 | 17.61 | 43.06 | 39.95 |
| E2 | 36.94 | 17.37 | 42.64 | 38.58 |
| E3 | 37.11 | 18.40 | 44.49 | 40.46 |
| Mean | 36.15 | 17.61 | 43.53 | 39.77 |
| SEM | 0.36 | 0.33 | 0.38 | 0.34 |
| Significance | ns | ns | ns | ns |

[1]Control: without enzymes; E1: ensiling with 5.0 mL of enzymatic extract kg of fresh forage$^{-1}$; E2: ensiling with 10.0 mL of enzymatic extract kg of fresh forage$^{-1}$; E3: ensiling with 15.0 mL of enzymatic extract kg of fresh forage$^{-1}$.

**Conclusions** Fibrolytic enzymes added in the ensiling of corn plant had no effect on gas production until 48 hours of incubation and dry matter and neutral detergent fiber degradation.

# Effect of corn silage with microbial inoculants on performance and microbial nitrogen supply of feedlot lambs

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**Introduction** Inoculants containing homofermentative lactic acid bacteria ($^{ho}$LAB) are added at ensiling to enhance the fermentation process, ensuring silage with better quality. Inoculants containing heterofermentative lactic acid bacteria are added in association with $^{ho}$LAB to ensure a control of aerobic deterioration of silage after silo opening, due to production of antifungal compounds from these microorganisms. Moreover, *Bacillus* species also can be used as microbiological additives to overcome the problem of silage aerobic spoilage. Thus, the animals fed with this silages can be able to consume higher amounts of nutrients due to less deterioration after silo opening. Furthermore, according Weinberg et al. (2004), LAB can survive in ruminal conditions, changing the microbial population of rumen and promoting high animal performance, e.g. act as probiotic effect. *Bacillus subtilis* are used as probiotic to pigs and poultry, but its effect in ruminants are few studied. Therefore, this study aimed to evaluate intake, daily gain and microbial nitrogen supply in lambs fed corn silage ensiled with different microbial inoculants.

**Materials and Methods** A corn hybrid Impacto Víptera (Syngenta) was harvested at 40.4% DM, chopped and treated with $1x10^5$cfu of *Lactobacillus plantarum* “MA18/5U” combined with $1x10^5$cfu of *L. buchneri* “CNCM I-4323” (LPLB) or $1x10^5$cfu of *B. subtilis* “AT553098” (LPBS) per gram of forage, remaining a treatment uninoculated (control silage) ensiled in three stack silos with 40 t each (closed for 85 d). Thirty crossbreed lambs (BW around 29±3.0 kg), males, were divided in ten blocks into three treatments. Animals were adapted to the environment and diets for 14 days. Diet was composed of 60% of silage and 40% of concentrate (ingredients: corn meal, soybean meal, urea and mineral supplement) and was balanced to daily gain of 200 g/d. Lambs were housed in individual pens and fed *ad libitum* twice daily (7 am and 5 pm). Orts were weighed daily and dry matter intake (DMI) was measured. On day 25, s*pot* urine was collected 4 hours after feeding with collection bags from all animals. The 10-mL urine sample was diluted with 40 mL of a 0.036 N solution of $H_2SO_4$ and stored at -20°C for later analysis of purine derivatives to estimate microbial nitrogen supply according to Chen and Gomes (1995). Lambs were weighed after fasting (16 hours) at the beginning and end of the experimental period (approximately 53 days of feedlot) to obtain the average daily gain (ADG). Data were analyzed as randomized block by ANOVA using MIXED procedure of SAS (v. 9.0). Differences between the means were determined using DIFF (level of significance 5%).

**Results and Discussion** Lambs fed with LBLP silage had lower DM intake than animals that received control and LPBS silages, which can result in lower microbial nitrogen supply. Since some factors affecting microbial nitrogen supply among these are supply of fermentable energy, supply of nitrogen compounds, rumen outflow rate (related with dry matter intake) and rumen environment (ruminal pH) (Verbic, 2002). Furthermore, animals fed LPBS silage had a higher microbial nitrogen supply, which may be due to the use of *Bacillus subtilis*, because is a microorganism widely used as probiotic in pig and poultry diets and these microorganisms may have benefited the rumen microorganisms. Although, we have found differences on DM intake and microbial N supply the average daily gain was not affected by the different inoculants added on the ensilage.

**Table 1** Dry matter intake, microbial N supply and average daily gain (ADG) of lambs fed corn silages inoculated with microbial additives.

| | Control | LBLP | LPBS | SEM[2] | P value |
|---|---|---|---|---|---|
| DMI (kg/d) | 1.54[a] | 1.28[c] | 1.46[b] | 0.06 | 0.0001 |
| Allatoin (mmol/d) | 18.87[b] | 10.85[c] | 25.42[a] | 2.99 | 0.0001 |
| Uric acid + Hypo + Xan (mmol/d)[1] | 2.56[ab] | 3.08[a] | 2.32[b] | 0.29 | 0.0180 |
| Purine derivatives (mmol/d) | 21.87[b] | 15.76[c] | 26.85[a] | 2.65 | 0.0001 |
| Microbial N supply (g/d) | 18.90[b] | 13.60[c] | 23.20[a] | 2.35 | 0.0001 |
| ADG (kg/d) | 0.232 | 0.213 | 0.212 | 0.01 | 0.2211 |

[1]Sum of hypoxanthine, xanthine and uric acid. [2]SEM: Standard error of the mean.

**Conclusions** The use of *Lactobacillus plantarum* combined *B. subtillis* added on the ensilage of corn plant affected the dry matter intake and microbial nitrogen supply of lambs.

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# Composition of corn hybrids harvested as silage at Guarapuava PR

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**Introduction** The maturity stage of corn crop harvest as silage is the parameter that can affect production by dry matter accumulation and silage quality by modifying the plant chemicals that have direct relation with agronomic parameters, nutritional quality and bioeconomic response (OLIVEIRA, 2010), and it is precisely the most common mistake observed in such process, a fact that highlights the importance of research in the stages of corn crop harvest as silage. The aim of this study was to evaluate the plant composition from several corn hybrids harvested as silage at Guarapuava PR.

**Material and methods** The experiment was developed at Animal Production Center (NUPRAN) of the Agricultural and Environmental Sciences Department from the Midwest State University (UNICENTRO) located in Guarapuava, PR. It was evaluated plant physical structure and dry matter from six different corn hybrids: SG 6030 YG, LG PRO 6036, PRO 6038 LG, BRAS 3010, PL 6880 and PL 1335. Whole plant samples (original material) of each treatment were obtained in a homogeneous and representative form, weighed and dried in a forced-drought oven at 55 °C. After 72 hours drying in forced-air oven, they were weighed again to determine dry matter (DM), according to AOAC (1984).
The experiment was conducted in a completely randomized design with four replications and six treatments: SG YG 6030, PRO LG 6036, LG 6038 PRO, BRAS 3010, PL 6880 and PL 1335. The collected data for each parameter were subjected to variance analysis with mean comparison at the significance level of 5% by Tukey test, through the SAS (1993).

**Results and discussion** Table 1 shows plant dry matter and plant components from six corn hybrids harvested as silage in Guarapuava PR. There were not significant differences ($P<0.05$) among hybrids for whole plant dry matter (DM) and plant structural components: stem, leaves and bracts and cob, with average values of 20.16%, 26.03% and 31.74%, respectively. For grains component were found differences ($P>0.05$) in dry matter. The hybrids LG PRO 6038 (58.47%), SG 6030 YG (59.31%), LG PRO 6036 (59.92%) and BRAS 3010 (63.12%) stood out, showing higher DM in grains, which makes them interesting for silage, because hybrids for this purpose need greater deposition of starch in the grain filling up stage, due to better "stay green" at plants harvest for silage or better starch deposition rate during grain filling up when compared with hybrids PL 6880 and PL 1335 with grain DM values of 55.87% and 54.47% respectively.

Oliveira (2010) found in his experiment also located in Guarapuava with corn hybrid AS-1545 values of dry matter for stem 23.7%, leaves 26.5%, bracts and cob 26.8%, grain 40% and whole plant 27.8%, showing that the hybrids studied in this work stood out, especially BRAS 3010 that obtained 23,12% more dry matter in grain than the hybrid AS-

1545, and this component is directly linked with silage quality, because as increases the share of grains increases the silage quality (Paziani et al, 2009).

**Table 1** Average levels of plant dry matter and botanical composition at 133 days after emergence of corn plants

| Hybrids | Dry matter content,% | | | | |
|---|---|---|---|---|---|
| | Component | | | | |
| | Stem | Leaf | Bracts/cob | Grain | Whole plant |
| LG 6038 PRO | 21.08 [a] | 25.89 [a] | 33.26 [a] | 58.47 [ab] | 33.75 [a] |
| LG 6036 PRO | 20.99 [a] | 24.14 [a] | 33.22 [a] | 59.92 [a] | 33.00 [a] |
| SG 6030 YG | 18.99 [a] | 26.08 [a] | 33.22 [a] | 59.31 [a] | 32.21 [a] |
| BRAS 3010 | 18.42 [a] | 26.23 [a] | 31.88 [a] | 63.12 [a] | 31.68 [a] |
| PL 6880 | 22.00 [a] | 25.66 [a] | 31.30 [a] | 55.87 [b] | 33.20 [a] |
| PL 1335 | 19.49 [a] | 28.16 [a] | 28.21 [a] | 54.47 [b] | 33.34 [a] |
| Average | 20.16 | 26.03 | 31.74 | 58.53 | 32.84 |
| P>F | 0.4864 | 0.6884 | 0.1673 | 0.0009 | 0.8060 |
| CV* | 14.35 | 12.60 | 8.80 | 3.79 | 6.96 |

Averages in the same column followed by different letters for each variable differ by Tukey test at 5%.
*CV: Coefficient of Variation

**Conclusion** The hybrids LG6038PRO (58.47%), SG6030YG (59.31), LG6036PRO (59.92%) and BRAS3010 (63.12%) had the highest values for grain dry matter, which implies in better silage quality, but for other components evaluated, leaves, stems, bracts and cob the hybrids did not differ statistically.

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# Plant´s physical structural components harvested as silage (*Zea mays* L.)

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**Introduction** The culture of election for silage is corn (Zea mays L.), for its superiority production per area, easy cultivation, high digestibility and energy concentration, always focusing in the corn hybrids choice to obtain the highest production as possible (Reinehr et al. 2012). According to Neumann et al (2002) due the lack of information as the agronomic conduct, production and quality of the materials offered by different companies, the choice of the hybrid for silage has been controversy, because beside the agronomic parameters, the portions of the plant fractions also influence the final quality of the silage. The aim of this study was to evaluate the plant´s physical structure, from corn hybrids growned at Guarapuava´s region PR.

**Material and methods** The experiment was developed at Animal Production Center (NUPRAN) of the Agricultural and Environmental Sciences Department from the Midwest State University UNICENTRO, located in Guarapuava, PR. Physical Structural components were evaluated from corn hybrids for silage: SG 6030 YG, LG PRO 6036, PRO 6038 LG, BRAS 3010, PL 6880 and PL 1335. Samples of the physical structural components from whole plant (original material) of each treatment were obtained in a homogeneous and representative form, weighed and dried in a forced-air oven at 55 °C. After 72 hours of drying in forced-air oven, they were weighed again to determine dry matter (DM), according to AOAC (1984). The design of the blocks was completely randomized with four replicates consisting of six treatments: SG 6030 YG, LG PRO 6036, PRO 6038 LG, BRAS 3010, PL 6880 and PL 1335. The collected data for each parameter were subjected to variance analysis with average comparison at the significance level of 5% by Tukey test, through the SAS (1993).

**Results and discussion** Table 01 shows the physical structure of the plant, and for the components as leaves, grains, and bracts and cob. Among the hybrids tested, it was not found statistic difference ($P>0.05$), with average values of 19.5%, 41.1% and 17.6 % respectively. The stem structure of the plant showed statistic difference ($P<0.05$) and hybrid PL6880 had the highest share 25.6%, when compared to hybrids LG PRO 6038, PRO 6036 LG, SG 6030 YG, BRAS 3010 and PL 1335 which had 21.9%, 21.2%, 20.1%, 20.0% and 22.2% respectively.
According to Beleze et al. (2003), based on the growth behavior of plants, that explain the changes in internal conditions of plant growth (plant composition and nutrients translocation) associated with the environment conditions (temperature, humidity, insolation and winds). Thus, the effect on the percentage of the plant dry matter can be explained by plant maturity changes, when happens nutrient transport between plant fractions. This fact explains that although the hybrid PL6880 had the greater amount of stem dry matter it had the lowest percentage of grain component in the plant, probably because the nutrients translocation in this hybrid was slower than in other corn hybrids.

**Table 1** Average levels of plant´s physical structural composition, % of dry matter (DM) on plant

| Hybrids | Components | | | |
|---|---|---|---|---|
| | Physical structural participation, % of DM on plant | | | |
| | Stem | Leaf | Bracts/Cob | Grain |
| LG 6038 PRO | 21.9 [b] | 19.1 [a] | 17.0 [a] | 42.1 [a] |
| LG 6036 PRO | 21.2 [b] | 21.3 [a] | 16.8 [a] | 40.7 [a] |
| SG 6030 YG | 20.1 [b] | 19.2 [a] | 16.1 [a] | 44.6 [a] |
| BRAS 3010 | 20.0 [b] | 19.9 [a] | 18.0 [a] | 42.0 [a] |
| PL 6880 | 25.6 [a] | 18.8 [a] | 20.3 [a] | 35.4 [a] |
| PL 1335 | 22.2 [b] | 18.5 [a] | 17.5 [a] | 41.8 [a] |
| Average | 21.8 | 19.5 | 17.6 | 41.1 |
| P>F | 0.0226 | 0.1656 | 0.2841 | 0.1530 |
| CV % | 9.73 | 7.69 | 13.91 | 10.77 |

Averages in the same columns followed by different letters for each variable differ by Tukey test at 5%.
CV: Coefficient of Variation.

**Conclusion** The average levels of plant´s physical structural composition, for the components leaves, grain, cobs and bracts did not differ significantly among the hybrids LG6038PRO, LG3036PRO, SG6030YG, BRAS 3010, PL6880, PL 1335, but the stem component of hybrid PL6880 stood out, probably because its lower rate of nutrients deposition when compared with other hybrids.

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**Production of green biomass and dry biomass of wheat cv. BRS Umbu subjected with two conservation systems and two levels of nitrogen fertilization**

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**Introduction** Although the use of winter cereal silage is unusual in Brazil, in regions where climatic instabilities occur during winter, there is an increasing use of these forages in comparison with corn and wheat is one of the more interesting because of its nutritional qualities (BUMBIERIS JR. et al., 2011). The objective is to demonstrate the results of green biomass production and dry matter of silage and hay produced with wheat cv. BRS Umbu dual purpose, evaluating two conservation systems and two levels of nitrogen fertilization.

**Materials and Methods** The project was conducted on the Center of Animal Production (NUPRAN) on the premises of the Department of Agricultural and Environmental Sciences of the Midwest University - UNICENTRO in Guarapuava - PR, located in the subtropical zone of Paraná. The climate according to Köppen classification is temperate altitude - Cfb (Subtropical humid mesothermal), with mild summers and mild winters with no dry season and severe frosts. The area of the experiment has a soil classified as Oxisol Typical. The sowing of wheat was made on May 13, 2011 with spacing of 17 cm sowing depth of 04 cm and seeding rate of 220 seeds / m². The planting fertilization was 400 kg $ha^{-1}$ of 08-30-20 formulation. The covering fertilization was done with urea (45-0-0). In the treatments with 120 kg $ha^{-1}$ nitrogen, coverage was performed in a single application 30 days after emergence. In the treatment with 180 kg $ha^{-1}$ nitrogen coverage was performed 30 and 60 days after emergence at rates of 120 kg $ha^{-1}$ and 60 kg $ha^{-1}$ respectively. The total experimental area was 312 $m^2$, and each plot had 9.75 $m^2$. The experiment design was a randomized block with 8 treatments and 4 repetitions. The cuts for silage and hay were carried out in stages of dormancy, flowering and mealy grain. After evaluation of green biomass, the material was dried in forced-air oven at a temperature of 55 ° C and evaluated after weight stabilization of the dry biomass. The results were submitted to analysis of variance and the averages were compared by Tukey test at 5% probability.

**Results and Discussion** In Table 1 is described the production of green and dry biomass weight of wheat cv. BRS umbu subjected to two systems of conservation, silage and hay, under two levels of nitrogen fertilization. Yield was higher ($P < 0.05$) of dry biomass in silage and hay in the mealy grain stage compared to silage conservation system in pre-flowering and pre-flowering hay. Similar result to that found by FLOSS et al (2003) with oat, where the dry matter yield ranged from 6900 kg $ha^{-1}$ at flowering to 11,400 kg $ha^{-1}$ at the stage of grain into stiff dough. It was also observed higher productivity ($P < 0.05$) of green biomass and dry biomass when the level of nitrogen applied was 180 kg ha$^{-1}$ compared to 120 kg ha$^{-1}$. The effects of additional nitrogen in wheat were obtained by Caviglia & Sadras (2001) ranging from 6350 kg ha$^{-1}$ in the absence of nitrogen, and 12420 kg ha$^{-1}$ with nitrogen.

**Table 1** Production of green biomass and dry biomass of wheat Cv. BRS Umbu subjected two preservation systems and two levels of nitrogen fertilization

| Conservation system | Fertilization levels | | |
|---|---|---|---|
| | 120 Kg.ha-$^{1}$ | 180 Kg.ha-$^{1}$ | |
| | Green Biomass Production, Kg.ha-$^{1}$ | | Average |
| Silage in pre-flowering stage | 23502 | 26856 | 25178 a |
| Silage in mealy grain stage | 19615 | 21678 | 20646 b |
| Haying in pre-flowering stage | 23542 | 27207 | 25374 a |
| Haying in mealy grain stage | 20695 | 23174 | 21934 b |
| Average | 21838 B | 24728 A | |
| | Dry Biomass Production, Kg.ha-$^{1}$ | | |
| Silage in pre-flowering stage | 4597 | 5020 | 4808 b |
| Silage in mealy grain stage | 9301 | 10284 | 9792 a |
| Haying in pre-flowering stage | 4741 | 5224 | 4982 b |
| Haying in mealy grain stage | 9637 | 10704 | 10171 a |
| Average | 7068 B | 7808 A | |

Averages followed by capital letters in the row differ by F test at 5%. Averages followed by lower case letters in the column differ by Tukey test at 5%

**Conclusions** The conservation system silage and hay in mealy grain stage with nitrogen level of 180 kg ha$^{-1}$ produced the highest biomass accumulation.

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# Composition of wheat plants cv. BRS Umbu subjected with two conservation systems and two levels of nitrogen fertilization

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**Introduction** The yield of silage winter cereals should be stimulated by maximizing the use of the land during winter to forage production as well as to reduce of the risk of lack of forages by bad weather, and minimize the competition areas by planting corn for silage in the summer, allowing the use of grain for marketing ensuring increased income (FONTANELI and FONTANELI, 2009). The objective of this experiment is demonstrate the results of the botanic composition of wheat plants cv. BRS Umbu dual purpose, subjected with two conservation systems and two levels of nitrogen fertilization.

**Materials and Methods:** The project was conducted on the Center of Animal Production (NUPRAN) of the Department of Agricultural and Environmental Sciences of the Midwest University - UNICENTRO in Guarapuava - PR, located in the subtropical zone of Paraná. The sowing of wheat was held on May 13, 2011 with spacing of 17 cm sowing depth of 04 cm and seeding rate of 220 seeds / m². The planting fertilization was 400 kg $ha^{-1}$ of 08-30-20 formulation. The covering fertilization was done with urea (45-0-0). In the treatments with 120 kg $ha^{-1}$ nitrogen, coverage was performed in a single application 30 days after emergence. In the treatment with 180 kg ha-1 nitrogen coverage was performed 30 and 60 days after emergence at rates of 120 kg $ha^{-1}$ and 60 kg $ha^{-1}$ respectively. The total experimental area was 312 $m^2$, and each plot had 9.75 $m^2$. The experiment design was a randomized block with 8 treatments and 4 repetitions. The cuts for silage and hay were carried out in stages of dormancy, flowering and mealy grain. After the cuts, the material was separated in stem, dried leaves, green leaves and sheath the material was dried in a forced air oven at a temperature of 55 ° C and evaluated after weight stabilization of the dry biomass. The results were submitted to analysis of variance and the averages were compared by Tukey test at 5% probability.

**Results and Discussion:** Table 1 describes the botanic composition of wheat plants cv. BRS Umbu subjected to two systems of conservation, silage and hay, under two levels of nitrogen fertilization. There was no significant differences ($p>0.05$) for the botanic components of the plant, except for the sheath. This could be explained, in agreement with Soares and Restle (2002) that evaluated the nitrogen fertilization, in despite of the benefic effects, can result in the prejudice for the grains, and, in consequence for the sheath.

**Table 1** Botanic Composition of wheat plants cv. BRS Umbu subjected with two conservation systems and two levels of nitrogen fertilization

| Conservation system | Fertilization levels 120 kg.ha$^{-1}$ | Fertilization levels 180 kg.ha$^{-1}$ | Average |
|---|---|---|---|
| | Stem in % Dry Matter | | |
| Silage in pre-flowering stage | 41.4 | 39.6 | 40.5 ab |
| Silage in mealy grain stage | 36.0 | 36.3 | 36.1 b |
| Haying in pre-flowering stage | 41.7 | 42.3 | 42.0 a |
| Haying in mealy grain stage | 40.8 | 44.0 | 42.3 a |
| Average | 39.9 A | 40.5 A | |
| | Dried leaves, in % Dry Matter | | |
| Silage in pre-flowering stage | 4.6 | 7.0 | 5.8 a |
| Silage in mealy grain stage | 4.3 | 4.5 | 4.3 a |
| Haying in pre-flowering stage | 4.1 | 5.3 | 4.7 a |
| Haying in mealy grain stage | 5.0 | 4.5 | 4.7 a |
| Average | 4.4 A | 5.3 A | |
| | Green leaves, in % Dry Matter | | |
| Silage in pre-flowering stage | 38.0 | 39.2 | 38.6 a |
| Silage in mealy grain stage | 11.8 | 11.8 | 11.7 b |
| Haying in pre-flowering stage | 37.0 | 37.2 | 37.1 a |
| Haying in mealy grain stage | 8.8 | 11.0 | 9.8 b |
| Average | 23.8 A | 24.7 A | |
| | Sheath in % Dry Matter | | |
| Silage in pre-flowering stage | 16.0 | 14,2 | 15.1 c |
| Silage in mealy grain stage | 47.5 | 47.5 | 47.5 a |
| Haying in pre-flowering stage | 17.2 | 15.2 | 16.2 c |
| Haying in mealy grain stage | 45.5 | 40.5 | 43.0 b |
| Average | 31.5 A | 29.3 B | |

Averages followed by capital letters in the row differ by F test at 5%.
Averages followed by lower case letters in the column differ by Tukey test at 5%

**Conclusion:** There were no significant differences in the botanic composition of wheat plants with except for the sheath at different levels of nitrogen fertilization.

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# *In vitro* gas production of the corn silages inoculated with microbial additives

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**Introduction** Microbial additives containing homofermentative lactic acid bacteria ($^{ho}$LAB) such as *Lactobacillus plantarum* are used to rapidly decrease the pH of forage during ensilage, thereby avoiding undesired fermentation. However, corn plants have a high content of water soluble carbohydrates (WSC), which are fermented by the natural LAB, resulting in lactic acid (LA). The WSC and LA are consumed by yeast and mold in the post-opening of silos, raising the silage pH and resulting in aerobic deterioration, which reduces the silage quality. Therefore, inoculants containing heterofermentative LAB (he LAB), such as *L. buchneri* are used to improve the aerobic stability of the silage by producing high levels of acetic acid. It has been suggested that other types of inoculants, such as propionic acid bacteria and *Bacillus* species, can be used as microbiological additives to overcome the problem of silage aerobic spoilage. Moreover, some strains of LAB and *Bacillus* ssp. can produce ferulate esterase enzyme (FAE), which may increase the susceptibility of plant cell walls to enzymatic hydrolysis because ferulic acid is released from cell wall arabinoxylans (Donaghy et al., 1998; Nsereko et al., 2008). Thus, the purpose of this study was to evaluate the effects of microbial additives on the *in vitro* gas production of corn silage.

**Material and Methods** An AG1051 corn hybrid was harvested, chopped and the following treatments were applied to the fresh forages: untreated (**control**), *L. buchneri* NCIMB 40788 (**LB**), *B. subtilis* AT553098 (**BS**), *Propionibacterium acidipropionici* MA26/4U (**PA**), *L. plantarum* MA18/5U (**LP** - 1 x $10^5$ cfu/ g), and the combinations *L. buchneri* and *L. plantarum* (**LBLP**), *B. subtilis* and *L. plantarum* (**BSLP**) and *P. acidicipropionici* and *L. plantarum* (**PALP**). All inoculants were applied at a rate of 1 x $10^5$ cfu/ g. Inoculants were diluted in water (5 mL/kg of fresh forage) and applied by spraying with a constant mixing. The control silage received a similar amount of water. An amount of chopped forage from each treatment was packed into 7L plastic bucket silos in quadruplicate; these silos were sealed with a lid and adhesive tape, stored at room temperature and remained closed for 96 d. Thus, the *in vitro* gas production was performed. Dry samples (200 mg) were incubated in a water bath at 39°C in serum bottles (115 mL) with 30 mL buffered rumen fluid (Menke et al., 1979). Rumen fluid was collected from 2 rumen-cannulated steers fed 60% corn silage without inoculant and 40% concentrate (on DM basis), in the morning before feeding. The accumulated headspace gas pressure measurements were made using a needle attached to a pressure transducer connected to a visual display. Readings were taken 2, 4, 6, 8, 10, 12, 24, 48 and 72 h post-inoculation. Flasks containing buffered rumen fluid without samples were used as blanks. However, the blank correction was omitted according to Cone et al. (1997). The relative gas production was calculated by dividing the gas production at a given time by the gas production at 72 h. Data were analyzed using a completely randomized design with 4 replicates and as a mixed model using the MIXED procedure of SAS (v. 9.0). Differences between the means were determined using DIFF (level of significance 5%).

**Results and Discussion** Silages containing LP had higher gas production volumes and faster relative rates of gas production than the control silage until 24 h (Table 1). In silages containing LP, we observed that 50% of the total of gas production (72 h) occurred between 10 and 12 h. The FAE breaks the ester linkage between ferulic acid and the attached carbohydrate, releasing ferulic acid from the cell walls of the plant, which leaves the remainder of the polysaccharide chain open for further hydrolysis by other cell wall degrading enzymes (Yu et al., 2005). This could increase the digestibility of silage or gas production volumes as we found in the present study.

**Table 1** *In vitro* gas production and relative *in vitro* gas production of the corn silages inoculated with microbial additives for incubation times (IT).

| IT (h) | *In vitro* gas production (mL/ g DM) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | LB | BS | PA | LP | LBLP | BSLP | PALP | *P value* | SEM[1] |
| 2 | 67.9$^{c}$ | 75.5$^{bc}$ | 73.6$^{cb}$ | 76.5$^{ab}$ | 86.2$^{a}$ | 78.7$^{ab}$ | 80.1$^{ab}$ | 78.8$^{ab}$ | 0.006 | 2.702 |
| 4 | 97.7$^{c}$ | 106.6$^{bc}$ | 106.6$^{bc}$ | 107.7$^{b}$ | 117.6$^{a}$ | 109.3$^{ab}$ | 115.1$^{ab}$ | 111.5$^{ab}$ | 0.008 | 3.183 |
| 6 | 125.9$^{c}$ | 140.4$^{b}$ | 140.4$^{b}$ | 138.4$^{b}$ | 154.2$^{a}$ | 151.4$^{a}$ | 152.3$^{a}$ | 145.5$^{b}$ | 0.003 | 3.753 |
| 8 | 146.7$^{d}$ | 158.0$^{bcd}$ | 160.3$^{bc}$ | 156.8$^{cd}$ | 170.5$^{a}$ | 166.6$^{ab}$ | 169.9$^{ab}$ | 163.1$^{abc}$ | 0.008 | 4.162 |
| 10 | 162.3$^{c}$ | 177.2$^{ab}$ | 179.8$^{ab}$ | 173.7$^{cb}$ | 188.9$^{a}$ | 182.9$^{ab}$ | 189.5$^{a}$ | 180.8$^{ab}$ | 0.005 | 4.414 |
| 12 | 178.9$^{c}$ | 194.7$^{ab}$ | 195.4$^{ab}$ | 190.0$^{bc}$ | 205.2$^{a}$ | 192.3$^{b}$ | 204.9$^{a}$ | 197.4$^{ab}$ | 0.008 | 4.401 |
| 24 | 254.9$^{c}$ | 277.8$^{ab}$ | 277.9$^{ab}$ | 272.3$^{b}$ | 284.6$^{ab}$ | 274.6$^{ab}$ | 290.1$^{a}$ | 277.1$^{ab}$ | 0.013 | 5.648 |
| 48 | 336.4 | 352.5 | 359.6 | 349.2 | 347.1 | 346.3 | 351.1 | 329.3 | 0.846 | 3.456 |
| 72 | 380.7 | 396.0 | 411.5 | 396.5 | 409.7 | 388.5 | 398.3 | 377.9 | 0.852 | 7.540 |
| | Relative *in vitro* gas production | | | | | | | | | |
| 2 | 0.178$^{c}$ | 0.191$^{bc}$ | 0.180$^{c}$ | 0.193$^{bc}$ | 0.211$^{a}$ | 0.203$^{ab}$ | 0.201$^{ab}$ | 0.209$^{a}$ | 0.001 | 0.005 |
| 4 | 0.257$^{c}$ | 0.269$^{bc}$ | 0.260$^{c}$ | 0.272$^{bc}$ | 0.287$^{ab}$ | 0.282$^{ab}$ | 0.289$^{ab}$ | 0.295$^{a}$ | 0.006 | 0.007 |
| 6 | 0.331$^{c}$ | 0.354$^{bc}$ | 0.342$^{c}$ | 0.349$^{c}$ | 0.377$^{ab}$ | 0.390$^{a}$ | 0.382$^{a}$ | 0.384$^{a}$ | 0.001 | 0.008 |
| 8 | 0.385$^{c}$ | 0.399$^{bc}$ | 0.391$^{bc}$ | 0.396$^{bc}$ | 0.416$^{ab}$ | 0.428$^{a}$ | 0.426$^{a}$ | 0.432$^{a}$ | 0.004 | 0.009 |
| 10 | 0.426$^{d}$ | 0.447$^{bcd}$ | 0.439$^{cd}$ | 0.439$^{cd}$ | 0.461$^{abc}$ | 0.471$^{ab}$ | 0.476$^{ab}$ | 0.478$^{a}$ | 0.005 | 0.010 |
| 12 | 0.470$^{d}$ | 0.492$^{bcd}$ | 0.477$^{cd}$ | 0.480$^{bcd}$ | 0.501$^{abc}$ | 0.495$^{bcd}$ | 0.514$^{ab}$ | 0.522$^{a}$ | 0.014 | 0.010 |
| 24 | 0.700$^{b}$ | 0.702$^{ab}$ | 0.679$^{b}$ | 0.687$^{b}$ | 0.695$^{ab}$ | 0.707$^{ab}$ | 0.728$^{a}$ | 0.734$^{a}$ | 0.034 | 0.014 |
| 48 | 0.883 | 0.890 | 0.879 | 0.881 | 0.848 | 0.892 | 0.883 | 0.872$^{a}$ | 0.707 | 0.017 |

[*]Means follows of the same letter did not differ to 5% of significance. Silages - Control: without inoculant; LB: *L. buchneri*; BS: *B.subtilis*; PA: *P. acidipropionici*; LP: *L. plantarum*; LBLP: *L. buchneri* and *L. plantarum*; BSLP: *B. subtilis* and *L. plantarum*, PALP: *P. acidipropionici* and *L. plantarum*. [1]SEM: Standard error of the mean for the incubation time.

**Conclusion** The microbial inoculation changed the *in vitro* gas production of the corn silages.

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# *In vitro* ruminal fermentation, gas production and true digestibility of the corn silages inoculated with microbial additives

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**Introduction** Homofermentative lactic acid bacteria ($^{ho}$LAB) are used to rapidly decrease the pH of forage during ensilage, thereby avoiding undesired fermentation. Inoculants containing heterofermentative LAB, such as *Lactobacillus buchneri*, or *Bacillus* species are used to improve the aerobic stability of the silage. Moreover, some strains of LAB and *Bacillus* ssp. can produce ferulate esterase enzyme, which may increase the susceptibility of plant cell walls to enzymatic hydrolysis (Nsereko et al., 2008; Donaghy et al., 1998). Furthermore, *in vitro* cumulative gas production techniques were developed to predict fermentations of ruminant feedstuffs (Rymer et al., 2005). Thus, the purpose of this study was to evaluate the effects of microbial additives on the *in vitro* ruminal fermentation, gas production and true digestibility of the corn silages.

**Material and Methods** During three consecutive years (2010, 2011 and 2012) microbial additives were evaluated in corn silage in farm silos, which remained closed for 165, 70 and 88 d, respectively. The corn hybrid studied were Maximus (Syngenta), 2B688Hx (Dow AgroSciences) and Impacto Víptera (Syngenta). The whole corn plants were harvested, chopped and the following treatments were applied: *2010* - untreated (control 1), *L. buchneri* "NCIMB 40788" (LB 1), and the combinations *L. buchneri* and *L. plantarum* "MA18/5U" (LBLP 1); *2011* - untreated (control 2) and *L. buchneri* "NCIMB 40788" (LB 2) and; *2012* - untreated (control 3), the combinations *L. buchneri* "CNCM I-4323" and *L. plantarum* "MA18/5U" (LBLP 2) and *B. subtilis* "AT553098" and *L. plantarum* "MA18/5U" (BSLP). All inoculants were applied at a rate of 1 x $10^5$ cfu/ g. Inoculants were diluted in water and applied by spraying with a constant mixing. Samples were collected during feedout, taken to oven (55°C for 72h), processed in order to pass through 1 mm screen sieves and weighed (0.5g) into filter bags (F57, ANKON). The bags were heat-sealed, placed into 115 ml vials (duplicate for sample) and incubated with 60 ml of anaerobic buffered rumen fluid (Menke et al., 1979). The vials were sealed and incubated at 39°C in a water bath for 24 h. Rumen fluid was collected from 2 rumen-cannulated wethers fed 60% corn silage without inoculant and 40% concentrate (on DM basis), in the morning before feeding. Head space gas production (GP) was measured at 3, 6, 12 and 24 h post inoculation. Flasks containing buffered rumen fluid without samples were used as blanks. At 24 h, vials were removed from the water bath, placed on ice. The serum bottles were opened, samples were collected to measure pH values and volatile fatty acids (VFA). The bags were washed until excess water ran clear. Neutral detergent fiber (NDF) was determined according to Van Soest et al. (1991) using thermostable α-amylase in the Ankom 2000 Fiber Analyzer (Ankom Tecnologies) to determine the *in vitro* true dry matter digestibility (IVDMD). Data were analyzed using a completely randomized design with 6 replicates and as mixed model using the MIXED procedure of SAS (v. 9.0). Differences between the means were determined using DIFF (level of significance 5%).

**Results and Discussion** During the years the parameters response to microbial inoculants was different. On 2010, LB silage had the highest GP and, the highest total VFA was produced from LB and LBLP silages incubation**.** On the other hand, on 2011 a greater total VFA was produced from control silage. Ever on 2012, the control silage presented the highest IVDMD. Aside years, hybrids and strains studied, factors that may have contributed to the different effects include differences in epiphytic bacterial population, water activity, water soluble carbohydrate content and cell wall component concentrations (McDonald et al., 1991).

**Table 1.** *In vitro* gas production (GP), true dry matter digestibility (IVDMD) and ruminal fermentation of the corn silages inoculated with microbial additives in different years.

| Treatments | Variables[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP | IVDMD | pH | AA | PA | AAPA | BA | Others VFA | Total VFA |
| | | | | | 2010 | | | | |
| Control 1 | 153.70[b] | 47.90 | 6.67 | 35.80 | 13.60[b] | 2.66[a] | 2.60[b] | 10.61[b] | 73.18[b] |
| LB 1 | 164.00[a] | 49.14 | 6.64 | 40.83 | 15.50[a] | 2.65[a] | 3.66[a] | 12.63[a] | 85.21[a] |
| LBLP 1 | 155.90[b] | 48.40 | 6.66 | 40.50 | 15.83[a] | 2.56[b] | 4.00[a] | 11.71[a] | 83.48[a] |
| SEM[2] | 2.19 | 0.89 | 0.01 | 1.47 | 0.57 | 0.02 | 0.22 | 0.49 | 3.04 |
| P value | 0.01 | 0.35 | 0.26 | 0.05 | 0.04 | 0.01 | 0.01 | 0.03 | 0.03 |
| | | | | | 2011 | | | | |
| Control 2 | 196.80 | 60.02 | 6.57 | 41.33 | 17.83 | 2.35 | 3.83 | 12.45 | 77.77 |
| LB 2 | 194.20 | 61.87 | 6.58 | 36.66 | 15.11 | 2.42 | 3.16 | 10.42 | 67.77 |
| SEM | 4.15 | 0.70 | 0.01 | 0.71 | 0.29 | 0.02 | 0.31 | 0.54 | 1.34 |
| P value | 0.67 | 0.09 | 0.75 | 0.01 | 0.01 | 0.04 | 0.16 | 0.23 | 0.01 |
| | | | | | 2012 | | | | |
| Control 3 | 210.95 | 67.43[a] | 6.53 | 37.16 | 17.00 | 2.20 | 3.83 | 11.51[ab] | 69.51[a] |
| LBLP 2 | 199.00 | 60.88[b] | 6.58 | 37.00 | 15.50 | 2.40 | 3.40 | 13.26[a] | 69.16[a] |
| BSLP | 211.38 | 62.62[b] | 6.55 | 34.00 | 15.20 | 2.25 | 3.83 | 10.05[b] | 63.05[b] |
| SEM | 4.90 | 0.64 | 0.02 | 1.02 | 0.62 | 0.06 | 0.18 | 0.59 | 1.89 |
| P value | 0.16 | 0.01 | 0.28 | 0.08 | 0.12 | 0.05 | 0.17 | 0.01 | 0.04 |

[*]Means follows of the same letter did not differ to 5% of significance.[1]GP - mL/g; IVDMD - %DM; AA: acetate – mmol/g; PA: propionate – mmol/g; AA:PA: acetate to propionate ratio; BA: butyrate – mmol/g; Others VFA: sum of valerate, isovalerate and isobutyrate – mmol/g; Total VFA: Total of volatile fatty acids – mmol/g. [2]SEM: Standard error of the mean.

**Conclusion** The microbial inoculation changed the *in vitro* ruminal fermentation, gas production and true digestibility of the corn silages, depending on year, hybrid and strain studied.

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**Effect of pruning of sabiá (*mimosa caesalpiniifolia* benth.) in different seasons on production and chemical composition of DM**

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**Introduction** The Northeast Region of Brazil covers an area of 1,561,177.80 km$^2$, 75% of which are classified as semi-arid(IBGE, 1999). The predominant vegetation is Caatinga, which is characterized by xerophytic species that are usually deciduous. With a considerable production of DM, but constantly confronted with the dry season, causing severe reduction in available forage and also with the conservation of these species forage in the period of greatest availability (rainy season) is indispensable. With this, sabiá can represent up to 70% forage consumed by ruminants (Mendes, 1989). Introducing chemical composition from the aerial part into hay or green foliage of: DM 35 to 96%, CP 7 to 20%, NDF 44 to 56% and ADF 24 a 31%. Being that,the proper management can provide better utilization for breeding responding to low pruning (0.4 m), medium pruning (0.8 m) and high pruning (1.2 m above the ground). We had as objective analyze the forage production from the annual pruning of twigs with leaves from sabiá, in the months of March or June, and the effect of the chemical composition.

**Material and Methods** A study in Nova Olinda/CE, Olho D'Agua de Santa Barbara Farm (7° 8'13"S and 39°38'42"W), between March 2005 and June 2006, in the woods sparse (187 plants ha$^{-1}$) of sabiá. The area is a result of germination and regrowth of a native sabiá after sowing *Andropogon gayanus* and grazing by cattle and goats. We collected data from annual production of green matter of the sabiá from the pruning of branches and leafy diameter ≤ 10 mm. Annual pruning was done in full vegetation period (March) and at the end of the vegetation period (June) in 2005 and 2006. The material collected from each tree was weighed, crushed, homogenized and sampled (250 to 1000 g). The fresh samples were dried in the sun for three days, and in oven with air circulation (65 ± 2º C) for 24 h, for later determination of DM, CP, NDF and ADF. Each tree was considered as the sampling unit and was used a randomized complete block design with two replications (trees) per treatment in each of the three blocks. Treatments (cutting times) consisted of control (T1), where the tree has not suffered the annual pruning of its branches, the annual pruning in March (T2) or June (T3). They were subdivided in time (2005 and 2006). For comparison of means we used Tukey test at 5%, when necessary.

**Results and Discussion** The average production of DM of sabiá hay showed interaction between mowing season x year ($P<0.01$), (Table 1). There was a reduction in forage production between the first and second year when the cut was made in March ($P<0.01$), while the regrowth tended to increase forage production in relation to the first cut when held in June ($P>0.05$) (Table 1). The average production of DM between the first collection in March 2005 and cut the sprouts one year after decreased ($P<0.01$), 76.31%, showing significant stress on plants pruned in March,while pruning in June there was a non-significative increase on the mean of 13.46% from one year to another. Probably, the nutrient reserves were exhausted in March, and they had already recovered in June, so that the cut later in the rainy season favored regrowth (Carvalho et al. 1998). Another explanation refers to the largest expense reserves by plants pruned in March, which re grew leaves thirty days after the pruning and had no time to replenish reserves before the end of the rainy season. This regrowth faded naturally senescent and re-vegetate only in the following year after the start of the rainy season. The plants pruned in June had almost completed its cycle and reset their reserves, then went to sleep and waited for the next rainy period. Decreases in forage production between annual pruning done in April or June, were observed in jurema preta (*Mimosa tenuiflora* (Willd.) Poiret), more expressive when held in April (Bakke, 2005), and therefore, showing that jurema preta is more sensitive to cutting than sabiá. The CP contents were affected (P<0.01), by harvest time (Table 2). We observed that the average CP in the forage were higher in the collected of March (16.09%) and 2006 (15.68%) (P<0.01). Results similar to Pereira et al. (1999), working with sabiá hay (leaves and tender stems cut in the pre-flowering stage) which had CP values of 16.78, 18.23 and 19.28%, respectively. The NDF were affected (P<0.01) by harvest time (Table 2). Being lower in June (P<0.01), which was expected, given the more advanced vegetative stage. Additional studies should be conducted in the attempt to explain why forages in the vegetative stage advances content NDF. The ADF contents were affected by the interaction between mowing season x year (P<0.05) (Table 2) and decreased significantly (P<0.05), between March 2005 and March 2006 (63.20% x 58.16%) and showed anot significant inverse trend (P>0.05) between June 2005 and June 2006 (46.51% x 49.30%). Vasconcelos et al. (1997) studied the chemical characterization of hay forage in the Brazilian semi-arid and dry rainy season, found for the ADF (31.00 and 24.00%) respectively, lower than the values obtained in this study, since the aforementioned author worked with the material obtained from the leaf fraction, without the presence of thin branches, they confirm in part the results of this study, as the level of ADF decreased from March (rainy season) and June (dry season) in the years 2005 and 2006.

**Table 1** - Production of DM (kg tree) of Sabiá Hay in Different Seasons Cut

| **Cut Season** | 2005 | 2006 |
|---|---|---|
| T2 - Pruning - March | 15.33A | 3.63B |
| T3 - Pruning - June | 11.08A | 12.57A |

**Table 2 –** CP, NDF and ADF of Sabiá hay in Different Seasons Cut

| Cut Season | 2005 | 2006 | Average |
|---|---|---|---|
| | CP | | |
| T2 - Pruning - March | 14.66 | 17.52 | 16.09 A |
| T3 - Pruning - June | 13.07 | 13.85 | 13.46 B |
| | NDF | | |
| T2 - Pruning - March | 77.44 | 76.74 | 77.09 A |
| T3 - Pruning - June | 65.43 | 67.13 | 66.28 B |
| | ADF | | |
| T2 - Pruning - March | 63.20 a | 58.16 b | 60.68 A |
| T3 - Pruning - June | 46.51 a | 49.30 a | 47.90 B |

**Conclusions** - The pruning of the branches of sabiá for hay production in consecutive years should be held in June to ensure greater DM production.

**Evaluation of biological forage dehydration accelerator (Bacillus amyloliquefaciens H-57) on alfalfa hay**

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**Introduction** Biological forage dehydration accelerator (*Bacillus amyloliquefaciens*) produces an action on the crop by bacteria that produce protease (subtilisin), acting on high molecular weight proteins, from an intermediate product that generates a triad forming an imidazole group. This protease action generates the rupture of cell walls, making the release of water retained in the cell faster. On stored hay, the product of these bacteria generates an action that changes the permeability of membranes of the fungi, which produce a fungicide action. In the trial we evaluated the effect of the product on the drying rate of the mowed alfalfa, the storage period and the hay quality 40 days after the large square bales (LSB) were made. LSB were made with hay, with moisture levels above the recommended moisture (between 25 and 28% moisture) for alfalfa hay.

**Materials and Methods** We designed, on alfalfa pasture, 6 plots of 5 hectares (ha) each, distributed in a completely randomized design, 3 plots without additives (control) and 3 plots with additives. Additive treatment consisted of the application of 20 g/tonne (as feed) of HenoSilo ® (*Bacillus amyloliquefaciens* H-57) before mowing. Each plot was sampled every 4 hours during the day (from 0800 to 2000 h) to determine the rate of dehydration until the moisture level was approximately 25%.

When moisture reached 25 to 28%, we prepared four LSB of approximately 500 kg for each treatment, these LSB the temperature was monitored over the 40 days of storage, at this moment temperature was stabilized. At the end of the stabilization period (40 days after the making), samples were taken from each LSB for laboratory analysis by wet chemistry. All laboratory variables obtained were considered as dependents, taking control and additive treatment as classification variables, considering the dry matter (%DM) as covariate. Statistics were carried out in Infostat 2011 using ANOVA considering of time effects, using time-sequence analysis.

**Results and discussion** The results obtained by field determinations showed that additive treatment resulted in faster rate of dehydration, reaching the moisture (25%) to make the LSB 24 hours before the control treatment. In this trial we observed the major difference in the rate of dehydration until 10 hours from mowing (HFM). Average final values demonstrate that additive treatment, achieves a higher rate until 77 HFM dehydration, 6.5% higher.

The temperature dynamics showed significant differences between treatment at 124, 171.5 and 290.5 hours made. The highest temperature value for the control was found at 290.5 hours, being 84.57°C, for additive treatment, the highest temperature reached at 264 hours being 54.9 °C.

There are significant differences ($p<0.05$) between treatments in variables such as, Acid detergent fiber (ADF) and Acid detergent insoluble nitrogen (ADIN). This shows that the quality could be suitably maintained in hay made with higher moisture content to the optimum, considering that the ADF for additive treatment is 55.8% lower than the control. ADIN, was 3.16 times higher in the control, maintains consistency with the results of the dynamic temperature of the bales. Crude Protein (%), Ash (%) and Neutral Detergent Fiber (NDF%), does not pose significant differences between treatments.

**Table 1** Dehydration rate % Moisture / Hour

| | Treatments | | |
|---|---|---|---|
| HFM | Control | Additive | p-values |
| 6 | 0.77 | 1.54 | .0480 |
| 10 | 0.75 | 1.24 | .0297 |
| 52 | 0.97 | 1.01 | .5034 |
| 77 | 0.76 | 0.81 | .0270 |

**Table 2** Quality LSB by treatment 40 days after making.

| | Treatment | | |
|---|---|---|---|
| Item | Control | Additive | p-values |
| CP% | 26.73 | 26.39 | .9452 |
| NDF% | 48.42 | 42.93 | .0641 |
| ADF% | 37.41 | 24.01 | .0316 |
| ADIN % | 2.37 | 0.75 | .0483 |
| Ash % | 11.47 | 11.13 | .7217 |

**Conclusions** We observed a higher rate of dehydration in pasture with additive treatment, with the greatest difference at 6 hours mowed. The LSB under additive treatment reached maximum values of temperature increase 54% lower than the control. Also, in the treated LSB the final quality was better than the control, this shows the ADF % (-13.4 percentage points) and the ADIN % (-1.62 percentage points).

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**Evaluation of inoculated corn silage in primiparous Holstein cow milk production**

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**Introduction** Improvement in dairy food resources leads to achieving more efficient production with the need to get more responses with the same amount of food, thus the seeking of helpful technologies. A trial was performed to assess the level of milk production (MP) and individual dry matter intake (DMI) of primiparous Holsteins cows fed corn silage treated with enzyme-bacterial homofermentative inoculant (EBHoI) in partially mixed ration.

**Materials and Methods** We employed 28 Holstein primiparous cows in 4 homogeneous herds (2 herds in each treatment) with 7 cows each**.** The animals were fed with isoenergetic and isoproteic PMR (Partial Mix Ration), changing only the corn silo between treatments**.** Each PMR was formulated, on dry basis, with: 6.50 Kg corn silage (inoculated with EBHoI LactoSilo ® and non inoculated), 1.70 kg rye grass silage, 2.00 kg soybean expeller, 2.00 kg soybean meal, 0.80 kg corn grain, 3.20 kg wheat middlings, 2.80 kg commercial feed, 1.00 kg whey permeate, 0.07 kg urea and 0.40 kg vitamin-mineral complex.

The measurements were made by milk production (MP) controls in the 2 milking per day by herd, every 20 days. PMR consumption was determined on the day prior to each production control. Milk production was analyzed as 4% fat-corrected milk (FCM; Gaines and Davidson, 1923). Additional information was conversion efficiency and body condition score.
Statistics were carried out in Infostat 2011 using ANOVA considering of time effects, using time-sequence analysis.

**Results and Discussion** Table 1 shows the response variables analyzed for this study, the MP day values 5.4% higher for inoculated treatment than the control and the corrected for 4%FCM showed 5% higher for the inoculated treatment, this difference was significant ($p < 0.10$). These data are consistent compared to that reported by Moran and Owen (1994), who showed in 14 studies of lactating cows, that the inoculant (*L. plantarum*) increased dry matter intake by 4.8%, and milk production was increased 4.6% when the inoculant was applied to pasture grasses, corn or alfalfa.

**Table 1** Average milk production and consumption by treatment

| | Treatment | | |
|---|---|---|---|
| Item | Inoculated | Control | p-values |
| Milk production per day, L cow$^{-1}$ | 28.42 | 26.96 | .1642 |
| Milk production per day 4%FCM, L cow$^{-1}$ | 25.27 | 24.06 | .0833 |
| Individual intake, Kg DM day$^{-1}$ | 17.27 | 17.18 | .9401 |

There were no statistically significant differences ($p > 0.10$) in the PMR intake, being 17.27 kg DM day$^{-1}$ and 17.18 kg DM day$^{-1}$ (+0.52%) for inoculated treatment and control respectively. The conversion efficiency to 4% FCM (liters of milk by kg PMR), was better in the inoculated treatment, 1.46 L of milk by kg of PMR and the control was 1.40 L of milk by kg of

PMR. The body condition score (BCS), at the beginning was in the average values of 3.50 and 3.59 BCS for the inoculated treatment and control respectively. At the end of the trial, the values were 3.37 BCS for the inoculated treatment and 3.21 BCS for the Control.

**Conclusions:** The inoculated treatment was 5.4% and 5% higher in MP and 4% fat-corrected milk respectively. Similar results were obtained by Kung and Muck (1997) with a 3% increase in MP (Contreras-Govea et al., 2009). PMR intake was 0.52% higher for the inoculated treatment, not significant. Kung and Muck (1997) showed that in a total of 67 studies, 19 had increased intake response. The conversion efficiency to 4% FCM (liters of milk by kg PMR), was better in the inoculated treatment (+4.2%).

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**Evaluation of inoculated sorghum silage in Holstein heifer weight gain**

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**Introduction** The use of silage additives is recommended to preserve the nutritional value of the crop when certain circumstances could compromise proper fermentation. The enzyme-bacterial homofermentative inoculants (EBHoI) are a type of silage additives available, and they have been classified as stimulators of fermentation. For forage sorghums, a high relationship plant status / panicle, the dry matter concentration (% DM) of the whole plant is low, making that the fermentation requires higher concentration of lactic acid for proper pH decrease. The EBHoI had better fermentation and conservation of the silage. When this silage is used in heifer diets it could improve the animal performance. A trail was performed to assess the body weight (BW) gain and dry matter intake (DMI) in Holstein heifers using sorghum silage treated with enzyme-bacterial homofermentative inoculant (EBHoI) in total mixed ration (TMR).

**Materials and Methods** Sixty Holstein heifers were used, they were about 220 kg initial live weight and average 11 months old. Each treatment was divided into 3 groups of 10 animals each. The experimental period lasted 40 days. The TMR was composed (DM based) 72% of sorghum silage (inoculated and non inoculated), 11.5% soybean meal, 15.7% corn grain, 0.189% urea. TMR was formulated with same ingredients and amounts, giving isoproteic and isoenergetic characteristics for both treatments. The inoculated treatment consisted of TMR with forage sorghum silage inoculated with LactoSilo ® and Control, forage sorghum silage TMR non-inoculated. Measurements were made every 13 days, weighing the entire group for each repetition. TMR consumption was determined on days weighing for each group too. Statistics were carried out in Infostat 2011 using ANOVA considering of time effects, using time-sequence analysis.

**Results and Discussion** Also, Kung and Muck (1997) concluded that homofermentative bacteria reduce the loss of DM to the minimum level (2-3%), getting the pH down, decreasing proteolysis and the ammonia training, the lactic acid increase and the digestibility too. (Contreras-Govea et al., 2009). The values measured in the groups, the number of affected animals and testing days to generate the data are shown in Table 1.

**Table 1** BW increase and consumption

| | **Treatment** | | |
|---|---|---|---|
| Item | Control | Inoculated | p-values |
| Final BW, kg animal$^{-1}$ | 272.68 | 280.15 | .0001 |
| BW gain, kg day$^{-1}$ | 0.630 | 0.730 | .0354 |
| DM intake, kg DM day$^{-1}$ | 7.37 | 7.49 | .0013 |
| Conversion efficiency, kgDM/kgBW$^{-1}$ | 12.03 | 10.65 | .1135 |

Initial BW was 248.33 Kg animal$^{-1}$ for the Control and 252.00 Kg animal$^{-1}$ for the inoculated treatment, were used like covariate for statistical analysis. The increase in daily individual BW in the inoculated treatment animals showed 15.8% higher than control, and this difference is significant. The initial weigh showed a difference between the weight of lots of treatment and control, the initial difference was of 3.67 kg animal$^{-1}$ and this was taken like covariate. In the end of this test, the difference was 7.5 Kg animal$^{-1}$.

There was a statistically significant difference in the consumption of TMR, being 1.62% more for inoculated treatment. The conversion efficiency of KgDM kgBW$^{-1}$, has better efficiency by inoculated treatment, requiring 1.38 KgDM kgBW$^{-1}$ less than the control, also this difference is not significant. A review of research studies by Kung and Muck (1997) reported that the inoculants improve weight gain in beef cattle and milk production of lactating cows in 50% of the studies (Contreras-Govea, 2009)

**Conclusions** Better weight gain was showed for treatment, about 15.8%. Kung and Muck (1997) concluded that when the silage was inoculated it had a positive effect, the average increase in expected weight gain was 5%, while milk production increased 3% (Contreras-Govea, 2009).

Kung (2007) reported that after the review of 14 works published in the United States corn silage inoculated with EBHoI, only 3 showed increases in animal performance. Moreover, of 15 studies analyzed by Kung and Muck (1997), 8 were positive in respect to higher weight gains from the use of inoculated silage.

Consumption was 2.6% higher for the inoculated treatment, Kung and Muck (1997) showed that in a total of 67 studies, 19 had increased intake response.

Although, the control needed 12.9% Kg DM more than the inoculated treatment to produce one Kg BW, also this difference is not significant.

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# Effects of wilting and addition of microbial additive and common salt on fermentation profile, dry matter losses and aerobic stability of elephant grass silages

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**Introduction** The use of supplementary forage on dry season is essential to achieving greater productivity, being one of the options the use of tropical grass silages, such as elephant grass (*Pennisetum purpureum* Schum.). Recently introduced in Brazil the elephant grass Paraiso is an inter-specific hybrid resulted of crossing of elephant grass with millet [*Pennisetum glaucum* (L.) R.Br.], being propagated by seeds, which facilitates its establishment. Due to the low content of dry matter (DM), ensilage of elephant grass requires wilting or microbial additives to improve the fermentation process. However, some farmers from the northwest region of the São Paulo state have used common salt (NaCl) as additive, with obtaining elephant grass silages with good appearance and animal feed intake, although research findings suggest that the use of this additive does not promote improvements in the quality of the silage. The objective of this study was to evaluate the effects of wilting and addition of microbial inoculant and common salt on elephant grass ensilage.

**Materials and Methods** This study was conducted at Nossa Senhora Aparecida farm in Andradina (20°53'46"S and 51º22'46"W), situated in Northwest of the São Paulo state, at an average altitude of 405 m. The elephant grass cultivars Napier and Roxo and the elephant grass Paraíso were cut with 12 weeks of growth, in June 2010. After harvesting, the material was exposed to sunlight for about 6 hours to wilting. The chopped material was subjected to treatments: control, application of microbial additive and adding common salt (NaCl) at doses of 0.5, 1.0 and 1.5% (fresh matter basis). The inoculant Lausil® CL (Lallemand) was diluted with distilled water (2 mg/mL) and applied at the rate of 1 mL/kg of forage to provide *Lactobacillus plantarum* ($1.0 \times 10^5$ cfu/g of fresh forage) and *Pediococcus acidilactici* ($3.0 \times 10^4$ cfu/g of fresh forage). The forage was ensiled in experimental silos (plastic buckets with a capacity of 10 liters, containing 2 kg of sand). At ensiling and silo opening (60 days of storage), samples were collected for DM determination in an oven (at 55°C) and subsequently milled. The buffering capacity to hydrochloric acid was determined on forage dried samples. Subsequently, 25 g of fresh samples (at the time of ensiling and opening the silos) were added to 225 mL of deionized water and processed in industrial blender for one minute. The pH was determined through direct reading using pH meter. Then the extract was filtered (filter paper of medium filtering), the filtrate obtained was stored in a freezer (-20°C) for later determination of water-soluble carbohydrates concentrations. The silos were properly weighed at closing and opening to determine the dry matter losses, gas losses and effluent production. To determine aerobic stability, immediately after the opening of the silos, portions of about 1.5 kg of silage were transferred to plastic buckets, which were maintained at ambient temperature conditions. The temperatures were recorded every 12 hours (19:00 PM and 07:00 AM) for 5 days. Aerobic stability was calculated as a rate of temperature rise (°C/h) using the maximum observed temperature (°C) divided by time (in hours) required to reach maximum temperature. The experimental design was completely randomized in a factorial 3 x 6, three grasses and six treatments, with three replications. The results were submitted to analysis of variance by PROC GLM of SAS and means were compared by Tukey test at 5% probability.

**Results and Discussion** The DM contents in fresh forages were 24.50%, 30.18% and 20.34% for Paraíso, Roxo and Napier cultivars ($P<0.05$), respectively. This large difference observed for the same growth period (12 weeks) can be attributed to the growing conditions of each forage. These high DM values may be related to low rainfall observed during the experiment (dry season). Differences in DM led to alterations in silage densities, which was higher for the Napier cultivar (666.22 kg/m$^3$) and lower for the Roxo cultivar (454.42 kg/m$^3$). In turn, wilting also resulted in a greater DM ($P<0.05$) for the three forages evaluated. In general the buffering capacity of the elephant grass Paraíso was higher ($P<0.05$) than that of Roxo and Napier cultivars. For all forages, NaCl reduced the buffering capacity, especially for the dose 1.0%. Water-soluble carbohydrates content was higher ($P<0.05$) in Napier cultivar (12.01% DM) than in other cultivars (8.08 and 8.66% DM for Paraíso and Roxo, respectively). The treatments did not affect water-soluble carbohydrates concentrations. Despite the differences observed for DM and water-soluble carbohydrates, as well as for buffering capacity, the pH values obtained for all silages are within the optimal range (3.8 to 4.2), indicating that the fermentation process was adequate. It was also observed that the pH values of silages from Napier cultivar were significantly lower, despite the lower DM content at ensiling, probably because the higher content of water-soluble carbohydrates. Although wilting raise ($P<0.05$) the silage pH compared to control treatment (3.92 vs. 3.83, respectively), for all cultivars, gas losses and total dry matter losses were not affected by wilting. The use of 1.0% NaCl decreased ($P<0.05$) these losses only for silages made with Napier cultivar. Regarding the aerobic stability, wilting was effective only for Paraíso cultivar, providing the lowest rate of temperature rise (0.0213°C/h) that differed ($P<0.05$) from other treatments. The silages of elephant grass cultivar Roxo had the lowest rates of temperature rise, compared to other cultivars. The addition of common salt did not affect aerobic stability parameters for any of the cultivars. Furthermore, the use of inoculant was not effective to improve the fermentation process as well as aerobic stability.

**Conclusions** Under the conditions in which the experiment was conducted, it is concluded that: 1) wilting would be recommended only for elephant grass Paraíso silage, 2) inoculation was not effective for ensiling the grasses evaluated, 3) the addition 1.0% of common salt could be recommended for ensiling elephant grass cultivar Napier, and 4) elephant grass cv. Roxo silages showed the best aerobic stability.

# Effects of *Lactobacillus buchneri* DSM 13573 on the fermentation and the aerobic stability of silages as affected by inoculation rate

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**Introduction** In order to improve aerobic stability of silages, heterofermentative lactic acid bacteria inoculants of the *Lactobacillus buchneri* (LB)-type have been widely used. However, there have been discussions about the least required inoculation rate (IR). Positive effects of increased IR have been observed by Kleinschmidt and Kung (2006), but some of the LB strains, which are used in commercial inoculants across the world, were not included in the analysis. Therefore, the aim of this study was to test specifically the effects of *Lactobacillus buchneri* DSM 13573 on the fermentation and the aerobic stability of different silage types.

**Material and methods** A total of six ensiling experiments was conducted from 2006 to 2009, using different forages, which were ensiled 1.5 L glass jars (n=3 per treatment) and stored at 20 °C. Details on dry matter (DM) of the ensiled forages, IR of *Lactobacillus buchneri* DSM 13573 and ensiling conditions are summarized in table 1. Silage fermentation pattern was analyzed by HPLC (lactic acid) and GC (volatile organic acids, alcohols). Losses of DM were calculated according to Weissbach (2005). Aerobic stability (ASTA) was measured by the temperature method, and silage was considered unstable if its temperature had increased by 2 K above ambient. The ASTA testing period was set at 10 days for trials 1, 2, 5, 6 and at 7 days for trials 3 and 4. Statistical analyses by ANOVA were performed by employing the PROC MIXED of SAS, version 9.2. Significant differences were declared at $P<0.05$, and pair-wise comparisons between least square means were performed by using the Tukey´s test.

**Table 1** Forage types, DM level, IR and ensiling conditions used in the lab-scale trial series.

| Trial no | Forage type | DM (%) | IR (cfu/g forage) LB1 | IR (cfu/g forage) LB2 | Ensiling conditions |
|---|---|---|---|---|---|
| 1 | Whole-crop maize | 38.0 | $1x10^5$ | $5x10^5$ | 60 days fermentation, no air ingress |
| 2 | Whole-crop maize | 45.1 | $1x10^5$ | $5x10^5$ | 90 days fermentation, no air ingress |
| 3 | High-moisture corn | 61.6 | $1x10^5$ | $4x10^5$ | 49 days fermentation, air ingress for |
| 4 | High moisture corn | 63.6 | $1x10^5$ | $4x10^5$ | on day 28 and 42 |
| 5 | Natural grassland | 40.6 | $1x10^5$ | $5x10^5$ | 109 days fermentation, air ingress for 1 day on day 102 |
| 6 | Ryegrass | 39.2 | $1x10^5$ | $5x10^5$ | 107 days fermentation, air ingress for 1 day on day 100 |

**Results and discussion** Significant interactions were observed between trial and treatment for all variables (table 2). This may be explained by the use of different types of forages and varying ensiling conditions. Lower lactate and higher acetate concentrations that are normally associated with the use of LB were not found in the two maize trials. In all other trials, acetate contents were increased by inoculation, but only in the high-moisture corn experiments a dose-dependent effect on this parameter was detected. Application of LB consistently increased the concentration of 1,2-propanediol, the co-product of anaerobic lactate degradation by LB. This finding clearly confirmed the activity of the added LB. Most importantly, ASTA was improved by LB treatment across all silage types, and inoculation rate did not affect ASTA in any of the trials.

**Table 2** Effects of *L. buchneri* DSM 13573 on DM losses, fermentation and aerobic stability.

| Trial | Treatment | DML[1] (%) | pH | Lactate (g/kg DM) | Acetate | Ethanol | 1,2-PD[2] | ASTA[3] (days) |
|---|---|---|---|---|---|---|---|---|
| 1 | Control | $10.4^{aBC}$ | $3.64^{aA}$ | $53.0^{aC}$ | $10.3^{aC}$ | $20.8^{aE}$ | $0^{aA}$ | $3.8^{a}$ |
| | LB1[4] | $5.5^{aABC}$ | $3.67^{aA}$ | $50.5^{aD}$ | $10.8^{aB}$ | $25.1^{aD}$ | $2.0^{bA}$ | $10.0^{b}$ |
| | LB2[5] | $5.4^{aABC}$ | $3.67^{aA}$ | $54.0^{aC}$ | $11.1^{aB}$ | $24.6^{aD}$ | $2.7^{cAB}$ | $10.0^{b}$ |
| 2 | Control | $7.2^{bC}$ | $3.84^{aB}$ | $33.1^{aB}$ | $5.8^{aB}$ | $8.2^{aD}$ | $0^{aA}$ | $6.9^{a}$ |
| | LB1[4] | $4.2^{aA}$ | $3.85^{aB}$ | $47.3^{bD}$ | $7.3^{aA}$ | $8.2^{aC}$ | $1.5^{bA}$ | $10.0^{b}$ |
| | LB2[5] | $4.3^{aA}$ | $3.89^{bB}$ | $36.5^{aB}$ | $8.0^{aA}$ | $8.3^{aC}$ | $2.2^{cA}$ | $10.0^{b}$ |
| 3 | Control | $3.5^{aA}$ | $3.98^{aC}$ | $23.2^{baA}$ | $2.1^{aA}$ | $2.4^{aA}$ | $0^{aA}$ | $1.0^{a}$ |
| | LB1[4] | $3.7^{aA}$ | $4.05^{aCD}$ | $12.0^{aA}$ | $6.6^{bA}$ | $2.3^{aA}$ | $1.1^{aA}$ | $6.3^{b}$ |
| | LB2[6] | $3.7^{aA}$ | $4.01^{aBCD}$ | $13.2^{aA}$ | $8.9^{cA}$ | $2.3^{aA}$ | $3.8^{bB}$ | $7.0^{b}$ |
| 4 | Control | $3.6^{aA}$ | $4.03^{aC}$ | $19.2^{bA}$ | $2.3^{aA}$ | $3.0^{aAB}$ | $0^{aA}$ | $1.8^{a}$ |
| | LB1[4] | $3.6^{aA}$ | $4.03^{aC}$ | $21.5^{bB}$ | $6.6^{bA}$ | $2.5^{aA}$ | $1.8^{bA}$ | $7.0^{b}$ |
| | LB2[6] | $3.7^{aA}$ | $4.04^{aC}$ | $11.1^{aA}$ | $7.6^{cA}$ | $2.5^{aA}$ | $2.2^{bA}$ | $7.0^{b}$ |
| 5 | Control | $6.6^{aC}$ | $4.53^{bD}$ | $38.7^{aB}$ | $16.6^{aCD}$ | $4.0^{aBC}$ | $1.5^{aB}$ | $2.7^{a}$ |
| | LB1[4] | $7.4^{bC}$ | $4.39^{aE}$ | $32.2^{aC}$ | $36.3^{bD}$ | $5.8^{bB}$ | $15.8^{bC}$ | $10.0^{b}$ |
| | LB2[5] | $7.7^{bC}$ | $4.40^{aE}$ | $29.9^{aB}$ | $34.3^{bC}$ | $6.2^{bB}$ | $15.8^{bD}$ | $10.0^{b}$ |
| 6 | Control | $5.7^{aB}$ | $4.09^{aC}$ | $53.9^{bC}$ | $19.1^{aD}$ | $4.7^{aC}$ | $0^{aAB}$ | $2.3^{a}$ |
| | LB1[4] | $6.5^{bB}$ | $4.11^{bD}$ | $31.8^{aC}$ | $28.7^{bC}$ | $6.9^{bBC}$ | $10.5^{bB}$ | $10.0^{b}$ |
| | LB2[5] | $6.7^{cB}$ | $4.17^{cD}$ | $32.1^{aB}$ | $29.7^{bC}$ | $5.7^{abB}$ | $13.1^{cC}$ | $10.0^{b}$ |
| Significance level (ANOVA F test) | | | | | | | | |
| Trial (n=6) | | *** | *** | *** | *** | *** | *** | - |
| Treatment (n=18) | | * | *NS* | *** | *** | *NS* | *** | *** |
| Trial x Treatment | | *** | *** | *** | *** | ** | *** | - |

[1]dry matter losses; [2]1,2-propanediol; [3]aerobic stability; [4]IR:100,000 cfu/g; [5]IR: 400,000 cfu/g; [6]IR: 500,000 cfu/g; - due to different periods for aerobic stability testing only one-way ANOVA performed; LSMEANS in columns bearing unlike superscripts within experiment and capital superscripts within treatments differ (Tukey´s test), *$P<0.05$, **$P<0.01$; ***$P<0.001$, *NS* not significant,

**Conclusions** *Lactobacillus buchneri* DSM 13573 consistently improved aerobic stability of different types of silages. There was no additional benefit in terms of efficacy in using higher inoculation rates than $1x10^5$ cfu/g fresh forage, which is recommended by the manufacturer.

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Weissbach, F. 2005. A simple method for the correction of fermentation losses measured in laboratory silos. In: Silage production and utilisation. Park, R.S. and M. D. Stronge (eds), 278.

# Inoculant type affects fermentation characteristics, dry matter losses and aerobic stability of baled grass silage

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**Introduction** Aerobic instability is a common problem in well-fermented grass silage containing high lactic acid concentrations but only small amounts of acetic acid, which is normally observed in silage treated with homofermentative lactic acid bacteria ($LAB_{ho}$; Conaghan *et al.*, 2010). The use of heterofermentative lactic acid bacteria ($LAB_{he}$) promotes acetic acid production, which improves aerobic stability (AS; Kleinschmidt and Kung, 2006). The use of a dual-purpose microbial inoculant ($LAB_{ho+he}$) was shown to improve fermentation characteristics and AS of grass silage (Driehuis *et al.*, 2001). However, most of these experiments have been conducted in small scale silos. This experiment aimed at investigating the effects of different types of inoculants on fermentation characteristics, dry matter (DM) losses and AS of chopped grass silage pressed in large round bales.

**Material and methods** The grass sward was mowed on June 4, 2012 as a first cut and wilted to an average DM content of 31% (10.5% CP, 22% water-soluble carbohydrats (WSC), 49% NDF of DM) before being precision chopped to 25 mm length and pressed into round bales with a stationary baler (Orkel MP 2000) on June 5, 2012 at Götala Research Station, Swedish University of Agricultural Sciences, Skara, south-west Sweden. The following inoculants (ADDCON EUROPE GmbH) were applied at chopping of the forage; KOFASIL LAC (KLAC) containing $LAB_{ho}$ (*Lactobacillus plantarum* DSM 3676, 3677), $1x10^5$ cfu/g, KOFASIL S, (KS) containing $LAB_{he}$ (*Lactobacillus buchneri* DSM 13573), $1x10^5$ cfu/g and KOFASIL DUO (KDUO), a combination of KLAC and KS, $2x10^5$ cfu/g. The bales were stored outside for 91 days before drilled samples were taken from five bales per treatment used as replicates. The treatments were compared with an untreated control (CON). Fermentation characteristics and WSC were determined by routine analytical procedures. The DM losses during fermentation were calculated (Weissbach, 2005) and the AS was determined as the number of days for the silage to reach a temperature of 2°C above ambient temperature. Data were statistically evaluated by using the procedures GLM and REG of SAS (version 9.3). When a significant *F*-test was detected ($P$<0.05), a pair-wise comparison between LSMEANS was performed by using the Tukey´s test and significance declared at $P$<0.05.

**Results and discussion** There was an overall treatment effect on all the variables studied in the grass silage (Table 1). KLAC showed a homolactic fermentation pattern and aerobic instability. The DM losses were lowest for KLAC although it had the highest ethanol content. Contents of acetic acid and 1,2-propanediol increased from KLAC to KDUO and KS, indicating anaerobic lactate degradation by *Lactobacillus buchneri*. As a result, AS increased from KLAC to KDUO and KS, which did not differ from CON. The AS was highly correlated with the acetic acid/lactic acid ratio in the silages (Figure 1). No butyric acid was detected in the silages. The WSC content was highest for KLAC and KDUO. All inoculants decreased proteolysis in the silages (Table 1).

**Table 1** Effects of inoculants on fermentation characteristics, water-soluble carbohydrate (WSC) content, DM losses and aerobic stability of grass silage after 91 days of storage (n=5).

| Parameter | CON[1] | KLAC[1] | KDUO[1] | KS[1] | SEM | *P*-value |
|---|---|---|---|---|---|---|
| pH | 3.90[a] | 3.89[a] | 3.78[b] | 3.91[a] | 0.012 | <0.0001 |
| Lactic acid (g/kg DM) | 51.2[c] | 71.8[a] | 63.6[ab] | 59.5[bc] | 2.12 | <0.0001 |
| Acetic acid (g/kg DM) | 27.9[b] | 15.6[c] | 25.7[b] | 33.2[a] | 1.02 | <0.0001 |
| Ethanol (g/kg DM) | 10.4[b] | 15.2[a] | 10.6[b] | 10.8[b] | 0.55 | <0.0001 |
| 1,2-Propanediol (g/kg DM) | 11.5[b] | 0.1[d] | 7.4[c] | 16.5[a] | 0.92 | <0.0001 |
| WSC (g/kg DM) | 25.5[b] | 49.6[a] | 42.0[a] | 25.8[b] | 3.14 | <0.0001 |
| $NH_3$-N (% total N) | 11.3[a] | 10.0[b] | 9.9[b] | 10.4[b] | 0.16 | <0.0001 |
| DM losses (%) | 5.4[a] | 4.0[b] | 5.2[a] | 5.6[a] | 0.16 | <0.0001 |
| Aerobic stability (days) | 10.0[a] | 2.4[c] | 6.3[b] | 9.7[a] | 0.53 | <0.0001 |

[1]for description see Material and methods, [a-c]LSMEANS in rows with unlike superscripts differ ($P$<0.05)

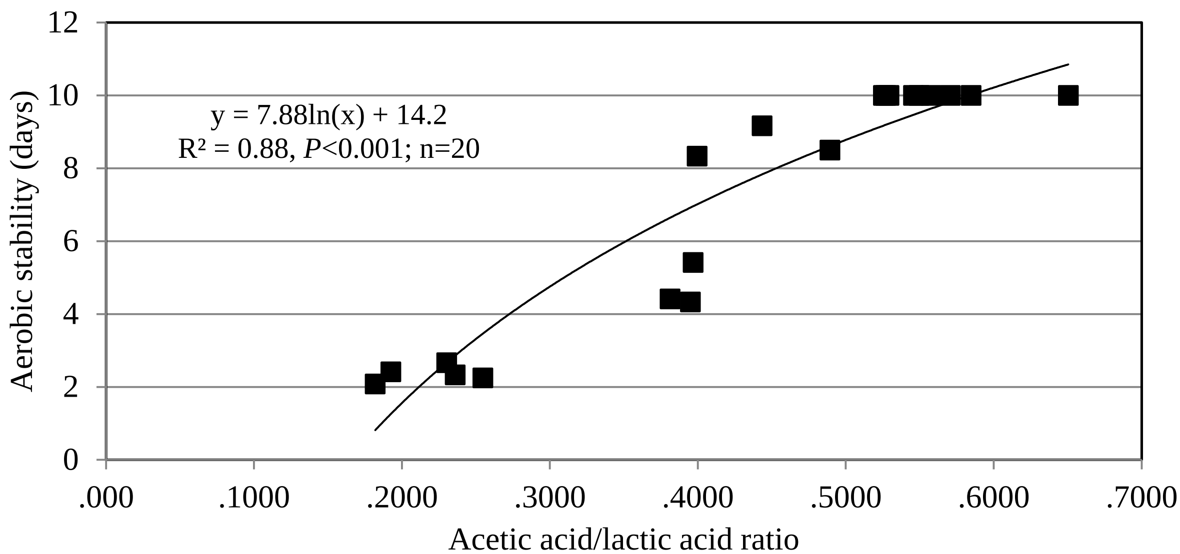


**Figure 1** Relationship between acetic acid/lactic acid ratio and aerobic stability of grass silage.

**Conclusions** The dual-purpose inoculant containing $LAB_{ho}$ and $LAB_{he}$ improved the fermentation of chopped grass silage in bales and alleviated the negative effect of the sole $LAB_{ho}$ use on aerobic stability.

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Weissbach, F. 2005. A simple method for the correction of fermentation losses measured in laboratory silos. In: Silage production and utilisation. Park, R.S. and M.D. Stronge (Eds), 278.

# Additive type affects dry matter losses, fermentation pattern, aerobic stability and clostridia counts of baled red clover-grass silage

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**Introduction** Silage quality may be impaired by the growth of undesired spoilage micro-organisms, e.g. clostridia, yeasts and moulds. As reviewed in detail by Kung *et al*. (2003), homofermentative lactic acid bacteria ($LAB_{ho}$) inoculants are known to improve fermentation by suppressing clostridia by rapidly decreasing pH. However, they frequently increase susceptibility to heating by fungi if silages are exposed to air during feed-out. Heterofermentative lactic acid bacteria ($LAB_{he}$) products of the *Lactobacillus buchneri*-type as well as antimycotic chemicals (e.g. sodium benzoate, potassium sorbate) are used to enhance aerobic stability. The combination of either of those two additive types with $LAB_{ho}$ aims at concurrently improving the fermentation process and the aerobic stability (AS) of silage (Auerbach *et al*., 2013). As most silage trials are conducted using laboratory silos, the aim of this study was to compare the effects of different additive types regarding the quality of red clover-grass silages produced in big round bales.

**Material and methods** A third cut red clover-grass ley (75%/25%) was mown on September 4, 2011 in Skara, south-west Sweden, wilted to 30-35% dry matter (DM), chopped and ensiled in big round bales by a stationary baler (Orkel MP 2000). The wilted herbage contained (DM based): 9.9% ash, 15.8% CP, 9.6% water-soluble carbohydrates (WSC) and 44.2% NDF. The following additives, produced by ADDCON EUROPE GmbH, were applied on the chopper: KOFASIL LAC (KLAC) containing $LAB_{ho}$ (*Lactobacillus plantarum* DSM 3676, DSM 3677), inoculation rate (IR): $1x10^5$ cfu/g; KOFASIL S (KS), containing $LAB_{he}$ (*Lactobacillus buchneri* DSM 13573), IR: $1x10^5$ cfu/g; KOFASIL DUO (KDUO), combination of KLAC and KS, IR: $2x10^5$ cfu/g, KOFASIL COMBI (KCOM), combination of KLAC (IR: $1x10^5$ cfu/g) and a mixture of sodium benzoate and potassium sorbate (270 g/t). All additives were compared with an untreated control (CON). Five replicate bales per treatment were produced and stored outside for 121 days. Samples from individual bales were taken by drilling and subjected to analysis for pH and ammonia-N, lactate (HPLC), volatile acids and alcohols (GC), WSC (anthrone method) and clostridia (MPN method). The DM losses were calculated according to Weissbach (2005). The AS was measured by the temperature method and silages considered unstable if its temperature had increased by 3 °C above ambient. Data were statistically evaluated by using PROC GLM of SAS, version 9.3. When a significant *F*-test was detected ($P<0.05$), a pair-wise comparison between LSMEANS was performed by employing the Tukey´s test ($P<0.05$).

**Results and discussion** With the exception of AS, which was high across treatments (>11 days), an overall treatment effect was detected for all variables (Table 1). Silages of the treatments KLAC, KDUO and KCOM showed lower DM losses and higher WSC concentrations than that of CON, indicating a more efficient fermentation process. This was reflected by lower pH and ammonia levels as well as higher lactate contents. Concentrations of butyric and propionic acids and of all measured alcohols were low in CON but were further reduced by inoculants containing $LAB_{ho}$. Clostridia growth was inhibited by treatments KLAC and KDUO when compared with CON. The sole use of $LAB_{he}$ in KS resulted in the typical fermentation pattern of *Lactobacillus buchneri*, which is characterized by anaerobic lactate degradation to acetic acid and 1,2-propanediol, resulting in higher DM losses. Obviously, this inoculant type was not capable of improving the fermentation process of the red clover-dominated ley. The beneficial effects of all $LAB_{ho}$-containing additives on silage quality can very likely be attributed to a faster acidification rate during the initial phases of fermentation than was observed in untreated silage. This parameter was measured in laboratory silos, which were filled with the same material that was used in the bales. On the contrary, the effect of $LAB_{he}$ on pH after 3 days of fermentation was only marginal (KLAC: 4.43 *vs*. KDUO: 4.49 *vs*. KCOM: 4.47 *vs*. KS 4.87 *vs*. CON: 5.13).

**Table 1** Effects of additive type on DM losses, fermentation pattern, aerobic stability and clostridia counts in red clover-grass silage (n=5 bales per treatment).

| Parameter | CON[1] | KLAC[1] | KS[1] | KDUO[1] | KCOM[1] | SEM | *P*-value |
|---|---|---|---|---|---|---|---|
| DM loss (%) | $4.8^{ab}$ | $3.3^{c}$ | $5.7^{a}$ | $3.5^{c}$ | $3.8^{bc}$ | 2.51 | <0.0001 |
| WSC[2] | $4.9^{d}$ | $8.7^{b}$ | $3.9^{d}$ | $6.9^{c}$ | $11.8^{a}$ | 0.27 | <0.0001 |
| pH | $4.48^{b}$ | $4.27^{c}$ | $4.76^{a}$ | $4.28^{c}$ | $4.22^{c}$ | 0.021 | <0.0001 |
| Ammonia-N (% total N) | $10.7^{a}$ | $8.1^{b}$ | $11.3^{a}$ | $8.1^{a}$ | $8.3^{a}$ | 0.21 | <0.0001 |
| Lactic acid[2] | $77.4^{b}$ | $102.7^{a}$ | $57.7^{c}$ | $105.1^{a}$ | $104.8^{a}$ | 1.78 | <0.0001 |
| Acetic acid[2] | $24.4^{b}$ | $16.4^{cd}$ | $31.1^{a}$ | $19.7^{bc}$ | $13.6^{d}$ | 1.25 | <0.0001 |
| Butyric acid[2] | $3.4^{b}$ | $0.3^{c}$ | $6.1^{a}$ | $0.4^{c}$ | $0.1^{c}$ | 0.40 | <0.0001 |
| Propionic acid[2] | $1.1^{b}$ | $0^{c}$ | $2.1^{a}$ | $0.1^{c}$ | $0^{c}$ | 0.08 | <0.0001 |
| Ethanol[2] | $5.2^{b}$ | $2.5^{c}$ | $7.5^{a}$ | $2.8^{c}$ | $2.1^{c}$ | 0.25 | <0.0001 |
| n-Propanol[2] | $1.8^{b}$ | $0^{c}$ | $3.6^{a}$ | $0.2^{c}$ | $0^{c}$ | 0.11 | <0.0001 |
| 1,2-Propanediol[2] | $1.7^{b}$ | $0.6^{b}$ | $4.5^{a}$ | $1.1^{c}$ | $0.6^{b}$ | 0.28 | <0.0001 |
| Aerobic stability (days) | 13.4 | 11.4 | 13.3 | 12.2 | 13.5 | 0.55 | 0.06 |
| Clostridia (lg MPN/g) | $4.6^{ab}$ | $1.8^{c}$ | $4.9^{a}$ | $1.7^{c}$ | $2.6^{bc}$ | 0.53 | <0.001 |

[1]for description see Material and methods, [2]g/kg DM, [a-d]LSMEANS in rows bearing unlike superscripts differ ($P<0.05$)

**Conclusions** Only the use of additives containing $LAB_{ho}$ alone or in combination with $LAB_{he}$ and antimycotic substances, respectively, concurrently improved fermentation and ensured high aerobic stability. Consequently, those additives can be recommended for red clover-dominated silages, in which clostridia growth accompanied with poor fermentation quality is to be expected.

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**Effect of the inclusion of glycerin on organic acids production in corn silage**

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**Introduction** The silage is based on spontaneous lactic fermentation, where under anaerobic conditions the soluble carbohydrates are fermented with lactic acid production and rapid decrease in pH. Corn is considered the best forage to be ensiled due to its high dry matter productivity, low buffer capacity and adequate levels of soluble carbohydrates for fermentation (McDonald et. al. 1991). The use of crude glycerin as ingredient in ruminant concentrates has been studied in the last years (Gonçalves et. al. 2006; França et. al. 2012). The objective of this work was to evaluate the changes on concentrations of organic acids in corn silage occurring during the use of crude glycerin.

**Material and Methods T**he experiment was carried out at the Embrapa Dairy Cattle, located in Juiz de Fora, MG, Brazil. Four levels of crude glycerin (0, 5, 10 and 15% wet basis) were added to corn silage and evaluated in a completely randomized experimental design with five replications. The experimental silos were polyvinyl tubes 50 cm long with 10 cm diameter with Bunsen valve in the upper cap. Sixty days after silos closure, they were opened and sampled to bromatological analyses. Organic acids were determined in a high production liquid chromatography (HPLC) coupled to an ultra violet (UV), using a wavelength: 210 nm. Data were submitted to variance and regression. The best model choice was based on the determination coefficients and the significance of regression coefficients.

**Results and discussion:** Crude glycerin addition to corn silage caused a negative linear effect on lactic acid concentration ($P<0.05$) (Table. 1), with a 0.3% decrease for each 1% of glycerin addition. This result was similar to that observed by França et al. (2012). However, glycerin addition didn't affect propionic acid concentration and decreased butyric acid concentration ($P<0.05$). For each 1% of glycerin added to silage there was a 0.26% increase in the dry matter content and that may have caused butyric bacteria inhibition.

**Conclusions** The addition of glycerin reduced the levels of lactic acid as well as butyric acid in corn silages.

**Table 1** Regression equations and coefficients of determination ($R^2$) for latic, acetic, propionic and butyric acids and dry matter of corn silages with glycerin.

| Variable | Percent glycerin added to corn silage (wet basis) | | | | Regression Equation | |
|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | | |
| Lactic acid (% DM) | 15.9 | 14.69 | 12.32 | 11.66 | Y = 15,9 - 0,3011x | $R^2$ = 65.6 |
| Acetic acid (% DM) | 6.76 | 5.65 | 4.59 | 4.92 | Y = 6.8 - 0.348x + 0.0144 $x^2$ | $R^2$=55.2 |
| Propionic acid (% DM) | 2.89 | 2.73 | 2.59 | 2.78 | Y = 2.9 | |
| Butiric acid (% DM) | 3.45 | 2.65b | 2.25 | 1.64 | Y = 3.37 – 0.117x | $R^2$=57.7 |
| Dry matter (%) | 28.8 | 29.2 | 30.8 | 32.6 | Y = 28.41 + 0.264x | $R^2$=60.0 |

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# Ruminal degradability of starch from corn silage containing different glycerin concentrations

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**Introduction** The use of glycerin as energy source for ruminants is a viable option (ÍTAVO et al., 2011), once its energetic value is similar to corn starch (Duque et al., 2011). Gomes et al. (2011) verified that glycerin, purified or not, added to roughages improves the *in vitro* digestibility of organic matter and the total digestible nutrients. Many others researches were carried out to study the effects of glycerin in ruminant feeding and animal production (Duque et al., 2011; Gomes et al., 2011).

**Material and methods T**he experiment was carried out at the Embrapa Dairy Cattle, located in Juiz de Fora, MG, Brazil. Four levels of crude glycerin (0, 5, 10 and 15% wet basis) were added to corn silage and evaluated in a completely randomized experimental design with five replications. Twenty experimental silos, made from polyvinyl tubes 50 cm long with 10 cm diameter with Bunsen valve in the upper cap, were used. Sixty days after silos closure, they were opened and sampled for starch analysis using the technique described by (Passos, 1996).
The *in situ* degradability of starch was evaluated using nylon bags and Mehrez and Orskov (1977) methodology. Ruminal degradability parameters were determined using PROC NLIN procedure. Determination of effective degradability (DE) were done according Orskov and McDonald (1979) model, considering 0.0341%/h as the passage rate through the rumen.
Four rumen cannulated Holstein-Zebu cows with 450 kg of average weight were used. Cows were fed a total mixed ration with 60% corn silage and 40% concentrate (dry matter basis). Silages in the diets were prepared with glycerin levels similar to silages incubated in the rumen (0, 5, 10 e 15% of glycerin in wet basis).

**Results and Discussion** Table 1 shows the data from starch degraded in the rumen. Although potential degradable fractions were higher in silages with 5 and 10% of glycerin, the constant degradation rate of degradable fraction and effective degradability were higher in silage with 15% glycerin. Corn silage with 15% glycerin presented higher starch degradability, probably due to the fact of crude glycerin be able to positively affect starch availability. Also, glycerin could have improved rumen environment and the growing of amylolytic bacteria population.

**Conclusions** Starch degradability of corn silage was higher when 15% of glycerin (wet basis) was added during silage making.

**Table 1** Parameters of rumen degradation of starch from corn silage prepared with different glycerin concentrations (as fed basis).

| Glycerin (%) | A (%) | B(%) | c (/h) | S(%) | DE (%) |
|---|---|---|---|---|---|
| 0 | 77.30 | 60.82 | 0.0356 | 0 | 31.06445 |
| 5 | 91.23 | 63.92 | 0.0267 | 13.3 | 41.37013 |
| 10 | 95.75 | 66.30 | 0.0225 | 13 | 39.35601 |
| 15 | 86.91 | 47.18 | 0.0493 | 40.3 | 68.18938 |

*A = potentially degradable fraction, B = potentially degradable fraction under microbial action, c = constant rate of degradation of the potentially degradable by microbial action, and S = soluble fraction more particles reduced in size that pass through the pores of the nylon (SAMPAIO, 1988).

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**Occurrence of the mycotoxin Zearalenone related to maize ensilage practices**

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**Introduction** When ensilage practices and silo management are not adequate, fungal contamination and mycotoxin formation can occur. Mycotoxins are secondary metabolites produced by a variety of filamentous fungi. Zearalenone is one of the most important mycotoxins in animal production due to its reproduction-related effects (Whitlow and Hagler Jr., 2005). Lack of information hinders the adoption of strategies to prevent and control the contamination of animals and their products by mycotoxins. The objective of this work was to undertake an assessment of the occurrence of Zearalenone in corn silages under farm conditions, and its relationships with ensiling practices, milk production and control.

**Materials and Methods** In 2011, silages were evaluated belonging to 108 silos in properties located in the state of Paraná, Brazil. Information was collected on silo type (bunker or surface), color of the tarp used to cover the silo (black, white, black and white, black and gray), tarp cover (dirt, none, others), form of silage removal (manually with pitchfork, tractor hopper, mill silage loader, silage block cutter), harvest (self or outsourced) and forage harvester type (self-propelled or tractor-pulled). Silage density (DE) was determined according to the methodology proposed by D'Amours and Savoie (2005). The following levels were determined: dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), relative nutritional value (RNV), in vitro dry matter digestibility (IVDMD), starch, hydrogenionic potential (pH) and mean particle size (MPS) using Penn State particle separators. Occurrence of the mycotoxin Zearalenone was determined by thin layer chromatography (TLC) according to Scott (1997).

**Results and Discussion** Of the total 108 evaluated silos, 88 samples were contaminated with Zearalenone (81% of total), being that 54 samples (50% of total) had values over the acceptable limit of 285 ppb (Schmidt et al., 2011). The mean rate of this mycotoxin in the silages was 309 ppb, with a standard deviation of 241 ppb and a range of 0 to 1000 ppb. There was no significant difference between Zearalenone concentrations and variables harvest, machine type, hybrid cycle, silo type, tarp color, silo cover, form of removal and inoculant use. Among the studied variables, there was an effect only of corn hybrid (conventional or *Bt*). There was a reduction in Zearalenone levels with the use of corn containing the gene *Bt*. This technology can reduce mycotoxin levels due to lower insect infestation in corn grains, blocking fungal development. The occurrence of Zearalenone in silages of *Bt* hybrids was 240.9 ppb, and 355.0 ppb in conventional corn silages. There was no correlation between Zearalenone levels and silage chemical quality (DM, CP, ADF, NDF, TDN, RNV, IVDMD and pH), nor with mean particle size of the silage. No correlation was found between Zearalenone levels in the silages and milk production and composition in the evaluated properties (Figure 1). This result differs from the work by Whitlow and Hagler Jr. (2005), who reported lower milk production in diets including approximately 660 ppb of Zearalenone and 440 of Deoxynivalenol. Although no correlation was observed between Zearalenone and milk production, reproductive problems may be occurring as observed by Whitlow and Hagler Jr. (2005), but were not evaluated in this work.

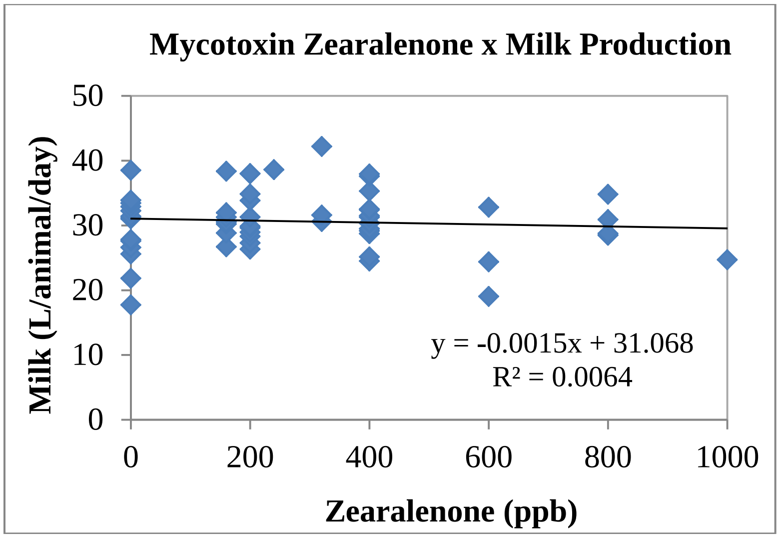


**Figure 1** Correlation between levels of the mycotoxin Zearalenone in silage and milk production.

**Conclusion** Silages of *Bt* corn hybrids had lower contamination by the mycotoxin Zearalenone. There was no correlation between Zearalenone levels in the silages with regard to silage nutritional composition and milk production and quality.

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## Silicon fertilization in the development and production of wheat crop

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**Introduction** The wheat (*Triticum aestivum* L.) is a crop of great importance in the world and is used in animal feeding in the form of green fodder and hay, dual purpose, and vegetation cover, green manure and also in food in the form of grain (Scheeren, 1984). Wheat as a dual-purpose crop has been used in several countries such as the United States, Uruguay and Argentina, as excellent financial return to farmers (Fontaneli et al., 2007). The importance of silicon, which is not considered essential but beneficial to plants is mainly related to increased growth and crop production through various indirect actions, making leaves erecter with decreased self-shading, greater structural rigidity of tissues, reduced lodging, protection against both abiotic stresses, such as reducing the toxicity of iron, manganese, aluminum and sodium as biotic stresses, increased protection from pathogens and phytophagous insects (Epstein, 1994) and (Marschner, 1995). Hence, this study aimed the evaluation of the effects of calcium silicate doses on the development and production of wheat crop.

**Material and Methods** The experiment was conducted in a greenhouse at the Department of Experimental Stations of Unioeste, Marechal Cândido Rondon – PR campus, from May to July 2012. The experiment was established and conducted in polyethylene pots of 8.5 $dm^{-3}$, containing 8 $dm^{-3}$ of soil sieved at 5 mm mesh. The soil used for filling the vessel had clayey, which was collected from the plow layer of 0-0,2 m, the city of Marechal Cândido Rondon - PR rated Oxisol, with the following attributes: pH ( $CaCl_2$): 5.55 MO (g $kg^{-1}$): 20.51; P (mg $dm^{-3}$): 16,91; H + Al, K, Ca, Mg, SB and CTC: 4.4; 0.06; 3.74; 0.62; 4.42 and 8.82, and V (%) of 50.11. The experiment was conducted in randomized block design with five doses of calcium silicate (0, 1.2; 2.4; 4.8 and 9.6 t $ha^{-1}$) and four replications, totaling 20 experimental units. Calcium silicate ($CaSiO_3$) which trade name is *Agrossilício* was used as a source of silicon, so that this product has the composition of 25% calcium, 6% magnesium and 10.5% silicon. At the time of seeding fertilization was performed according to basic Raij et al. (1997), with application of 30 kg N $ha^{-1}$, 60 kg $ha^{-1}$ of $P_2O_5$ and 45 kg $K_2O$ $ha^{-1}$ as urea, superphosphate and potassium chloride, respectively. After 30 days of culture, there was topdressing, applying 45 kg $ha^{-1}$ of N as urea. Five seeding in wheat seeds per pot were used, BRS Pardela, and after ten days thinning was performed leaving three seedlings per pot. The pots were irrigated daily, trying to keep soil moisture close to 80% of its field capacity. At the end of the cycle plant height was evaluated right before the cutting of the plants, it was obtained by measuring from the base to the apex of plants (cm) and then there was the cutting of the shoots to quantify shoot dry matter (g), the number of tillers and yield per pot (g). The data were subjected to variance analysis through F test. When effects were significant, polynomial regression studies were applied (Pimentel-Gomes & Garcia, 2002), using SAEG 8.0 (SAEG, 1999) statistical program.

**Results and Discussion** Regarding dry matter production of shoots, plant height, number of tillers and grain yield there was no significant difference due to the increasing doses of calcium silicate (Table 1).

**Table 1** Shoots dry matter production, plant height, number of tillers, and wheat crop productin, due to increasing doses of calcium silicate, Marechal Cândido Rondon - PR, 2012.

| Silicate Dose | Dry Matter | Height | Tillers | Production |
|---|---|---|---|---|
| t $ha^{-1}$ | g/pot | cm | n°/pot | g/pot |
| 0 | 11.7 | 87.8 | 5.0 | 6.6 |
| 1.2 | 12.4 | 86.5 | 4.8 | 7.7 |
| 2.4 | 12.3 | 81.7 | 4.5 | 5.4 |
| 4.8 | 11.3 | 85.2 | 4.3 | 6.8 |
| 9.6 | 12.1 | 83.9 | 5,0 | 6.5 |
| Average | 11.9 $^{ns}$ | 85.0 $^{ns}$ | 4.7 $^{ns}$ | 6.6 $^{ns}$ |
| C.V (%) | 14.99 | 4.91 | 16.37 | 24.4 |

Means followed by same lowercase on the row do not differ by Tukey test at 5% probability ($P < 0.05$)

It is clear that for dry matter production the dose of 1.2 t $ha^{-1}$ resulted in the highest accumulation of dry matter, with 12.4 g/pot while the dose 4.8 t $ha^{-1}$ resulted in less dry matter accumulation, with 11.3 g/pot, but no significant difference. Corroborating research developed by Korndorfer et al. (2010) and Melo et al. (2003) to study the *Brachiaria* sp, reported that application of Si in the soil increased concentration of Si in plants, but did not alter dry matter production of *Brachiaria* sp. For plant height the control provided 87.8 cm, and the dose of 2.4 t $ha^{-1}$ provided 81.7 cm, yet statistically similar. The results are in agreement with those obtained by Rocha et al. (2011) who, studying the residual effect of the slag in sorghum, observed that the height of sorghum plants was not affected by silicon fertilization. It was observed that the dose of 1.2 t $ha^{-1}$ provided the highest production 7.7 g/pot, and the dose 2.4 t $ha^{-1}$ gave a lower production 5.4 g/pot, however no significant differences. On the other hand Barbosa Filho et al. (2004) studied the silicate slag grain yield of upland rice and detected significant production increase within two years of rice cultivation.

**Conclusions** Fertilization with calcium silicate influenced neither dry matter of shoots, plant height, the number of tillers nor production of wheat crop.

## Temperature of vaquero hay stored in closed or open shed

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**Introduction** When fodders are preserved as hay, they can have their food value modified by the managed procedures during its production, storage and microbiological and biochemical phenomena that occur during such process. This has great influence on chemical composition, intake, fodder digestibility (Jobim, 2007) as well as on sanitary quality. Hay storage has been little studied in tropical conditions and it is known that part of it is used in livestock feeding since it is produced during summertime and stored for months until the winter comes, when tropical pastures have reduced their dry matter yield. Thus, this trial aimed at evaluating the variations on bales temperature of vaquero hay in both open and closed shed within 30 days.

**Material and Methods** The trial was carried out in a farm that has been producing Tifton 85 bermudagrass and vaquero (*Cynodon dactylon* L.) hay in Marechal Candido Rondon municipality, Paraná, Brazil. Hay fertilization on field was 30 days before its cutting with $70m^3.ha^{-1}$ from swine manure biofertilizers. The cutting at the experimental area was carried out on November 10th, 2012 with a mower with free swinging nylon flail fingers. The drying time was 44 hours and there was a turning with rake 16 hours after cutting. After baling, the bales were stored in appropriate places, in piles of five (5) bales (5 piles) under wooden pallets. Bales temperatures were measured daily at 1400 h (5 bales per treatment) as well as the room temperature was recorded with a skewer type thermometer. The experimental design was in a randomized block design with split plots over time with two storage systems and a 30-day evaluation of temperature with five replications. Data were submitted to analysis of variance and when there was some significance by F test, the averages were compared by Tukey test at 5% probability, according to SAEG program, version 8.0 for analysis.

**Results and Discussion** It was found out that temperature of bales in open shed differed from hay temperature in a closed shed (P <0.05), although, this difference was 0.68 °C higher in the closed one (Table 1). The studied bales were evaluated during 30 days, although they showed no significant difference (P> 0.05) during 13 days among temperatures (Table 1). Temperatures of bales in open shed had been superior when compared to the closed one for 14 days. The temperature variation between sheds ranged from 0 to 4°C. The variation in room temperature ranged from 1 to 5$^{o}$C in both sheds and it was observed the same temperatures in the different storage systems during three days. The temperature in the open shed was lower than in the closed one during 18 days. Muck & Shinners (2001) highlight the importance of researching in order to understand the processes that affect hay quality during its production, storage and sanitary aspects. The lowest observed temperature in bales in closed shed was 22.8°C and the highest was 32.8°C. While, bales from open shed showed values that ranged from 24.8 to 30.4°C for minimum and maximum temperature, respectively. Room temperature in the closed shed ranged from 25 to 35°C, as minimum and maximum records, while for open shed, these answers were 26 and 35°C, respectively. Since, the intense activity of microorganisms promotes an increase in hay temperature and it can also record values above 65°C and even spontaneous combustion. High humidity conditions and temperatures above 55°C are propitious to non-enzymatic reactions occurrence among soluble carbohydrates and amino groups of amino-acids, whose results are compounds called Maillard reaction products (Reis & Rodrigues, 1998). The extent of color changes provides some direction regarding heat intensity at storage and Maillard reaction occurrence (Moser, 1995). It should be noted that during rainfalls, a shed that has side walls (closed) also promotes greater protection of bales since there is an increase of moisture that can decrease their nutritional and sanitary answers.

**Conclusions** It was observed that storage systems little influenced on temperature variations.

**Table 1** Temperatures of bales and of storage places of vaquero hay

| Storage days | Temperature (°C) | | | |
|---|---|---|---|---|
| | Closed Shed Place | Closed Shed - Bale | Open Shed Place | Open Shed - Bale |
| 1 | 31 | 28.0b | 29 | 29.0a |
| 2 | 25 | 22.8b | 26 | 24.8a |
| 3 | 28 | 26.0b | 29 | 27.2a |
| 4 | 29 | 28.0 | 30 | 27.6 |
| 5 | 28 | 25.0 | 26 | 24.8 |
| 6 | 29 | 25.0b | 31 | 28.6a |
| 7 | 29 | 27.0a | 27 | 25.8b |
| 8 | 29 | 24.8b | 28 | 26.4a |
| 9 | 30 | 27.0 | 30 | 27.0 |
| 10 | 30 | 26.8b | 30 | 28.6a |
| 11 | 29 | 27.0b | 29 | 29.6a |
| 12 | 27 | 26.0b | 27 | 27.0a |
| 13 | 27 | 26.0 | 27 | 25.8 |
| 14 | 27 | 24.8b | 27 | 27.0a |
| 15 | 28 | 27.8 | 28 | 27.6 |
| 16 | 32 | 28.0b | 32 | 29.6a |
| 17 | 28 | 26.2b | 28 | 27.6a |
| 18 | 26 | 26.0a | 26 | 25.8b |
| 19 | 29 | 27.8 | 29 | 27.6 |
| 20 | 31 | 29.6 | 31 | 30.4 |
| 21 | 29 | 28.0b | 29 | 29.4a |
| 22 | 30 | 29.0 | 30 | 28.8 |
| 23 | 30 | 30.0 | 30 | 29.6 |
| 24 | 29 | 26.8b | 29 | 28.6a |
| 25 | 28 | 28.0 | 28 | 28.2 |
| 26 | 35 | 32.8a | 35 | 29.8b |
| 27 | 31 | 32.0 | 31 | 29.8 |
| 28 | 29 | 29.4 | 29 | 28.6 |
| 29 | 31 | 30.0 | 31 | 29.8 |
| 30 | 29 | 27.2b | 29 | 29.8a |
| Averages | | 27.42b | | 28.01a |
| CV(%)1 2.39 | | CV (%) 2 2.49 | | |

Means followed by same lowercase on the row do not differ by Tukey test at 5% probability (P <0.05)

**Corn silage: yield, quality and harvest window**

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**Introduction** The whole plant corn silage is a forage resource that has been increasingly important in Argentina for beef and milk production. The stage of maturity at harvesting and choice of the hybrid influence the physical and chemical characteristics of cell wall and nonstructural carbohydrates in the silage of corn crops (Johnson *et al.*, 2003). In addition, harvest time is variable because farmers do not have their own machinery, so harvest process relay on contractors. As the crop develops, starch is accumulated in the grain, dry matter digestibility decreases in the stover fraction and indigestible NDF fraction increases. Therefore, from the practical point of view, it is important to have hybrids with low drying rates when they have between 30 - 40% dry matter, in order to extend the harvest window (Rodriguez *et al.*, 2009). Consistent with those aspects, the objective of this study was to evaluate, in four corn hybrids, the yield, quality and harvest window of whole plant corn silage.

**Materials and Methods** Corn hybrids were sown (September 28$^{th}$, 2011) in Pergamino, Buenos Aires, Argentina, in rows 5 m in long and 0.7 m apart. Treatments were three stages of maturity: early dent (R5), 1/2 milkline (R5.5) and black layer (R6) in four hybrids: NK 900 (H1), DK 747 (H2), PAN 5e 202 (H3) and SU 9939 (H4). Treatments were arranged in a split-plot design with hybrid as the main plot and stage of maturity as the sub-plot and three replicates. Sampling for dry matter yield (DMY) was done in an area of 2.1 $m^2$ (R5 and R6) and 7 $m^2$ (R5.5). For experimental unit, five plants were separated for determination ear/whole plant ratio (E/WP) and another fifteen were chopped and ensiled in containers 20 l capacity. Silage samples were dried (65 ºC) for analyses: dry matter (%DM), *in vitro* DM digestibility (IVDMD) and NDF digestibility (NDFD). With DMY and IVDMD was calculated digestible DMY (DDMY). Whole plant drying rate (WPDR) was estimated from different maturity stages as the ratio of % DM/growing degree day (GDD). Data were analyzed with the MIXED procedure of the SAS system (SAS Institute, Inc., 2008). WPDR was determined by fitting regression using analysis of covariance. Means were compared by LSD test ($P < 0.05$).

**Results and Discussion** The interaction between maturity stage and hybrid were not significant for all variables analyzed. Significant main effects were detected for most variables except for IVDMD, as there were not different among hybrids. DMY decreases as the maturity stages progresses due to loss of leaves (Table 1). There was also a decrease in IVDMD. As a consequence, there was a sharp decline in DDMY as harvest stage was delayed. This was partially explained by a low NDF digestibility due to an increase in the complexity of the structure of the cell wall as time go through (Di Marco *et al.*, 2002). The larger harvest window (Figure 1) due to lower WPDR, not necessarily was related with a decrease in IVDMD and NDFD (Table 1).

**Conclusions** Management practices such as harvest stage and hybrids selection are important factors affecting yield and quality of corn silage. These characteristics could be successfully combined to get a wide harvest window.

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**Table 1** Dry matter yield (DMY), ear/whole-plant ratio (E/WP), *in vitro* dry matter digestibility (IVDMD), NDF digestibility (NDFD), digestible dry matter yield (DDMY) and whole plant drying rate (WPDR) for four hybrids harvested at three stages of maturity.

| | DMY, $tn/ha^{-1}$ | E/WP, % DM | IVDMD, % DM | NDFD, % DM | DDMY, $tn/ha^{-1}$ | WPDR, % DM/GDD |
|---|---|---|---|---|---|---|
| Hybrid | | | | | | |
| H1 | $14.9^{b}$ | $51.8^{ab}$ | $79.4^{a}$ | $48.8^{b}$ | $11.6^{b}$ | $0.025^{ab}$ |
| H2 | $12.4^{c}$ | $56.3^{a}$ | $78.1^{a}$ | $54.7^{a}$ | $9.7^{c}$ | $0.037^{c}$ |
| H3 | $14.3^{b}$ | $46.2^{b}$ | $78.0^{a}$ | $53.4^{a}$ | $11.3^{b}$ | $0.032^{bc}$ |
| H4 | $17.3^{a}$ | $49.5^{b}$ | $77.7^{a}$ | $51.5^{ab}$ | $13.5^{a}$ | $0.020^{a}$ |
| Maturity stage | | | | | | |
| R5 | $16.0^{a}$ | $39.8^{a}$ | $81.4^{a}$ | $58.5^{a}$ | $12.7^{a}$ | |
| R5.5 | $15.2^{a}$ | $55.3^{b}$ | $79.4^{b}$ | $52.6^{b}$ | $11.5^{ab}$ | |
| R6 | $12.9^{b}$ | $54.6^{b}$ | $74.1^{c}$ | $45.2^{c}$ | $10.4^{b}$ | |

[a-c] Means within a column with different superscripts differ ($P < 0.05$).

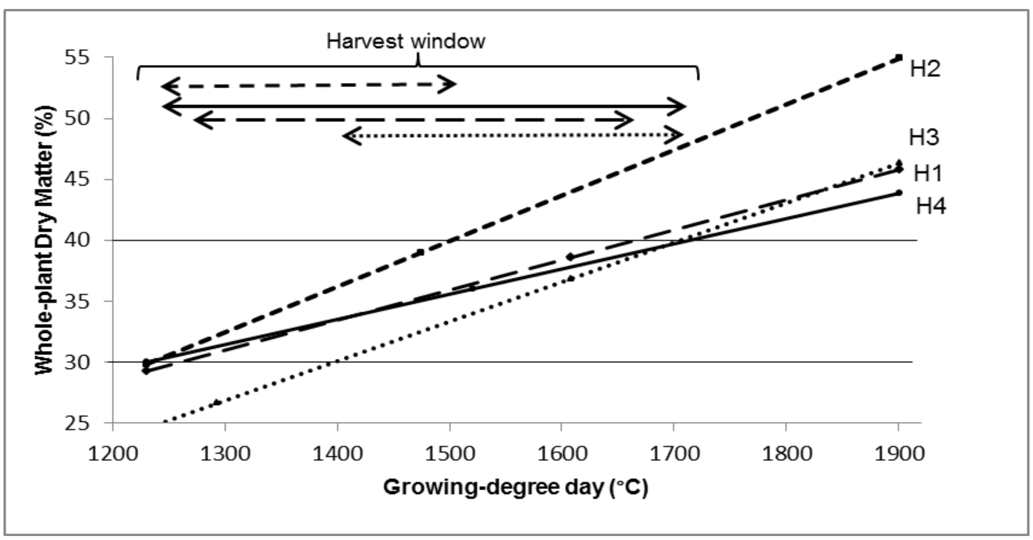


**Figure 1** Drying rate effect on the harvest window (30-40% DM) in four hybrids

**Effect of net wrapping and processor of fiber in the Alfalfa's hay (*Medicago sativa* L.)**

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**Introduction** The round balers came to Argentina in 1984 and revolutionized the way of conserving fodder, because it allowed machining tasks in the making of hay. In the last five years the trend in hay making in Argentina, has shifted to the use of mega balers (750 - 1000 kg / bale). Because of this round balers have had to evolve to increase efficiency in order to lower operating costs and increase the quality of hay made, which added to the lower cost of acquisition they own, are positioned as an implement of great adoption in Argentina, where the use is primarily domestic, unlike mega balers whose use is 95% commercial (mega bale sales). The industry has incorporated to the most advanced models of round balers, tools such as net wrapping and processor of fiber. In this study we evaluated the influence of these technologies on the quality of hay from field work conditions.

**Materials and methods** The experience was held on April 6, 2011 in the agricultural experimental station INTA Manfredi, Cordoba Province, Argentina. The trial was conducted in a batch of Alfalfa (*Medicago sativa* L.), implemented in the field number 5 of that establishment. The climatic conditions prevailing at the time of the trial allowed the rows of Alfalfa (*Medicago sativa* L.), take 5 days after cutting to reach proper humidity conditions for haymaking. Three treatments were applied: Treatment 1: round baler with compacted drum system, net wrapping and fiber processing system; Treatment 2: round baler with compacted drum system, net wrapping and fiber processing system disconnected; Treatment 3: round baler compacting system with straps, wire wrapping without fiber processor. Bales were made under the three treatments, by choosing the position of each treatment in a completely randomized way in the field. The material losses of the collector and the mechanisms of the machine were sampled by a tarp placed underneath each machine at work. This canvas also caught the portion of foreign material lifted by the round baler in each treatment. Each sample extracted from the processing rolls was divided into two equal parts. One sample was used in the Penn State particle separator, to evaluate the proportions of the various fractions of particles and analyze hay achieved throughout the fractions above 19 mm. The other part of the samples were sent to the laboratory of Animal Production EEA INTA Manfredi, where it was performed quality analysis:% CP,% NDF,% ADF,% digestibility, ME and % Ash.

**Results**

**Table 1** Average characteristics of Alfalfa round bales (*Medicago sativa* L.) obtained from the different treatments of the test and the material collected as waste along the round bales making.

| Treatment | Treatment 1 | Treatment 2 | Treatment 3 |
|---|---|---|---|
| Bale weight (kg) | 404 | 358 | 747 |
| Bale density ($kg/m^3$) | 180 | 160 | 241 |
| Total weight lost (kg) | 14.7 | 6.9 | 22.8 |
| Dust fraction of losses (kg)* | 5.6 | 3.3 | 9.7 |
| Crop fraction of losses (kg) | 9.1 | 3.6 | 13.1 |
| Crop fraction of losses (%) | 2.3 | 1 | 1.7 |
| Crop fraction of losses (% crude protein) | 23.9 | 24.0 | 25.9 |

***** This data record ash values higher than 80% in all cases.

**Table 2** Results of Penn State particle separator after the process of processing round bales of Alfalfa (*Medicago sativa* L.) in a vertical mixer.

| Treatment | Treatment 1 | Treatment 2 | Treatment 3 |
|---|---|---|---|
| % Portion > 19 mm | 58 | 61.5 | 73 |
| % Portion > 8mm | 27.5 | 21.5 | 14 |
| % Blind tray | 14.5 | 17 | 13 |
| Average fiber length (cm.) | 10-20 | 30-40 | 40-60 |

**Conclusions** Treatment using configuration 1 achieves a high efficiency hay utilization in ruminants, because it can obtain an average fiber length between 10 and 15 cm, favoring the fiber feed rate, and ensuring a proper effective salivation. In the case of bales obtained in treatments 2 and 3, the length of the fibers is between 40 to 60 cm, this reduces the rate of intake, because it needs more time chewing. In treatments 1 and 2, vegetable portion losses were not significant due to the few number of turns required to wrap the plant material with net. If using bales obtained from treatment 1, is reduced to one third work stage shredding and chipping of the bales by the vertical mixers. The efficiency of the mixer wagon increases by 300% when the same is loaded with hay made with fiber processor.

## Performance of crossbred young bulls fed rations with sugarcane silage treated with *Lactobacillus buchneri*

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**Introduction** The ensiling of sugarcane can be an option to overcome operational difficulties of daily harvest and to provide increased efficiency of agronomic management practices (Siqueira et al., 2012). However, the alcoholic fermentation can cause reduction in sugarcane quality. In recent years many studies have examined the effect of microbial inoculation (*Lactobacillus buchneri*) on sugarcane quality, but few evaluated if this roughage can be effectively used in cattle fattening diets. A trial was conducted to evaluate the effect of sugarcane silage inoculated with two dosages of heterolatic bacteria *Lactobacillus buchneri* on young beef bulls performance, in comparison with other traditional forages.

**Materials and Methods** Thirty-five animals (mean initial weight 463 kg) were allotted to individual pens, in a completely randomized design, with five treatments characterized by rations formulated with one of those forages: sorghum silage, fresh sugarcane, sugarcane silage without additive, sugarcane silage inoculated with low dose of *Lactobacillus buchneri* ($5 \times 10^4$ cfu/g fresh forage) and sugarcane silage inoculated with high dose of *Lactobacillus buchneri* ($1 \times 10^5$ cfu/g fresh forage). The ensiling of sugarcane was performed in stack silos and the forage was stored during 30 days before being offered to the animals. The diets were formulated to be isonitrogen (14% CP) and isoenergetic (70% TDN). The ingredients of concentrate were ground corn, soybean meal, minerals, urea and limestone. The total experimental period was 84 days, with three periods of 28 days (21 days of adaptation and 7 days of sampling). Animals were fed twice a day, approximately at 9h and 16 h. The silage and the concentrate, referring to each pen, were weighed separately in an electronic scale. Refusals were quantified daily for adjustment of next day feeding, to allow *ad libitum* consumption of rations (10% refusals). Animals were weighed in days 0, 28, 56 and 84, after 12 hours of fasting (solid feed), for analysis of body weight gain. Data relative to animal performance were analyzed using the GLM procedure of SAS (SAS Institute, 2001).

**Results and Discussion** Dry matter intake (% BW) was greater ($P < 0.05$) for animals fed rations containing sorghum silage. On the other hand, no difference ($P > 0.05$) was observed for dry matter intake in kg per day. Daily weight gain was significantly higher ($P < 0.05$) for animals fed sorghum silage in relation to those fed sugarcane silage and inoculated sugarcane silages, but did not differ ($P > 0.05$) from animals that consumed fresh sugarcane (Table 1). The feed conversion ratio was not significantly affected ($P>0.05$) by treatments, but the values observed can be considered low, especially for animals consuming sugarcane silages (Table 1). Pedroso et al. (2011) evaluated the performance of young bulls fed total rations prepared with sugarcane silages treated or untreated with *Lactobacillus buchneri* ($5.0 \times 10^4$ cfu/g). They observed that rations did not affect neither body weight gain nor dry matter intake, but feed conversion was better for animals that received sugarcane silage untreated in relation to those fed inoculated silage. Roman et al. (2011) evaluated the performance of beef cattle in feedlots fed diets containing whole-crop maize silage or sugarcane silage inoculated with *Lactobacillus buchneri* ($5.0 \times 10^4$ cfu/g). The authors did not observe effect of the silages on average daily gain (1.348 kg/animal/day), but the diets with whole-crop maize silage promoted grater dry matter intake (10.5 kg and 2.4% BW) in relation to diets with sugarcane silage (10.1 kg and 2.35 BW). Feed conversion was not affected by the silage source too. The performance of dairy cows fed sugarcane silages treated with additives compared to cows fed fresh forage was evaluated by Pedroso et al. (2010). They observed that cows fed rations with silages treated with *Lactobacillus buchneri* (5 x $10^4$ cfu/g) showed lower dry matter intake (18.5 vs 21.4 kg/day) and lower milk production in comparison to those fed ration with fresh sugarcane.

**Table 1** Performance of beef bulls fed rations containing sugarcane silages.

| Item | Treatment[1] | | | | | CV |
|---|---|---|---|---|---|---|
| | SS | FSC | SCS | $ISCS_l$ | $ISCS_h$ | |
| Dry matter intake, kg/day | 10.89[a] | 9.26[a] | 8.87[a] | 8.70[a] | 9.06[a] | 15.74 |
| Dry matter intake, % BW | 2,15[a] | 1,83[b] | 1,78[b] | 1,73[b] | 1,83[b] | 8,88 |
| Daily gain, kg/day | 1.27[a] | 1.06[ab] | 0.85[b] | 0.88[b] | 0.77[b] | 24.39 |
| Feed conversion (kg DM/kg BW) | 8.84[a] | 9.18[a] | 10.62[a] | 10.88[a] | 11.79[a] | 23.81 |

[a-b] Means within a row with different superscripts differ ($P < 0.05$).

[1]Treatments: SS = sorghum silage; FSC = fresh sugarcane; SCS = sugarcane silage without additive; $ISCS_l$ = sugarcane silage inoculated with low dose of *L. buchneri* (5 x $10^4$ CFU/g); $ISCS_h$ = sugarcane silage inoculated with high dose of *L. buchneri* (1 x $10^5$ CFU/g).

**Conclusions** The use of sugarcane silage in diets for finishing beef cattle is an alternative to fresh sugarcane, but the addition of microbial inoculant containing *Lactobacillus buchneri* was not effective to improving the animal performance of animal fed sugarcane silages.

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**Nutritive value and fermentation parameter of Yacón (*Smallanthus sonchifolius*), Orange (*Citrus sinensis*) and pineapple shell (*Ananas comosus*) ensiled in different mixture in Colombia**

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**Introduction** Colombia has an important vegetal diversity and by-products with potential use in animal feeding. One of the options within the plant, the Yacón and is generated from the agro-products, which are a problem to give a final destination, its use as silage for cattle feed, be established as a viable option handling.Yacón is a native plant of the Andes. The leaves of Yacón are not harvested for feeding ruminants. This forage does not compete with human food and has not been extensively studied in the country, in terms of animal nutrition. The orange and pineapple shell are agro-products interesting of use in animal feeding as silage. In this study the nutritional value and fermentation parameters of silage leaves of Yacón *(Smallanthus sonchifolius)*, orange (*Citrus sinensis)* and pineapple (*Ananas comosus*) shell were evaluated as option of supplementation in animal feeding.

**Material and Methods** Samples of Yacón were taken from the existing planting on the campus of La Salle University in Bogotá. Eleven treatments were evaluated with different inclusion rates of leaves Yacón with each shells of orange and pineapple respectively. Control treatments were leaves Yacón 100%, orange 100% and pineapple 100% . Then leaves Yacón 90: orange shell 10; leaves Yacón 80: orange shell 20¸ leaves Yacón 70: orange shell 30 and leaves Yacón 60: orange shell 40 and the same mixtures and levels but using pineapple shell. These mixtures were stored at ambient temperature in small plastic bags of around 1 kg fresh matter for a period of 42 days. At the end of the fermentation period, samples were taken for analysis of nutritional quality (dry matter, crude protein, in vitro digestibility of dry matter) and fermentation parameters (pH, ammonia nitrogen). The experimental design was completely randomized, eleven treatments and three replicates. Variables were analyzed by the GLM procedure of SAS.

**Results and Discussion**

*Fermentation parameters.*

pH: there was a difference between the treatments for pH ($P < 0.001$). The best pH value it had orange shells to 100% (3.7), followed by mixtures higher values to 4.0 and the 100% control Yacón and pineapple shells (100%) with the highest values (5.30 vs 5.39) respectively.

Ammonia nitrogen: values also differ significantly. The highest value was for 100% Yacón and mixtures had intermediate values.

*Nutritive value.*

Dry matter: difference was found between the treatments (P <0.001). The most content of DM was pineapple shells (26.3% vs 16%) of Yacón and orange shells. The mixtures with orange had the second-order, and finally mix with pineapple.

Crude protein: shows significant difference between treatments. The highest value for the Yacón 100% (19.1%), the mixtures had intermediate values and the lowest values were for controls with orange and pineapple (10.1 and 7.1%) respectively.

In vitro digestibility of dry matter IVDMD: differences were significant. More digestible silages were orange and pineapple shells (93.1 vs 75.9%) and the least digestible was Yacón with (52.06% IVDMD). The mixtures had intermediate values around 62%.

**Conclusions**

The utilization of Yacón in different mixtures show an interesting use as ensilage, because the use of mixed Yacón leaves these levels fermentation byproducts ensures adequate as long as the inclusion levels Yacón sheet not exceeding 80%, since the use of either orange or pineapple byproducts can be used but the orange is who shows better fermentation parameters and nutritional quality. This shows that the silages of these materials have great potential for use in animal feed.

**Utilization of elder *Sambucus nigra* silage as a supplement for dairy cattle in the Colombian High Tropic**

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**Introduction** The cattle production occupies the first line of importance in the livestock sector. This productivity is seriously affected by climate variability, which sometimes forage availability decreases and hence is diminished the milk production, logically affect the income of producers from different regions of the country. In this situation, it is important to promote the conservation of forage as a management option to be interesting to try decrease spread negative effects. The use of silage, forage supply provides leverage this in the rainy season, to be delivered in the summer. Colombia has a wide diversity of plants, which has not been fully studied, and it has an interesting potential for use in animal feed and agro-industrial by-products, which generate target problems and can also be used in cattle feed. As a result of this, the plant species known high tropical own Colombia known Elder (*Sambucus nigra*) and the use of products such as corn and potato mash evaluate as few know their effect silage as animal feed supplement. The aim of this study was to determine the nutritional value and fermentation parameters by silage of forage elder mixed with corn and potato by-products and their effect in animal feeding and dairy production.

**Material and Methods** Elder leaves were cut 90 days regrowth and 2 years of establishment. Two trials were realized.

*Trial 1*. Eight treatments and four replicates per treatment were evaluated. The elder leaves were chopped and mixed with corn bran and potato bran, at inclusion levels of 20, 40, 50 and 60% respectively. These mixtures were stored in 1 kg for 42 days. At the end of the fermentation period, samples were taken for analysis of nutritional quality (dry matter, crude protein and gross energy) and fermentation parameters (pH, ammonia nitrogen and its relation with total nitrogen). The experimental design was a 2x4 factorial, (Factor A: corn bran vs potato bran; Factor B: 20, 40, 50 and 60% inclusion level of corn bran or potato bran). Data were analyzed using the GLM procedure of SAS.

*Trial 2.*Eight crossbred Holstein × Normande cows, between 100 and 200 days of lactation were used in two treatments in the San Miguel Farm, Mosquera, Cundinamarca, Colombia. Treatment 1 with four cows that did not receive in silage and corn bran Elder, of trial 1 selected. And in the treatment 2, supplementation included silage. The animals had two assessment periods each of 14 days, with 7 days for adaptation and 7 days evaluation. Variables were evaluated milk production, milk quality: protein, fat and total solids, and the concentration of urea in milk. The experimental design was a Latin square. The data variables were analyzed with ANOVA and to detect differences between treatment means was employed Tukey's test in SAS. Version 9.2 of 2008.

**Results and Discussion**

*Trial 1.* Inclusion of corn bran resulted increased ($P<0.001$) dry matter (60.83 vs 19.38%) and gross energy concentrations (4.4 vs 3.9 Mcal/Kg) as compared to inclusion of potato bran. Inclusion of potato bran resulted in increased ($P<0.001$) crude protein (16 vs 12 %) as compared to inclusion of corn bran. The ratio of ammonia nitrogen/total nitrogen was greater for the potato bran treatments (14.4 vs 6.8%). There was no difference in pH but the critical value of pH and water activity required for stabilizing a silage were not sufficient in the elder leaves with potato bran silage because the DM values were low (DM 19% and pH 4.47) while in the elder leaves with corn bran silage the DM values were high (DM 60% and pH 4.39) which indicates the silage was stabilized. The DM, CP and GE values increased ($P<0.05$) with inclusion level of corn bran in the silage while with the inclusion level of potato bran these variable decreased ($P<0.05$).

*Trial 2.* Milk production for each treatment did not present significant difference. The milk production average was 11.3 liters/cow/day. There was also no difference in terms of quality of the milk, or for fat, protein, lactose, total solids. Likewise, milk urea nitrogen did not present significant difference.

**Conclusion**

The results of fermentation and nutritional quality showed that elder leaves is a good option when mixed with corn bran 50% may be a viable alternative to be used as a dietary supplement for dairy cows. The utilization de corn bran and elder silage don´t show difference when were offered to cows.

**Clostridium control during the fermentation of sugarcane silages added with lime**

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**Introduction** Sugarcane silage has a predominantly alcoholic fermentation, which is associated with high dry matter (DM) and net energy losses. Therefore, chemical and microbial additives have been recommended to mitigate nutrient losses. Lime is a chemical additive recognized to inhibit yeast growing and improve DM recovery of sugarcane silages (Schmidt, 2009). However, several studies have reported high contents of butyric acid in sugarcane silages added with lime. Furthermore, farmers and nutritionists have observed a poorer performance than that expected for feedlot cattle fed diets based on sugarcane silage added with lime. It suggests that despite the benefits on nutrient preservation (throughout yeast inhibition), lime would favor clostridium growth and disimprove the hygienic quality of silages. Thus, the aim of this study was to compare strategies to prevent clostridium grow in sugarcane silages added with lime.

**Materials and Methods** Sugarcane variety IAC 93-3046 (12 mo. regrowth, 18°Brix) was harvested and ensiled in 20 L plastic buckets. Treatments were Control: no additives; L: 1.5% lime; L + LP: 1.5% lime + *Lactobacillus plantarum* Ma 18/5U ($5\times10^5$ cfu/g fresh forage); L + LB: 1.5% lime + *Lactobacillus buchneri* 40788 ($5\times10^5$ cfu/g fresh forage); L + N: 1.5% lime + 0.07% sodium nitrite; L + B: 1.5% lime + 0.15% sodium benzoate. At ensiling and opening, samples were collected to determine pH, microbial counts (yeasts, lactic acid bacteria and clostridia), DM, soluble carbohydrates (SC) and buffering capacity (BC). Fermentability coefficient was calculated as: $FC = DM(g/kg) + [80 \times SC(g/kg) / BC(g/kg)]$. Acetic acid and butyric acid were determined by gas liquid chromatograph and lactic acid by a colorimetric method. Data were analyzed as a completely randomized design and means compared by Tukey test ($\alpha = 0.05$), using the mixed procedure of SAS.

**Results and Discussion** The composition of fresh and ensiled forages are shown in Table 1. As expected, untreated fresh forage had adequate DM, SC and BC, thus a suitable FC. However, lime addition led to increased BC, which in turn increased the risk of clostridium growth (Weissbach, 2011). Therefore, L, L+N, L+LB and L+LP treatments had higher counts of clostridia than the control, whereas L+B silage showed intermediate counts. The alkaline nature of lime raised the sugarcane pH, enabling clostridium growth. Consequently, treated silages had two- to three-fold more butyric acid than the untreated silage. Even the high content of lactic acid accumulated in lime treated silages was not enough to prevent clostridium grow, which was not expected based on traditional data. None of additives combined with lime were able to afford silages with low clostridium counts. Even the anti-clostridia effect of nitrite (Woods et al., 1981) did not offset the loss of hygienic quality of silages caused by lime. A higher dose of sodium nitrite should be further tested. Although clostridium count was fairly for L+B, butyric acid concentrations still high and there is no reason for combining those additives, because several studies has showed that sodium benzoate by self is good enough to preserve sugarcane as silage (Schmidt, 2009). Finally, the threshold developed by Weissbach to anticipate the run of silage fermentation (FC ≥ 450 denotes anaerobic stable silages) cannot be used for sugarcane, because all fresh forages presented FC greater than 450 whereas still having butyric fermentation.

**Table 1** Composition of fresh sugarcane and sugarcane silages

| Item[1] | Treatments[2] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Fresh forage* | C | L | L+B | L+N | L+LB | L+LP | | |
| DM, g/kg | 266 | 291 | 287 | 285 | 281 | 280 | | |
| pH | 5.95 | 10.05 | 10.38 | 9.62 | 10.38 | 9.61 | | |
| BC, g lactic acid/kg DM | 21 | 161 | 155 | 162 | 151 | 179 | | |
| SC, g/kg DM | 387 | 401 | 392 | 378 | 393 | 407 | | |
| FC | 1830 | 480 | 480 | 470 | 490 | 460 | | |
| LAB, log cfu/g | 4.94 | 3.85 | 4.52 | 4.94 | 5.4 | 3.48 | | |
| Yeasts, log cfu /g | 5.00 | 3.00 | 3.60 | 3.90 | 4.32 | 4.18 | | |
| Clostridia, log cfu/g | 3.81 | 3.40 | 3.00 | 3.60 | 3.78 | 3.70 | | |
| *Silages* | C | L | L+B | L+N | L+LB | L+LP | SEM | *P* |
| DM, g/kg | $224^{c}$ | $249^{b}$ | $266^{a}$ | $257^{ab}$ | $253^{b}$ | $252^{b}$ | 2.7 | <0.01 |
| pH | $3.62^{c}$ | $4.78^{ab}$ | $4.54^{ab}$ | $4.83^{a}$ | $4.41^{b}$ | $4.51^{ab}$ | 0.9 | <0.01 |
| SC, g/kg DM | 28.0 | 30.8 | 30.5 | 53.6 | 34.1 | 37.1 | 6.6 | 0.13 |
| LAB, log cfu/g | 7.52 | 7.82 | 8.13 | 7.9 | 8.62 | 7.44 | 2.1 | 0.06 |
| Yeasts, log cfu/g | $2.70^{ab}$ | $2.60^{ab}$ | $<2.0^{b}$ | $3.16^{a}$ | $3.56^{a}$ | $3.84^{a}$ | 3.2 | <0.01 |
| Clostridia, log cfu/g | $3.26^{c}$ | $6.74^{a}$ | $4.41^{bc}$ | $5.24^{b}$ | $5.96^{a}$ | $4.63^{b}$ | 2.9 | <0.01 |
| Lactic acid, g/kg DM | $35.3^{c}$ | $71.2^{b}$ | $91.5^{b}$ | $56.2^{b}$ | $115^{a}$ | $86.7^{b}$ | 3.6 | <0.01 |
| Acetic acid, g/kg DM | 75.4 | 72.3 | 76.7 | 62.8 | 82.0 | 68.6 | 4.2 | 0.07 |
| Butyric acid, g/kg DM | $6.70^{b}$ | $19.4^{ab}$ | $13.8^{ab}$ | $22.3^{a}$ | $14.3^{ab}$ | $21.8^{ab}$ | 3.5 | <0.01 |

[1]DM: dry matter, BC: buffering capacity, SC: soluble carbohydrates, FC: fermentability coefficient, LAB: lactic acid bacteria.

[2]C: control, L: 1.5% lime, L+LP: 1.5% lime + *L. plantarum* ($5\times10^5$ cfu/g), L+LB: 1.5% lime + *L. buchneri* ($5\times10^5$ cfu/g), L+N: 1.5% lime + 0.07% sodium nitrite, L+B: 1.5% lime + 0.15% sodium benzoate.

**Conclusions** None of additives combined with lime were able to provide butyric acid free silages.

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**Physical composition of corn plants under different seed treatments aiming silage production**

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**Introduction** The initial development and posterior improve in the performance of silage and grain corn culture many times is given by the use of agricultural defensives in the seed treatment, which provides some conditions of protection and productive potential to the plant.

The use of organomineral fertilizer in seed treatment and/or leaf application have being an option to potentiate the physiological development of the plant. There is also a great significance in the use of these fertilizers when is desired to obtain high yields and quality of the harvested product, being able to contribute for the stability of the system, improving the organic material levels in the ground, encouraging the producer to persist in the direct planting system (Santana, 2012).

This research had the objective of evaluate the physical composition variation of corn plants under different seed treatment aiming silage production.

**Materials and Methods** The research was conducted at the Animal production center (NUPRAN) of the environmental and agrarian sector of the Universidade Estadual do Centro-Oeste (UNICENTRO), Guarapuava, PR. The climate of Guarapuava, PR, is the Cfb (subtropical humid mesothermal), without a dry season, with warm summers and moderate winters as the Köppen classification, in altitude of nearly 1.100 m, mean annual precipitation of 1.944 mm, mean annual minimal temperature of 12.7°C, mean annual higher temperature of 23.5°C and air relative humidity of 77.9%.

It was evaluated the biomass production, physical composition and dry matter levels of the hybrid silage corn: SG 6030Y. The corn (*Zea mays*, L.) culture was implanted in October/November of 2012, in the direct planting system. In the tillage was utilized the between lines space of 0.4 m, depth of 4 cm and seeds distribution per meter looking for a final density of 80 hundred plants.ha$^{-1}$, in a total area of 6400 m$^2$. The base fertilizing constituted by 500 kg.ha$^{-1}$ of NPK in the formulation 08-30-20 ($N$-$P_2O_5$-$K_2O$), and in coverage, 30 days after the implantation were applied 160 kg.ha$^{-1}$ of N, as urea (45-00-00). The corn crop management, until 30 days after the plants emergence, involved practices for weed control utilizing herbicide based in *Atrazina* and *Simazina* (Siptran: 7.5 L. ha$^{-1}$) and the insecticide based in *Lambdacyhalothrin* (Karate: 150 ml.ha$^{-1}$) for the control of *Spodoptera frugiperda.*

For collecting the plants was made divisions in 3 blocks per seed treatment (conventional and organomineral), where in each block 3 plants has been collected, randomly, resulting in a total of 9 plants for the conventional sample and 9 for the sample with the additional seed treatment. All of them were measured and weighted for determination of the plant high and ear high (m) and the productive potential of fresh and dry matter and grains (.ha$^{-1}$). Plant composition was determined by components segmentation: stems, leaves, bracts more cobs and grains, were selected two plants from 9 of each sample, and that one was fragmented separating the components, and the other was completely fragmented. All the fragmentation was realized in the moment of the silage preparing (R4). The whole plant samples and the structural components of each treatment was obtained in a homogeneous and representative way; weighted and dried in an oven at 55°C. After 72 hours in an oven, samples were weighted again for determinate dry matter (AOAC, 1984). Data were submitted to analysis of variance with comparison of means at 5% of significance, by the statistical program SAS (1993).

**Results and Discussion** By the variance analysis, observed in Table 1 there was no significant difference ($P<0.05$), by the F test, in respect as the corn plant components proportion, with or without seed treatment. But related to the fresh biomass, was observed that the use of vegetal hormonal extract increased the biomass and grain productivity, whereas the variation coefficient for fresh and dry biomass.ha$^{-1}$, grains.ha$^{-1}$ and leaf area index was respectively 10.14%, 12.22%, 9.56 % and 10.35%, when comparing with normal treatment.

**Table 1** Stems, leaves, bracts with cobs (B+C) and ears proportion in the dry matter and dry matter level of each plant component, for silage corn under different seed treatments.

| | **Plant composition (%)** | | | |
|---|---|---|---|---|
| | Stem | Leaves | B+C | Grains |
| **Conv. Seed treat.** | 14.0 a | 21.1 a | 24.4 a | 40.5 a |
| **Org. Seed treat.** | 14.1 a | 20.5 a | 25.5 a | 39.8 a |
| **Mean** | 14.08 | 20.80 | 24.95 | 40.16 |
| **CV** | 4.78 | 2.45 | 2.94 | 3.47 |
| **PR>F** | 0.87 | 0.32 | 0.20 | 0.61 |

| | **Dry matter levels (%)** | | | | |
|---|---|---|---|---|---|
| | Stem | Leaves | B+C | Grains | Whole plant |
| **Conv. Seed treat.** | 19.27 a | 28.90 a | 33.46 a | 55.61 a | 34.88 a |
| **Org. Seed treat.** | 19.78 a | 28.76 a | 35.70 a | 55.71 a | 33.34 a |
| **Mean** | 19.52 | 28.82 | 34.57 | 55.66 | 34.10 |
| **CV** | 4.84 | 3.35 | 3.82 | 2.83 | 2.87 |
| **PR>F** | 0.57 | 0.87 | 0.17 | 0.94 | 0.19 |

Letters, in column, followed by different means differ from each other by the F test as 5%.

**Conclusion** In view of the non variant plant composition and dry matter levels in the different component of the plant, in despite of the higher production of fresh and dry biomass and grains, is acceptable to conclude as being the evaluated parameters not relevant to the corn productivity.

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**Bromatological composition of *Brachiaria humidicola* cv. BRS at different harvest ages**

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**Introduction** A product resulting from a selection process that took 18 years, coordinated by Embrapa Gado de Corte (Embrapa Beef Cattle), *Brachiaria humidicola* cv. BRS Tupi was selected based on productivity, vigor, seed production, support ability, and animal performance. When compared to *B. humidicola* cv. Comum, this cultivar has stoloniferous growth and forms bushes, with longer and denser runners, more intense tillering, longer and narrower leaf blades, short rhizomes and streaked leaf sheaths, yellow anthers, dark red stigmas, and visible pilosity in its spikelets. Its average size can reach vegetative height of 50 to 75 cm (Barbosa, 2012). The goal of this study was to evaluate the bromatological composition of *Brachiaria humidicola* cv. BRS Tupi at different harvest ages.

**Materials and Methods** The trial was carried out in a greenhouse in the Department of Soils of the Center of Agrarian Sciences of the Federal University of Paraíba, Campus Areia. The forage *B. humidicola* cv. Tupi was planted in 0.071 $m^2$ vases with light sandy loam. Soil acidity was amended and, after eight days, the seeds were planted in the vases with four holes with five seeds each, taking into account that the cultivar's germination rate is 50%. Twenty days after the plants broke soil, they were pruned and fertilized for their establishment and four plants were left in each vase. Seven days later, they were pruned for uniformity at 10 cm above the soil. Watering was controlled daily by weighing the vases and the soil was kept at 100% field capacity. The treatments consisted of harvesting the forage at 14, 28, 42, and 56 days. Dry matter, crude protein, mineral matter, neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin contents were determined. The study used a completely randomized design with four treatments (harvest ages of 14, 28, 42, and 56 days) and five repetitions. Tukey's test ($P<0.05$) and regression equations were used.

**Results and Discussion** The dry matter data fit a linear equation $Y=15.49+0.25x$ ($R^2= 0.98$) as expected since the dry matter productivity increased as the plants grew older. However, these results did not match those by Costa et al. (2011), who evaluated *B. humidicola* cv. BRS Tupi between 14 and 42 days of growth and found a quadratic behavior in the dry matter yield with the maximum value estimated at 39.1 days. The mineral matter data fit a linear regression $Y=7.54 – 0.05x$ ($R^2= 0.87$), which showed lower mineral matter content as the plants were older at harvest. The crude protein data fit the quadratic regression equation $Y=0.012x^2 – 1.2317x + 37.84$ ($R^2= 0.99$), in which the lowest point was recorded at 51 days of age. The high crude protein contents found at 14 days are related to the initial vegetative growth stage of the forage. According to Van Soest (1994), the reduction in cell content and consequent reduction in the crude protein content in the forages take place as they grow older. The data of the fiber fractions (NDF and ADF) and lignin did not fit the regression equations (Table 1). An increase ($P<0.05$) was found in the NDF fraction as the plants grew more mature. This result was expected due to the increase of the cell wall components. The ADF levels also increased ($P<0.05$) between 14 days and the other harvest ages and no difference was found after 28 days of harvest. The lignin levels were lower ($P<0.05$) at 14 days when compared to the other harvest ages. The high values found for the other harvest ages reduce the forage’s nutritional value. According to Van Soest (1994), the close physical association between lignin and cell wall polysaccharides are the main factors limiting the access of the microbial enzymes to this substrate, which will reduce the digestibility of structural carbohydrates and thus lower the forage’s nutritional value.

**Conclusions** According to the bromatological composition evaluation, *Brachiaria humidicola* cv. BRS Tupi, at 28 or 42 days of growth, can be used as roughage for animals.

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**Table 1** Fiber contents of *B. humidicola* cv. BRS Tupi at different harvest ages

| Variable (%) | Harvest ages (days) | | | | |
|---|---|---|---|---|---|
| | 14 | 28 | 42 | 56 | CV (%) |
| Neutral detergent fiber | 61.54 c | 73.00 ab | 71.66 b | 77.06 a | 3.19 |
| Acid detergent fiber | 28.87 b | 40.88 a | 40.15 a | 42.50 a | 3.64 |
| Lignin | 3.17 b | 5.05 a | 5.12 a | 5.43 a | 9.62 |

Different letters in the line differ by Tukey’s test (P<0.05).
CV= coefficient of variation

# Fermentation profile of Tifton-85 (*Cynodon* spp.) haylage

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**Introduction** Silages with high dry matter content, called haylages, are widely used in animal feeding in several countries in Europe, including equine diets as an alternative do hay, as reported by Müller and Udén (2007). The purpose of haylage is to preserve the fodder plant pre-dried and packed under vacuum (Bergero et al., 2002). The method or pre-drying before ensilage favors the fermentation process since it inhibits the growth of undesirable bacteria given that clostridia are particularly sensitive and require damp conditions to develop, while lactic acid bacteria are resistant to low moisture and are able to take over fermentation in these conditions (McDonald et al., 1991). The goal of this study was to assess the fermentation profile (at 0 [fresh grass], 1, 3, 7, 14, 28, and 56 days) of Tifton-85 (*Cynodon* spp.) haylage produced in tropical conditions.

**Materials and Methods** The grass plant was harvested at 30 days of growth and wilted until it reached 70% of dry matter, which was determined through sampling in a microwave oven. After drying, the forage was immediately collected and inoculated with a biological additive containing *Lactobacillus plantarum* and *Pediococcus pentosaceus* according to the manufacturer's recommendations. In order to make the haylages, 1.3 kg of green matter were stored in polyethylene bags, which were then vacuum-sealed according to the technique recommended by Kung Jr. et al. (2010). Each sample was mixed with distilled water at a 1:1 ratio and frozen for 24 hours so that the aqueous fraction was obtained. After this period, the material was thawed and the liquid was extracted with the use of a hydraulic press. The levels of volatile fatty acids (acetate, butyrate, and propionate), lactic acid, pH, and ammoniacal nitrogen ($N\text{-}NH_3$) were determined. The study followed a completely randomized design with four repetitions. The statistical model $Y_{ij} = \mu + T_i + e_{ij}$ was adopted, where $Y_{ij}$ = observation of treatment "i" in repetition "j"; $\mu$ = overall average; $T_i$ = effect of the time of opening, being "i" = 0, 1, 3, 7, 14, 28, and 56 days; $e_{ij}$ = experimental error. The formula $\log_{10} x + 100$ was used to transform the data of acetic, propionic, and lactic acids. Duncan's test ($P<0.05$) was used for VFA data and lactic acid and SNK ($P<0.05$) was used for pH and $N\text{-}NH_3$.

**Results and Discussion** Although pH was high, no differences were found ($P>0.05$). However, it must be pointed out that haylage pH cannot be compared to that of other silages since the dry matter is very limiting to the bacterial fermenting ability, although this resistance to pH reduction must also be considered along with other factors such as the buffer ability of fodder plants. In the current research, the high dry matter content led to higher resistance to pH reduction by limiting bacterial activity. Therefore, the wilting down to 70% of dry matter determined the lower intensity of the fermentation process. This result matches those of McDonald et al. (1991), who stated that the increase in pH that takes place due to the increase in dry matter content has a direct effect on the total count of lactic acid bacteria and the fermentation rate. According to Müller (2005), pH means only a restriction in fermentation and is not related to low quality silage. Higher acetic acid levels were found at 56 days, which was similar ($P>0.05$) at 14 days. This result is likely associated to the activity of heterofermentative bacteria at this stage of the silage and these concentrations are important to maintain haylage quality after the bag is opened since acetic acid has antifungal properties. The lactic acid content was higher (P<0.05) after 28 days of silage, again showing the slowing down of the fermentation processes as a consequence of the high dry matter content. According to Andrade and Melotti (2003), the more lactic acid in relation to acetic and butyric acids is produced, the less energy is spent to produce heat and form gases and the more pleasant to the animals the ensiled forage is regarding flavor and aroma. Butyric acid levels close to zero were found in the haylage, which indicates good quality, although the levels of this acid is not the only parameter to assess ensiled forage quality. Müller (2005) points out that haylages with high dry matter content have low levels of organic acids and high pH when compared to haylages with low DM content, and that these can be considered indicators of bad preservation. Thus, the standard used to evaluate haylage fermentation parameters must be different of those recommended for silages with high moisture content.

**Conclusions** Tifton-85 (*Cynodon* spp.) haylage had good fermentation quality over the period assessed, having adequate preservation status.

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**Table 1** Fermentation profile of Tifton-85 (*Cynodon spp.*) haylage

| Variable | Treatment (days) | | | | | | | CV |
|---|---|---|---|---|---|---|---|---|
| | Fresh grass | 1 | 3 | 7 | 14 | 28 | 56 | (%) |
| % $N\text{-}NH_3$/ total N† | 0.39 c | 0.41 c | 0.67 bc | 0.73 bc | 1.04 ab | 1.24 a | 1.10 ab | 29.81 |
| pH† | 5.48 a | 6.08 a | 5.19 a | 5.53 a | 5.37 a | 5.42 a | 5.21 a | 7.41 |
| Acetic acid* (g $kg^{-1}$ DM) | 0.91 b | 1.17 b | 0.60 b | 2.02 b | 2.14 ab | 1.85 b | 2.79 a | 34.54 |
| Propionic acid* (g $kg^{-1}$ DM) | 0.27 a | 0.10 b | 0.03 b | 0.11 b | 0.08 b | 0.10 b | 0.08 b | 66.67 |
| Butyric acid* (g $kg^{-1}$ DM) | 0.77 a | 0.70 ab | 0.18 c | 0. 36 c | 0.42 bc | 0.23 c | 0.20 c | 50.14 |
| Lactic acid* (g $kg^{-1}$ DM) | 2.26 cd | 0.35 d | 3.01 cd | 10.24 bc | 11.44 ab | 16.16 a | 26.06 a | 46.62 |

† Different letters in the line differ by SNK test (P<0.05).

* Different letters in the line differ by Duncan's test (P<0.05).

CV = coefficient of variation

**Chemical composition and *in vitro* digestibility of corn silages produced in different stages of maturity**

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**Introduction** Silage is a common method of preserving forage and is based on the conversion of carbohydrates into organic acids (mainly lactic acid) by the action of lactic acid bacteria under anaerobic conditions. As a result, the pH decreases and the forage are preserved against deterioration caused by microorganisms (McDonald et al., 1991). According to Filya (2004), the stage of maturity when the plant is harvested can be considered the main determinant of the nutritional value of silage. Thus, our objective was to evaluate the influence of maturity stage of corn plants on chemical composition and *in vitro* digestibility of corn silages.

**Material and Methods** A corn hybrid BM3061 was harvested in five maturity stages: without milk line (WML), 1/3 of milk line (ML), 1/2 ML, 2/3 ML and black layer (BL), corresponding to 261.3; 290.9; 321.1; 340.2 and 385.8 g of dry matter (DM)/kg fresh matter (FM). When established the ideal harvest (although observing reduction of the milk line in the grain), all plants of the sub-plot corresponding to the stage of maturity for silage were harvested and cut in particles close to 2.0 cm. As experimental silos were used PVC tubes (4 L; specific mass between 540-605 kg FM/$m^3$). After 55 days of ensiling, the silos were opened and samples were taken for characterization of silages. The DM, ash, organic matter (OM), total nitrogen (TN) and ether extract (EE) were determined following the recommendations of AOAC (1996). The crude protein (CP) content was obtained by the product between the TN and the factor 6.25. Contents of neutral detergent fiber (aNDF) and acid detergent fiber (ADF) were measured using the techniques described by Van Soest et al. (1991). Lignin content was determined after solubilization the cellulose in 72% sulfuric acid (Van Soest and Robertson, 1985). Total carbohydrates (TC) were calculated according to Sniffen et al. (1992). In assessing the *in vitro* digestibility of OM conducted a test *in vitro* gas production for 72 hours following the procedures described by Mauricio et al. (1999). From the test *in vitro* gas production, the *in vitro* organic matter digestibility (IVDOM) was calculated according to the following equation: IVDOM (g/g of OM) = 14.88 + (0.889 * PG24h) + (0.045 * CP) + (0.065 * MM); where: PG24h = gas production obtained after 24 hours of incubation, CP, and MM expressed in g/kg DM. Experiment was conducted in a completely randomized design. The test of *in vitro* gas production was conducted as split plot, where the factor of plots was the treatments, and the factor attributed to the sub-plots was the time, with four replicates. Data were subjected to ANOVA using the software SISVAR® and the treatment means were compared by Tukey test at 5% significance level.

**Results and Discussion** The OM contents were changed by stage of maturity; however, there was not standardization among the data. As for the CP content, silage produced with plants harvested in 1/2 ML stood out for having the highest value, although it was not significantly different stages of 1/3 ML and BL (Table 1).

The levels of CHO were changed by the maturity stage, noting only difference between stages 1/2 ML and 2/3 ML. These results are due more to the fact that variable to be calculated using the discount of CP, EE and MM, as there was no difference in the NDF. Overall, it was observed that with the advancement of the maturity stage, the coefficients of IVDOM decreased (Table 1). Plants harvested in less advanced phenological stages have higher sugar content, which have a high digestibility; however, with the advance of maturity, the more soluble compounds are translocated to the stem of the plant, in order to assist in sustaining the same, diminishing digestibility coefficients (Moore and Jung, 2001).

**Table 1** Chemical composition (g/kg of DM) and *in vitro* digestibility (g/g of OM) of corn silages produced at different stages of maturity.

| Item* | WML | 1/3 ML | 1/2 ML | 2/3 ML | BL | CV (%) | P value |
|---|---|---|---|---|---|---|---|
| Ash | 43.6[ab] | 39.2[ab] | 44.0[ab] | 37.2[b] | 45.3[a] | 7.94 | 0.0150 |
| OM | 956.3[ab] | 960.7[ab] | 955.9[ab] | 962.7[a] | 954.6[b] | 0.35 | 0.0150 |
| CP | 55.5[b] | 61.6[ab] | 69.7[a] | 52.9[b] | 59.2[ab] | 10.41 | 0.0160 |
| EE | 28.6 | 33.9 | 29.9 | 29.0 | 29.0 | 16.09 | 0.5250 |
| CHO | 872.2[ab] | 865.1[ab] | 856.2[b] | 880.8[a] | 866.3[ab] | 1.05 | 0.0221 |
| aNDF | 526.5 | 559.0 | 556.1 | 532.3 | 546.7 | 4.02 | 0.1989 |
| ADF | 288.9 | 274.8 | 314.4 | 280.9 | 315.1 | 7.71 | 0.0670 |
| Lignin | 52.7 | 47.7 | 59.2 | 53.9 | 47.8 | 13.8 | 0.1890 |
| IVDOM | 0.584[ab] | 0.631[a] | 0.562[b] | 0.532[bc] | 0.491[c] | 4.57 | <0.001 |

*Means followed by different letters differ by Tukey test (P<0.05). WML = without milk line; BL = black layer.

**Conclusions** There is no marked change in the chemical composition of corn silages because of the maturity stages. Corn silages produced from high moisture plants show higher coefficients of *in vitro* organic matter digestibility.

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**Chemical composition of corn silages inoculated with lactic acid bacteria and *Bacillus subtilis***

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**Introduction** Silage is a common method of preserving forage and is based on the conversion of soluble carbohydrates into organic acids (mainly lactic acid) by the action of lactic acid bacteria (LAB, as *Lactobacillus plantarum*) under anaerobic conditions. As a result, the pH decreases and the forage are preserved against deterioration caused by microorganisms. However, silages resultant of homo-fermentation presents low aerobic stability. Therefore, inoculants containing heterofermentative LAB, such as *L. buchneri* are used to improve the aerobic stability of the silage by producing high levels of acetic acid (inhibit action of yeasts and molds). *Bacillus subtilis* is used to control aerobic spoilage because this bacterium produces substances anti-microorganisms (e.g. bacteriocins) (Katz and Demain, 1977). However, the combination of the homo and heterofermentative microorganisms may improve the silage quality. Thus, our objective was to evaluate the chemical composition of corn silages inoculated with lactic acid bacteria and *B. subtilis*.

**Material and Methods** The hybrid Impacto Víptera (Syngenta) was harvested with average of 403 g/kg of dry matter (DM) and chopped by a conventional forage harvester to 0.5 cm. The treatments evaluated were: control (uninoculated); forage inoculated with *L. plantarum* MA18/5U and *L. buchneri* CNCM I-4323 at a rate of $1x10^5$ cfu/g fresh forage (LB + LP); forage inoculated with *L. plantarum* MA18/5U and *B. subtilis* AT553098 at a rate of $1x10^5$ cfu/g fresh forage (BS + LP). Inoculants were dissolved in water (0.7 L/t) and then applied with spray mounted on the fresh forage under constant mixing. The similar amount of water was applied in control silage. Three silos were filled with 40 t of corn forage each. Inoculation and packing was completed on the same day. After 88 days of ensiling, the silos were opened and samples were taken for determination of DM, mineral matter (MM), organic matter (OM), total nitrogen (TN) and ether extract (EE) contents following the recommendations of AOAC (1996). The crude protein (CP) content was obtained by the product between the TN and the factor 6.25. Neutral detergent fiber (aNDF) content was estimated using the techniques described by Van Soest et al. (1991). The total carbohydrates (CHO) and non-structural carbohydrates (NSC) contents were calculated according to Sniffen et al. (1992). Data were analyzed using a completely randomized design with 12 replicates using the MIXED procedure of SAS (v. 9.0). The treatment means were compared by Tukey test at 5% significance level, and tendencies between 5 and 10%.

**Results and Discussion** Corn silages inoculated with LAB and *B. subtilis* presented higher DM content (Table 1). This result is more related to the DM content in the moment of harvest of corn plants (Control = 379.0; LB + LP = 394.2; BS + LP = 435.5 g/kg of DM) than the inoculants applications. We observed difference in relation to ash and OM contents, where the BS + LP silage presented higher OM content and lower ash content than control and LB + LP silages. Silage still presented higher EE, CP and CHO contents in relation the LB + LP silage. Inoculants containing homofermentative LAB such as *L. plantarum* are often used to control the ensiling fermentation by rapid production of lactic acid and the consequent decrease in pH (Filya, 2003). The rapid decreases of pH values can inhibit the action of spoilage microorganisms in anaerobic condition, and ensure the chemical characteristics of the forage used in the ensiling process, and consequently the silage quality. However, the *B. subtilis* is used to control spoilage because mainly by production of substances anti-microorganisms (Katz and Demain, 1977). Already the *L. buchneri* presents higher effect after opening of the silos because of the acetic acid concentration. This inoculant also can change the fiber content because of the ferulic acid production from some strains (Nsereko et al., 2008), although the *L. plantarum* and *B. subtilis* also can produce this enzyme (Cavin et al., 1997; Donaghy et al., 1998). However, this result was not observed in this research.

**Table 1** Chemical composition (g/kg of DM) of corn silages inoculated with lactic acid bacteria and *Bacillus subtilis*.

| Item | Control | LB + LP | BS + LP | SEM[1] | P-value |
|---|---|---|---|---|---|
| DM | 345.6[c] | 362.1[b] | 392.0[a] | 0.324 | <0.0001 |
| Ash | 51.7[a] | 50.0[a] | 29.5[b] | 0.446 | 0.0004 |
| OM | 948.2[b] | 950.0[b] | 970.4[a] | 0.446 | 0.0004 |
| EE | 34.6[ab] | 33.1[b] | 37.1[a] | 0.108 | 0.0366 |
| CP | 92.7[b] | 91.3[b] | 96.8[a] | 0.127 | 0.0121 |
| CHO | 821.2[ab] | 810.7[b] | 836.0[a] | 0.461 | 0.0017 |
| aNDF | 372.3[a] | 392.4[a] | 382.8[a] | 0.642 | 0.1024 |
| apNDF[2] | 331.1[b] | 339.8[ab] | 352.4[a] | 0.623 | 0.0663 |
| NSC | 492.3[a] | 473.6[a] | 484.9[a] | 0.711 | 0.1751 |

Means followed by different letters differ by Tukey test (P<0.05).
[1]SEM = standard error of the mean; [2]apNDF = NDF corrected for residual ash and protein.

**Conclusions** The microbial inoculation did not changed the chemical composition of corn silages.

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## Nutritional value of corn silage harvested at 121 days after emergence in R4 stage, under the effect of different planting densities

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**Introduction** Corn silage has great importance in the production chain of cattle being fundamental in intensified systems. The quest for technologies that increase the yield of corn for silage should be constant, but great attention must be given to the silage quality result, and this will reflect in the performance of the animals fed. The increase in plantation density is one of the most efficient methods of raising the interception of solar radiation by the community of corn plants, and consequently increase their production (Demetrius et al., 2008). But at very high densities changes may occur in the plant as reduced grain fraction, leading to a decrease in the quality of the silage. Therefore, this work aimed to evaluate the impact of different planting densities on level of neutral detergent fiber (NDF), detergent fiber (ADF), hemicellulose, ash and total digestible nutrients (TDN) in silage resulting.

**Materials and Methods** The experiment was conducted at the Department of Animal Production (NUPRAN), Department of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO) in Guarapuava, PR. Temperate climate of altitude - Cfb. no dry season, with cool summers and mild winter according to the Köppen classification, The soil of the experimental area is classified as Oxisol the experimental area has been used in recent years with pastures annual cycle in the winter season, and corn and soybeans in the summer season. The contents of neutral detergent fiber (NDF), using heat-stable α amylase, acid detergent fiber (ADF) and ash, according to Van Soest et al. (1991). The hemicellulose was obtained by difference between NDF and ADF. The levels of TDN were obtained via equation [TDN% = 87.84 - (0.70 x ADF)] suggested by Bolsen (1996), and crude protein (CP) by the micro Kjeldahl method, hybrid used was SG-6030 YG grown in different planting densities (45, 55, 65, 75 and 85 000 plant/ha), and seeded in October in plots with a total area of 28.8 $m^2$ (4, 8 mx 6.0 m) was used to assess the quantitative and qualitative floor area of 16 $m^2$ (3.2 mx 5.0 m), the between line spacing used was 0.8 m. The plants were harvested, chopped and packed in PVC silos, with dimensions of 0.5 m long and 0.1 m diameter, equipped with valve "Bunsen". The silos were open 35 days after silage production, and these samples were dried in a forced air oven at 55 ° C for 72 hours ground in a mill type "Wiley," sieve of 1 mm mesh and used for laboratory testing. Data were subjected to analysis of variance comparison of means at 5% significance level, through the SAS (1993).

**Results and Discussion** Table 1 presents bromatolological parameters silage hybrid LG 6030-YG harvested at 121 days after emergence, the developmental stage dough, with a mean value of plant dry matter of 36.4. Only the NDF values differed significantly from the other parameters, and was lowest for the intermediate densities of 55 and 65 thousand plants per hectare, according to Alvarez et. al. (2006) low plant populations favor the formation of a more fibrous stem which can raise the NDF. Likewise, Barbosa et al. al. (1995) concluded that high plant densities are associated with a reduction ear fraction of the plant, which consequently increases the NDF silage resulting in agreement with the data presented in the study. The data show the versatility of hybrids tested, cultivated in different planting densities, for keeping up with NDF content below 50%, the FDA below 30%.

**Table 1** Nutritional value of corn silage hybrid SG-6030YG harvested at 121 days after emergence(DAE) plants, under the effect of different planting densities

| | Planting density of SG-6030YG (plants/ha) | | | | | |
|---|---|---|---|---|---|---|
| Constituents, % DM | 45000 | 55000 | 65000 | 75000 | 85000 | Mean |
| Crude protein | 6.86 [a] | 6.63 [a] | 6.15 [a] | 6.91 [a] | 6.48 [a] | 6.61 |
| Neutral detergent fiber | 47.11 [a] | 47.32 [a] | 45.39 [b] | 46.31 [b] | 48.38 [a] | 46.70 |
| Hemicellulose | 18.59 [a] | 17.98 [a] | 15.08 [a] | 17.45 [a] | 18.66 [a] | 17.55 |
| Acid detergent fiber | 27.52 [a] | 29.34 [a] | 30.30[a] | 28.86 [a] | 29.71 [a] | 29.15 |
| Ash | 2.19 [a] | 2.21 [a] | 2.30 [a] | 2.36 [a] | 2.23 [a] | 2.26 |
| TDN | 68.58 [a] | 67.30 [a] | 66.63 [a] | 67.64 [a] | 67.04 [a] | 67.44 |

[a,b]Means within a row with different superscripts differ by Tukey test at 5%.

**Conclusion** The densities of 65 and 75 thousand plants per hectare provided a decrease in NDF content of the resulting silage, indicating that for the hybrid GS-6030YG this population of plants provide a silage with higher potential for intake.

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# Nutritional value of corn silage of different hybrids harvested at 133 days after emergence plants

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**Introduction** Corn silage is consecrated as a food of high importance in ruminant feed. Currently there is a wide range of different corn hybrids for this purpose, and these materials is sought covering a high productivity per unit area, and also that they confer a high quality of food produced. Thus the agronomic characterization of genetic material available in the market is essential so that you achieve a high nutritional value of silage (ROSA et. al 2004). There is great variability in corn genotypes offered and it becomes an obstacle to the planning of the crop, the research in this area becomes important to evaluate these differences to enable the producer and technical information for the best choice of hybrid be planted. The aim of this study was to evaluate the nutritional value of silage from different corn hybrids evaluated at 133 days after emergence (DAE) plants.

**Materials and Methods** The experiment was conducted at the Department of Animal Production (NUPRAN), Department of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO) in Guarapuava, PR. Temperate climate of altitude - Cfb. Was determinated the values of neutral detergent fiber (NDF), using α amylase heat-stable, acid detergent fiber (ADF) and ash, according to Van Soest et al. (1991). The levels of total digestible nutrients (TDN) were obtained via equation [TDN% = 87.84 - (0.70 x ADF)] suggested by Bolsen (1996), and crude protein (CP) by the micro Kjeldahl method. The hybrids used were 6030 YG SG, LG PRO 6036, PRO 6038 LG, BRAS 3010, PL 6880 and PL 1335. Sowing of corn hybrids was conducted in plots with total area of 12 m2 (2.4 mx 5.0 m) was used to assess the quantitative and qualitative floor area of 6.4 m2 (1.6 mx 4.0 m). The spacing used was 0.4 m, and a population of 75000 plants per hectare. The plants were harvested, chopped and packed in PVC silos, with dimensions of 0.5 m long and 0.1 m diameter, equipped with valve "Bunsen". the silos were open 32 days after silage production, and these samples were dried in a forced air oven at 55 ° C for 72 hours ground in a mill type Wiley, sieve of 1 mm mesh and used for laboratory testing. Data were subjected to analysis of variance comparison of means at 5% significance level, through the SAS (1993).

**Results and discussion** In Table 1 are presented bromatological parameters of silages from different hybrids harvested at 133 days after emergence (DAE), the developmental hard dough stage, with a mean value of plant dry matter of 32.84%. The hybrids evaluated differed significantly only for the percentage of NDF content being this higher for the hybrid LG 6036 and 3010 BRAS, intermediate for hybrid PL 1335, and lower in hybrid LG 6038 PRO, SG 6030YG and PL 6880. According to Gomes et al. (2004) values of NDF below provide a higher digestibility of silage in question, which can positively influence the performance of the animals fed the same. In the remaining parameters silages showed no variation, Alvarez et. al. (2006) evaluating different hybrids also found no differences in CP, whereas for NDF levels there was variation in the different hybrids, and argues that this feature in particular is directly related to the particle passage rate through the digestive tract, and the lower the level of NDF the higher the dry matter intake, this being a very important characteristic for the assessment of different hybrids.

**Table 1** Nutritional value of corn silage harvested at different hybrid DAE 133 plant.

| Constituents, %DM | LG 6038 PRO | LG 6036 PRO | SG 6030 YG | BRAS 3010 | PL 6880 | PL 1335 | Mean |
|---|---|---|---|---|---|---|---|
| Ash | 1.83 [a] | 1.86 [a] | 2.06 [a] | 1.74 [a] | 1.62 [a] | 1.56 [a] | 1.78 |
| CP | 6.33 [a] | 6.28 [a] | 5.77 [a] | 6.30 [a] | 5.98 [a] | 5.54 [a] | 6.03 |
| NDF | 54.92 [b] | 59.40 [a] | 54.13[b] | 58.98 [a] | 54.04[b] | 56.26[ab] | 54.92 |
| ADF | 28.86 [a] | 28.49 [a] | 31.78 [a] | 28.58 [a] | 29.01 [a] | 28.32 [a] | 28.86 |
| TDN | 67.64 [a] | 67.89 [a] | 65.60 [a] | 67.84 [a] | 67.53 [a] | 68.01 [a] | 67.42 |

[a,b]Means within a row with different superscripts differ by Tukey test at 5%.

**Conclusions** The hybrid LG 6038 PRO, SG 6030YG and PL 6880, stood out from the others by presenting lower value of NDF, which may confer a higher digestibility of silage made with these materials.

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## Bromatological composition of vaquero grass in the summer in different storage systems

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**Introduction** Ruminants feeding is based mainly on forage crops, but in order that the animals' performances get suitable, they should be offered to grasses of high nutritional quality. Tifton 85 (*Cynodon* spp) is of *Cynodon* and stands out due to its high dry matter yield and crude protein content (Carvalho et al., 2000). Vaquero grass has been under prominence among hay producers because of its favorable morphological characteristics such as thin stems, which allow some fast dehydration. There is little scientific information about vaquero grass (*C. dactylon*) as its bromatological composition in tropical conditions as grazing and hay. Thus, this study aims at evaluating the contents of acid detergent fiber (ADF), neutral detergent fiber (NDF) and crude protein (CP) of vaquero grass before cutting time, at baling time and 30 days after its storage in a closed and open shed.

**Material and Methods** The trial was carried out in a hay producing farm in the municipality of Marechal Cândido Rondon - PR, whose coordinates are 24º 26' and 24º 46' South latitudes and 53º 57' and 54º 22' West longitudes, respectively. Vaquero grass has been cropped for two years exclusively for hay production and it is fertilized with swine wastewater from the farm. The grass cutting was carried out on November 10$^{th}$, 2012 with a mower conditioner with free swinging flail fingers, whose residual height was 5 cm from the ground when vaquero grass was 40 days age of resprouting. After a dehydration period of a 44 hour haying, fodder was baled. After baling, bales were stored for 30 days in open and closed sheds. Vaquero grass samples were collected before cutting, at baling time, 30 days after storage in open shed and samples with 30 days of storage in a closed shed. The experimental design was in randomized blocks with 4 treatments (cutting, baling, after 30 days of storage in closed shed - with sidewalls and 30 days after storage in open shed - without sidewalls) and 5 replications. The samples were wrapped in paper bags, taken to an oven with forced ventilation and kept at 55 ºC for 72 hours. After a pre-drying period, they were ground in a Willey mill type, with a 30-meshed sieve and packed in plastic bags for later bromatological analysis. The NDF and ADF determinations were in accordance with Van Soest and Robertson (1985) and to determine crude protein and Kjeldahl method was used according to AOAC (1990). NDF, ADF and CP contents were compared by Tukey test at 5% probability.

**Results and Discussion** There were no significant differences ($P > 0.05$) among the evaluation times and storage systems for ADF and NDF values (Table 1). Castagnara et al. (2011) observed 84.93% NDF contents for Tifton 85 and 40.87% for ADF at 42 days of resprouting in the summer. Such values were higher than those ones obtained in this study with vaquero grass (average values - 69.2% to NDF and 36.75% for ADF). For crude protein answer, at cutting time, vaquero grass showed a higher answer ($P<0.05$) when compared to other answers concerning times and storage systems. There was a decrease on crude protein content after 30 days of storage in a closed shed when compared to the other treatments (P<0.05). Castagnara et al (2011) obtained 10.87% CP for Tifton 85 at 42 days of regrowth.

**Table 1** NDF (%) ADF (%) and crude protein (%) values of Vaquero grass in the summer

| Parameters | Cutting | Baling | Storage in open shed | Storage in closed shed | CV% |
|---|---|---|---|---|---|
| NDF | 69.40*ns | 70.40 | 66.6 | 70.4 | 6.09 |
| ADF | 35.00 *ns | 37.20 | 36.80 | 38.00 | 5.10 |
| CP | 18.18a | 16.13ab | 17.03ab | 15.32b | 7.39 |

Averages followed by different letters in the row differ by Tukey test (P> 0.05).
* ns = not significant.

**Conclusions**: Vaquero grass can be recommended for hay production, but, it should be stored in open shed in order to keep unchanged its protein content.

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**Dehydration curve of Vaquero grass during summertime**

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**Introduction** Haying is one of the most versatile activities in preserving fodder when it is properly stored (Reis et al., 2001). The basic principle of haying is mostly based on preserving the nutritive value of fodder by fast dehydration, since the respiratory activity of plants and microorganisms is stopped. The fast dehydration can maintain fodder quality, which results in hay with high nutritive value (Calixto Junior et al., 2007). According to Mizubuti et al. (2006), the most available grasses for hay production are from *Cynodon* spp, whose main representative is Tifton 85 bermudagrass. There are also high productions of dry matter, crude protein content (Carvalho et al., 2000), fast growth during the summer and resistance to cold in the winter. Several cultivars of *Cynodon* sp have emerged in the market as options for hay production as Vaquero grass and Jiggs. Based on the structural features, Vaquero grass has thin stems, so its dehydration is faster when compared to Tifton 85 bermudagrass, hence, it has wide acceptance by hay producers. Thus, this study aimed at evaluating the dehydration curve of leaves, stems and whole Vaquero grass plant (*Cynodon dactylon* L.).

**Material and Methods** The trial was carried out in a farm that has been producing hay in Marechal Cândido Rondon municipality, PR, Brazil. The hay cutting was carried out on November 10$^{th}$, 2012 with a mower with free swinging nylon flail fingers, whose residual height was 5 cm from the ground when Vaquero grass was at resprouting age of 36 days. The dehydration curve was determined with sample collections from the whole plant and part of them were separated into leaf and stem in seven times. Time 0 corresponded to sample taken before cutting, obtained at 7:30 PM (DST) (time 0) and, on the other days, the procedures were at 08:30 AM, 1:30 PM and 5:30 PM. The evaluated times were at 0, 13, 18, 22, 37, 42 and 44 (baling time) after cutting. The experimental design for dehydration curve was in randomized blocks with subdivided plots over time with three parts of collection in plant height to determine DM (whole plant, leaf and stem), seven collection times as subplot and five replications. The leaves and stems were then wrapped in paper containers duly weighed and the same occurred to determine the dry matter of the whole plant. Then, the material was taken to an oven with forced ventilation and kept at 55 ºC for 72 hours. After this period, the dried samples were removed from the oven and weighed again, so that dry matter content of each sample could be determined. The stem diameter was evaluated using a digital caliper, based on the median region of the first internode. Data were submitted to analysis of variance and when there was a significant answer by F test, the dry matter contents were studied throughout dehydration period by regression analysis, with the model choice that would show a minimum significance of 5% by t test and the highest coefficient of determination ($R^2$).

**Results and Discussion** Changes in DM Vaquero grass were observed at different times after cutting (Figure 1), with rehydration of plants in the morning due to dew. During cutting time, the dry matter yield of Vaquero grass was 3500kg/ha. Dehydration in different parts of the plant also showed differences ($P<0.05$), while the leaves showed higher dry matter with an average 65.69%, the whole plant showed an average 58.37% and stem 55.80%.

The time required for baling was 44 hours after cutting when the plant reached 89.10 % dry matter. This value was superior to the one recorded by Castagnara et al. (2011), who observed that Tifton 85 bermudagrass after 45 hours dehydration and with two passages of conditioner and one pile turning, have obtained 80.33% dry matter content. Vaquero dehydration was faster due to its stem diameter, which reported an average of 0.64 mm.

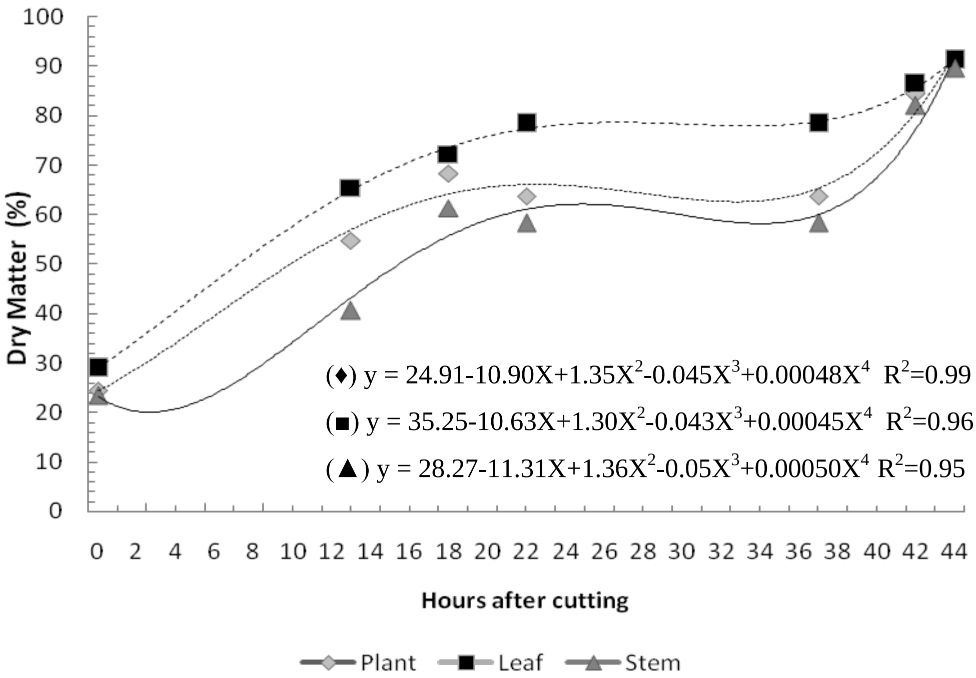


**Figure 1** Dehydration curve of the whole plant, leaf and stem after cutting of vaquero grass

**Conclusions** Vaquero grass has shown fast dehydration, thus, the possibility of losses on field due to rainfalls has decreased.

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**Variability of yield, composition and quality in sorghum hybrids for making silage**

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**Introduction** The use of corn or sorghum silage is a strategic tool for the intensification of livestock systems not only due to its high production potential and quality, but also because of its versatility. However, there are areas of limited rainfall or of marginal soil fertility were the corn crop is risky and of low productivity. Because of its drought tolerance, its safety and high forage production, the sorghum crop is an alternative for making silage mainly in the regions where there is high potential of production and the livestock production is increasing. In Argentine, especially in recent years, a lot of sorghum hybrids are suggested for making silage. The different types of plants according to its main usage destination (grain, forage, bioenergy) will produce differences in yield and quality of the whole plant destined to silage making. This paper aims to determine the variability in the forage productivity, the plant composition and the quality of the whole plant of sorghum hybrids for silage production.

**Materials and Methods** The experiment was conducted at the Agriculture Experimental Station of Manfredi in Cordoba Province, Argentine (latitude: 31º 49’ 12’’, longitude: 63º 46’ 00’’and an altitude of 292 m). In late October 2010, forty five hybrids of different sorghum types were sown in 1200 $m^2$ plots each one with three replicates in a randomized block design. The sowing was 0.52 m between lines and with 16 seeds per lineal meter. The hybrids were grouped into four categories according to the grain yield and treatments would correspond to the following genetic groups: G grain (grain main purpose) n = 20, DP: double purpose (grain and forage) n = 12, S: silage n= 11, and F: forage type n = 2. They were chopped when grain maturity was at paste stage and the % dry matter of the whole plant was near 35%, about 120 days from sowing. Before the silage making, 10 samples of 1 $m^2$ of each hybrid were taken in order to establish the total forage yield (kg DM/ha) and the relative participation of the different fractions of the plant (leaf, stem, grain and Brix grades). Three samples were taken to determine the nutritive value of the silages through NDF, ADF, CP and lignin content. The digestibility and energy concentration were estimated from the ADF. In order to perform a statistical analysis of the results, the data was subjected to an analysis of variance (ANOVA), processed by means of Infostat Professional v2007p, whereas the difference between means obtained for the treatments were determined by the LSD Fisher method.

**Results and Discussion** Rainfall during the growing season was 420 mm. The forage yield (t DM/ha) shows significant differences between the hybrids (with a maximum of 34.6 and a minimum of 16.5) with a coefficient of variation (CV) = 11.4% and between the different sorghum groups as presented in Table 1. There were significant differences in the proportions of the plant components among hybrids and groups. The highest coefficient of variation within all hybrids was in the proportion of grain (44.5%). These differences were reflected in the silage quality as shown in the nutritive values of the silages presented in Table 2. The digestibility shows the lowest CV (3.5%) but the difference between the maximum (73.2%) and the minimum (61.2) is relevant to animal production. There is a decreasing tendency in the silage quality among sorghum groups when grain contain decreases and yield increases, but the variability within the groups do not allow definite conclusions.

**Conclusions** Although there are some tendencies, high variability in yield, composition and quality of sorghum hybrids within and among groups of plant types, require better understanding of the characteristics of each genotype and the purpose of each case to select the best alternative.

**Table 1** Yield, proportion of the plant components and Brix grades of different sorghum hybrids grouped in four types.

| | | Groups of sorghum types[1] | | | | |
|---|---|---|---|---|---|---|
| Item | | G | DP | S | F | All hybrids |
| Yield (kg DM/ha) | average | 19635[a] | 21208[b] | 22217[b] | 25624[c] | 22171 |
| | CV (%) | 9.9 | 12.3 | 15.2 | 49.6 | 11.4 |
| Leaf (%) | average | 16.5[bc] | 16.8[c] | 15.7[ab] | 14.3[a] | 15.8 |
| | CV (%) | 7.9 | 13.6 | 17.9 | 3.1 | 7.2 |
| Stem (%) | average | 30.8[a] | 37.2[b] | 41.9[c] | 72.1[d] | 45.5 |
| | CV (%) | 6.9 | 9.8 | 22.5 | 18.5 | 40.2 |
| Grain (%) | average | 52.7[d] | 46.1[c] | 42.4[b] | 13.6[a] | 38.7 |
| | CV (%) | 4.9 | 9.2 | 20.4 | 94.6 | 44.5 |
| Brix grades | average | 5.8[a] | 8.3[b] | 9.1[bc] | 12.2[c] | 8.9 |
| | CV (%) | 29.2 | 27.1 | 30.5 | s/d | 29.8 |

[1]G: grain; DP: double purpose; S: silage; F: forage
[a-d] Means within a row with different superscripts differ (*P* <0.05)

**Table 2** Nutritional quality of silages in different groups of sorghum hybrids.

| | | Groups of sorghum types[1] | | | | |
|---|---|---|---|---|---|---|
| Item | | G | DP | S | F | All hybrids |
| CP (%) | Average | 7.6[c] | 6.9[b] | 6.9[b] | 5.8[a] | 6.8 |
| | CV (%) | 7.5 | 11.3 | 13.0 | 38.2 | 11.2 |
| NDF (%) | Average | 48.3[a] | 51.8[b] | 51.4[b] | 58.8[c] | 52.5 |
| | CV (%) | 7.3 | 6.8 | 5.4 | 11.7 | 8.6 |
| ADF (%) | Average | 25.4[a] | 28.0[b] | 28.3[b] | 33.5[c] | 28.7 |
| | CV (%) | 9.4 | 9.8 | 8.0 | 20.2 | 11.9 |
| Lignin (%) | Average | 5.2[a] | 5.7[a] | 5.6[a] | 5.0[a] | 5.4 |
| | CV (%) | 12.7 | 15.7 | 13.5 | 29.7 | 5.5 |
| Digestibility (%) | Average | 70.1[c] | 68.3[b] | 68.1[b] | 64.5[a] | 67.8 |
| | CV (%) | 2.4 | 2.8 | 2.3 | 7.3 | 3.5 |
| ME | Average | 2.5[c] | 2.5[b] | 2.5[b] | 2.3[a] | 2.4 |
| (Mcal /kg DM) | CV (%) | 2.4 | 2.7 | 2.3 | 7.3 | 3.6 |

[1]G: grain; DP: double purpose; S: silage; F: forage
[a-c] Means within a row with different superscripts differ (*P* <0.05)

# Degradability and digestibility of different corn grain densities at two maturity stages

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**Introduction** The chemical characteristics of corn make it one of the most widely used forage for dairy cattle in Brazil (Pereira et al., 2004), mainly due to its high production of grains, which provide high-energy diets. In Brazil, the corn kernels are mainly of hard texture (flint), while in the United States they are mostly of soft texture (dent) (Correa et al., 2002). According to Ribas et al. (2007) vitreousness or texture of the grain of corn is associated with the physical structure of the endosperm and starch degradation in the rumen. Correa et al. (2002), found a correlation coefficient of 0.87 ($P < 0.001$) between density and vitreousness, suggesting that the density can be a useful tool to compare vitreousness of corn. The aim of this study was to evaluate the ruminal degradation and in vitro digestibility of corn grain with different densities, in two harvesting points, in Brazilian and American hybrids.

**Materials and Methods** The study was conducted at the Experimental Station of the ABC Foundation, at the city of Castro, Paraná, Brazil, harvest 2011/2012. At point of silage (average 33.5% DM of plant and 57.5% DM of grain) were evaluated 11 Brazilian corn hybrids (FórmulaTL, P30F53H, DKB330, P32R22H, DKB240PRO, P30R50H, AG8041YG, AS1572YG, SG6030YG, P1630H and CD397YG). At the point of harvest of grains (average 90.1% DM grain), in addition to the 11 Brazilian hybrids were imported grains of four American hybrids (P1184HR, Gold B, Croplan 3390VT3 and 2520VT3). The analyzes were performed with three replicates per hybrid. The density of the grain was determined in a laboratory using the pycnometer. Samples were pre-dried in a forced ventilation oven air (60 °C) for 72 hours and ground in a Wiley type knife mill, sieve 1 mm. The *in vitro* digestibility of dry matter (DIV72), was estimated by the methodology proposed by Tilley and Terry (1963), which simulates the rumen degradation (48h) and intestinal digestion (24h), totaling 72 hours. For the evaluation of ruminal degradation (DEG24), the material remained in the equipment incubated for 24 hours. Statistical analysis was performed using SAS 9.3. Data were analyzed by Pearson's correlation coefficient at 5% level of probability.

**Results and Discussion** The density of the kernels of Brazilian corn hybrids ranged from 1.181 to 1.309 g $cm^{-3}$ (mean 1.226 g $cm^{-3}$) and the American hybrids from 1.047 to 1.188 g $cm^{-3}$ (mean 1.114 g $cm^{-3}$). Similar results were obtained by Correa et al. (2002), with the higher density for Brazilian hybrids (1.268 g $cm^{-3}$) and lower for American hybrids (1.201 g $cm^{-3}$).

Both at the point of silage as at the point of harvest of grain, there was no correlation of grain density with ruminal degradability (DEG24) and *in vitro* digestibility (DIV72), as in Figures 1 and 2. These results differ from Correa et al. (2002) who found a high correlation between density of corn grain and starch ruminal degradability. According to Pereira et al. (2004), the effect of the grain texture is more remarkable when the dry matter of the grains is greater than 65%, ie, after the point of silage. In the present work, even at the point of harvest of grain was not checked further degradation or digestibility for hybrids of lower density.

**Conclusions** American hybrids have lower density compared to the Brazilian hybrids. There was no correlation of density with degradability and digestibility of grain both in point of silage as the point of harvest of grain.

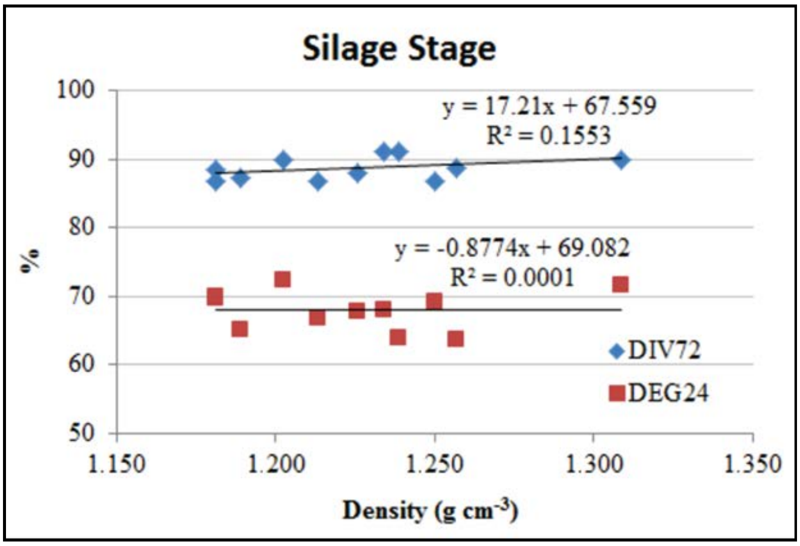

**Figure 1** DIV72, DEG24 of the kernel at point of silage. DIV72: *In vitro* digestibility 72h. DEG24: Degradability 24h.

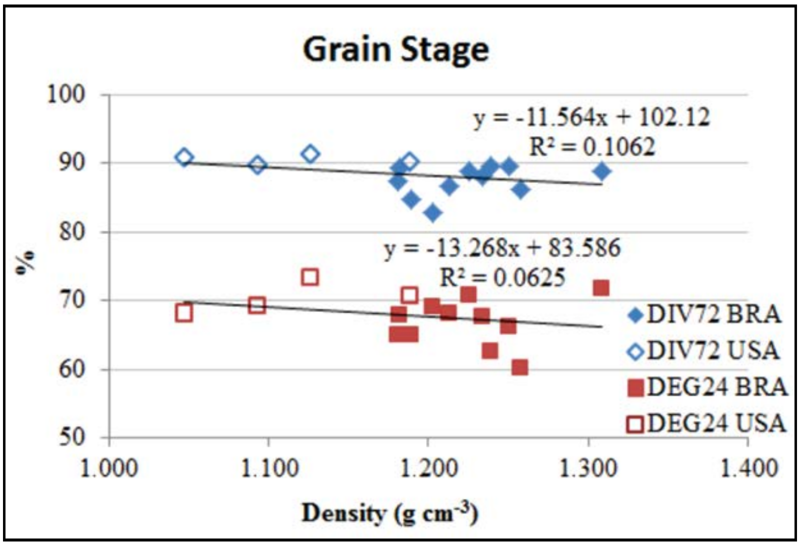

**Figure 2** DIV72, DEG24 of the kernel at point of harvest. DIV72 BRA: *In vitro* digestibility Brazilian hybrids 72h. DIV72 USA: *In vitro* digestibility American hybrids 72h DEG24 BRA: Degradability Brazilian hybrids 24h. DEG24 USA: Degradability American hybrids 24h

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**Heating after ensiling and aerobic stability of corn silage**

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**Introduction** The forage is the main component of ruminant diets (Senger et al., 2005). In the Campos Gerais region, Paraná, corn silage makes up 60-80% of the total dry matter of forages feed to dairy cows (Janssen, 2009). Conserved forages can have their food value changed according to the procedures used for their production and conservation (Jobim et al., 2007). The loss of aerobic stability of the silage results in spoilage and involves heat generation, loss of sugars and release of $CO_2$ and $NH_3$ (Muck et al., 2003). The objective of this work was to study the behavior of the temperature inside the silo and aerobic stability after opening.

**Materials and Methods** The study was conducted on a farm silo in the city of Castro, Paraná, Brazil. The corn hybrid used was P30R50H with dry matter content of 32%. The silage temperature data were collected through five temperature sensors (Model 107) connected to a data collection platform (model CR 1000, Campbell Scientific). The sensors were installed on the day of ensiling and recorded temperature values in 60 minute intervals during the period of 66 days between March 5 and May 10, 2012. The sensors were removed when they were one meter away of the silo panel. The panel temperature was measured on the day of remove of sensors with a digital thermometer type "skewer" (Incoterm brand), in a depth of 0 to 20 cm, in five points. Aerobic stability was evaluated using the methodology proposed by Borreani and Tobacco (2010). This method based on a comparison of the temperature in different parts of the silo panel, with the temperature at the midpoint of the panel, at the depth of 40 to 60 cm. Another indication of the breakdown of aerobic stability is the increase of the pH of silage exposed to air (Jobim et al., 2007). Therefore, the pH was measured on five points of the panel (0 to 20 cm) and inside the silage (40 to 60 cm).

**Results and Discussion** Figure 1 shows the data of temperature inside the silo (average of five points) and the external temperatures (maximum, average, and minimum). The peak of temperature was at 10 days after ensiling, reaching 39.6°C. The temperature variation inside the silo was slow and gradual and did not correlate with the external temperature (ambient).

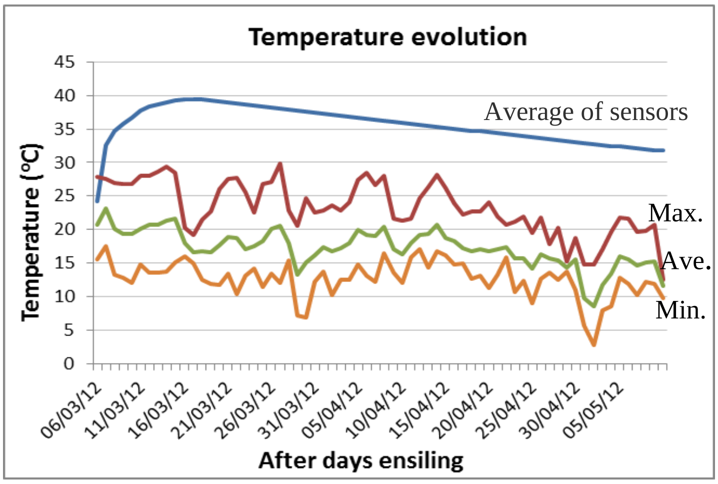


**Figure 1** Average of the five temperature sensors inside the silo and ambient temperature.

Figure 2 shows the data of temperature and pH on five point of the panel and inside of the silo on the day of remove of the sensors. The lower position sensors warmed faster after closing the silo, because the silage on these points was deposited and compacted before. The central sensor took longer to dissipate the accumulated heat. The points on top were lower temperature, indicating faster heat loss to the environment.


**Figure 2** Temperature and pH at the five points on the panel and inside of the silo.

After 66 days the average temperature in the five points at the panel of the silo (0 to 20 cm) was 26.5°C, above the ambient temperature of 11.5 °C. That could mean loss of stability. However, comparing the panel temperature with the internal mass of silage (40 to 60 cm), which was 33.4°C, we can conclude that the silage on the panel was not warming up, but cooling down. Borreani and Tabacco (2010) suggest that the silage temperatures above 5°C related inside of the silo have greater microbial activity, causing further deterioration of silage. The pH of the silage on the five points of panel was low (3.86 to 3.89) and did not differ with pH inside the mass of silage (3.89). The pH was not related to temperature, proving that the silage was stable without deterioration by aerobic microorganisms.

**Conclusions** The temperature of the silage mass has no correlation with the external temperature. With the time, dissipation of the heat accumulated in the mass of silage occurs to the environment, this effect can take months. The methodology proposed by Borreani and Tobacco (2010) was effective in evaluation of the aerobic stability of silage.

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**Morphology evaluation of two corn hybrids for silage in Guarapuava – PR**

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**Introduction** Corn silage is an alternative to bulky food in both intensive, beef or dairy cattle production chain, not only in terms of the indices of crop productivity and stability of production, but also for the great nutritional value and energy concentration (Neumann, 2006). The aim of this study was to evaluate the morphology of two corn hybrids for silage.

**Materials and Methods** In the present experiment, it was evaluated two corn hybrids for silage. The planting was carried out in commercial farm in Guarapuava - PR. The climate according to the Köppen classification is temperate altitude - Cfb (Subtropical humid mesothermal), with mild summers and mild winters with no dry season and severe frosts. The area of the experiment has a soil classified as Oxisol Typical. Were harvested twenty plants of each hybrid in the physiological dough subsequently underwent ratings and processed on the premises of the Center for Animal Production (NUPRAN). The plant height, ear height, plants weight, number of dry leaves and number of green leaves, green matter (GM) and dry matter (DM) production were measured. After this, the material was dried in an oven with forced air circulation at a temperature of 55°C and evaluated after stabilization of biomass dry weight.
The experimental design was a randomized block design with two blocks, two treatments and 10 repetitions. The collected data for each variable were subjected to variance analysis to compare means at the 5% significance through the SAS (2004).

**Results and Discussion:** The data concerning the morphology and composition of dry and green biomass of the two varieties of corn for silage are shown in Table 1.

**Table 1** Morphological composition and production of green and dry weight of two corn hybrids for silage production

| Parameters | Corn Hybrids | | Average | SD[2] | CV[3] (%) |
|---|---|---|---|---|---|
| | 2B688Hx | P30B39H | | | |
| Plant Height (cm) | 216.3 A | 219.2 A | 217.75 | 11.58 | 5.32 |
| Ear Height (cm) | 115.3 A | 116.85 A | 116.08 | 9.47 | 8.16 |
| Plant Weight(kg) | 1.10 A | 0.76 B | 0.93 | 0.27 | 28.83 |
| Green Leaves | 11.5 A | 8.95 B | 10.23 | 2.03 | 19.87 |
| Dry Leaves | 2.8 A | 4.3 A | 3.55 | 1.24 | 34.91 |
| % DM | 35.5 A | 34.7 B | 35.13 | 0.44 | 1.24 |
| Production GM/ha$^{-1}$ (kg)[1] | 77133 A | 52938 B | 65035 | 18750 | 28.83 |
| Production DM/há$^{-1}$ (kg)[1] | 27427 A | 18367 B | 22897 | 6791 | 29.66 |

[1]Production equated to a population of 70.000 plants / ha$^{-1}$
[2]SD = Standard deviation
[3]CV = Coefficient of variation

There were significant differences ($P<0.05$) for the variables weight of plants, green leaves, percentage of dry matter and yield of green biomass and dry biomass per hectare. The weight parameter plant has a direct correlation with the Green biomass, thus, the hybrid 2B688Hx had much higher performance, both in weight, but also with respect to production of green biomass and consequently of dry biomass with respect the hybrid P30B39H being likewise greater than indicated by Beleze et al. (2003) evaluated the morphological characteristics of five corn hybrids for silage. The amount of green leaves is also an important finding, and is directly related to the stay green plant, ensuring greater cropping window for silage production (Wilkinson and Hill, 2003). The hybrid 2B688Hx was also superior in this regard when compared with the P30B39H (11.5 vs. 8.95).

Regarding the production of green biomass and dry biomass corroborate the findings of Pinto et al. (2010) evaluated twelve different hybrids and found that among the hybrids, there was minimal difference in the production of dry matter per hectare, with better performance hybrid TORK. It is the exception that the dry is essential, since it represents the fraction that has the nutrients, which reflect the performance of the animals, so as to beef or dairy production (Berchielli et al., 2011). The dry matter observed in the present study was in agreement with the recommended values for silage, depending on the maturity stage, comprising 32 to 35% of DM according Zopollatto et al. (2009).

**Conclusion:** Through the final analysis, it can be concluded that the hybrid 2B688Hx outperformed the hybrid P30B39H in terms of higher plants and higher weight percentage of dry biomass and green biomass per hectare, and also higher amounts of green leaves.

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# Dry matter intake and digestibility in different maturity stages of corn

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**Introduction** Among forages used for silage production, corn is one of the best options, because of its high capacity of dry matter production, high energy content, relative ease of fermentation in the silo, and good acceptance by feedlot cattle. However, harvesting plants with inadequate maturity may be one of the reasons for low productivity and low nutritional value of the silage. Thus, this experiment was conducted to evaluate the effects of harvesting corn at different maturity stages for silage production on dry matter intake and digestibility of feedlot cattle.

**Material and Methods** The experiment was conducted at the Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais – Câmpus Muzambinho in the city of Muzambinho – MG. The experiment was conducted in a randomized complete block design, in a 2 x 4 factorial scheme, with two hybrids and four maturity stages. The hybrids were Agroceres 4051 (AG 4051) and Pioneer 30F90 (P 30F90) harvested at four maturity stages: without the milk line-(WML), 1/3 of milk line (1/3 ML), 1/2 of milk line (1/2 ML) and 2/3 of milk line (2/3 ML). The statistical analyzes were performed using the statistical software SISVAR and the means were compared by Scott-Knott (5%) test.

**Results and Discussion** It was noted that there was variation in DM digestibility (Table 1). The digestibility was positively correlated with advancing maturity of whole plant corn and there was no effect of hybrids. The highest digestibility coefficients were observed for 2/3 ML stage for both hybrids.

Dry matter intake is shown in Table 2. Regardless of the form of expression of the dry matter intake, the hybrids did not affect consumption, no statistical differences ($P > 0.05$) for silage hybrids studied. An increase in dry matter intake in that evolution occurred on maturation of the whole plant corn for all consumption characteristics evaluated. The best results in dry matter intake in kg / animal / day were obtained on maturation of 1/2 and 2/3 milk line, no differences ($P > 0.05$) from each other, but were different from other.

**Conclusions** Maturity stages for corn harvested for silage influence the performance of Nellore steers on termination. Harvesting maize plants at ½ milk line and 2/3 milk line is recommended for silage production.

**Table 1** *In situ* dry matter digestibility of corn silages according to maturity stages

| Hybrid | Maturity stage | | | | |
|---|---|---|---|---|---|
| | WML | 1/3ML | 1/2ML | 2/3ML | Average |
| AG 4051 | 44.24Ac | 44.14Ac | 52.60Ab | 58.37Aa | 49.84A |
| P 30F90 | 45.19Ab | 51.37Aa | 53.15Aa | 57.69Aa | 51.85A |
| Average | 44.71c | 47.76c | 52.88b | 58.03[a] | |
| CV(%) = 10.93 | | | | | |

CV – Coefficient of variation; ML- Milk Line; WML- Without Milk Line; Averages followed by the same lowercase and uppercase letter in the column and row do not differ by Scott Knott's test (P<0.05).

**Table 2** Dry matter intake (kg/animal/day) of diets containing corn silages at different maturity stages

| Hybrid | Maturity stage | | | | |
|---|---|---|---|---|---|
| | WML | 1/3ML | 1/2ML | 2/3ML | Average |
| AG 4051 | 9.13Ab | 9.29Ab | 10.62Aa | 11.68Aa | 10.18A |
| P 30F90 | 9.12Ab | 10.05Ab | 10.68Aa | 11.58Aa | 10.36A |
| Average | 9.13c | 9.67c | 10.65b | 11.63a | |
| CV(%) = 11.05 | | | | | |

CV – Coefficient of variation; ML- Milk Line; WML- Without Milk Line; Averages followed by the same lowercase and uppercase letter in the column and row do not differ by Scott Knott's test (P<0.05).

# Animal performance and feed conversion with corn silage harvested at different maturity stages

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**Introduction** The strategic use of high quality silage in cattle's feed reflects in significant increase in meat production and reduces feed costs. In this sense it was aimed to evaluate the effect of maize silage harvested at different maturity stages on performance and feed conversion in beef cattle feedlot.

**Material and Methods** The experiment was conducted at the Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais - Campus Muzambinho in the city of Muzambinho – MG, during the months from August to December, 2009. The experimental design was randomized blocks (DBC) in a 2 x 4 factorial scheme, with eight repetitions, two commercial hybrids and four stages of physiological maturity hybrids: Without Milk Line (WML), 1/3 of Milk Line (1/3 ML), 1/2 of Milk Line (1/2 ML) and 2/3 of Milk Line (2/3 ML), totalizing eight treatments and 64 experimental units (constituted by an animal, Nelore uncastrated bull, with an average age of 18 months and average weight of 354.59 kg). To determination of the average daily gain (ADG), the final weight was subtracted from the initial weight and divided by the number of days used for feedlot evaluation. The feed conversion was calculated as dry matter intake (DMI)/ADG. Statistical analyzes were performed using the statistical software SISVAR and the averages were compared by Scott-Knott (5%) test.

**Results and Discussion** It was found that there was change in ADG ($P<0.05$) with the advancement of maturity stage, without effect of hybrids (Table 1). The greatest performances were for the maturity stages 1/2 ML and 2/3 ML. There was interaction between maturity stage and ADG, whereas ADG was positively correlated with increasing grain maturity.
Hypotheses to explain the higher performance in higher stages of maturation would be due to the higher levels of CNF, DM digestibility and higher DMI. In this sense the highest DMI may result in a higher intake of nutrients accumulated in the plant during physiological maturity, as previously discussed.

There was no interaction between maturity stage x hybrid for feed conversion, not significantly different between treatments (Table 2). However, for stages of maturation significant differences were observed ($P<0.05$), on the average of feed conversion of cattle. The stages of maturation of 1/3ML and 1/2ML had the lowest feed conversion.

The economic viability of corn silage is directly related to accumulation of production of dry matter and the nutritional value that ensures adequate fermentation process, better preserving the nutrients that will be available to animals for the best animal performance. In this sense the maturity stage defines the proportion cost/benefit of silage's production.

**Conclusions** Maturity stages for corn harvested for silage influence on the performance of cattle. The crop of the maize plant in advanced stages of maturation, with 1/2 milk line and 2/3 milk line on the seed is a viable option for the production of silage.

**Table 1** Performance of animals fed diets containing corn silage with different maturity stages

| | Stages of maturation | | | | |
|---|---|---|---|---|---|
| **Hybrids** | **WML** | **1/3ML** | **1/2ML** | **2/3ML** | **Average** |
| | Average Daily Gain | | | | |
| **AG 4051** | 1.121Ac | 1.228Ab | 1.415Aa | 1.325Aa | 1.272A |
| **P 30F90** | 0.992Bc | 1.190Ab | 1.345Aa | 1.365Aa | 1.223A |
| **Average** | 1.056c | 1.209b | 1.380ª | 1.345a | |
| CV(%) = 8.05 | | | | | |

CV: Coefficient of variation, ML: Milk Line, WML: Without Milk Line.
Averages followed by the same lowercase and uppercase letter in the column and row do not differ by Scott Knott's test (P<0.05).

**Table 2** Average and coefficient of variation for treatments

| | Stages of Maturation | | | | |
|---|---|---|---|---|---|
| **Hybrids** | **WML** | **1/3ML** | **1/2ML** | **2/3ML** | **Averages** |
| | Feed Conversion | | | | |
| **AG 4051** | 8.17Aa | 7.55Aa | 7.57Aa | 8.86Aa | 8.04A |
| **P 30F90** | 9.27Aa | 8.47Aa | 8.00Aa | 8.57Aa | 8.58A |
| **Averages** | 8.72b | 8.01a | 7.79a | 8.72b | |
| CV(%) = 13.39 | | | | | |

CV: Coefficient of variation, ML: Milk Line, WML: Without Milk Line.
Averages followed by the same lowercase and uppercase letter in the column and row do not differ by Scott Knott's test (P<0.05).

**Losses in silage of *Brachiaria brizantha* cv. Piata treated with different inoculants and doses**

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**Introduction** In most animal production systems, food spending represent most of cost of the production, being necessary the use of appropriate technologies in food production, mainly for the use of unconventional forage as silage, such as grass Piata. Therefore, the uses of microbial and enzyme-microbial inoculants are important for obtaining satisfactory fermentation, ensuring high nutritive value with minimal losses during ensilage these forages. However, there are few accounts in the literature of the use of grass Piata as silage and the use of different inoculants on ensiling unconventional forage. Considering the above, the objective was to evaluate the different inoculants and doses about silage losses in *Brachiaria brizantha* cv. Piata.

**Materials and Methods** The experiment was conducted at the Animal Nutrition and Forage Laboratory - ICAA / UFMT / Sinop, Mato Grosso. The grass Piata was harvested at Embrapa Agrosylvopastoral with equipment suitable for the production of silage, which were prepared using 24 PVC mini silos, with 0.1 m diameter and 0.35m of length, with volume of 2.75 x $10^{-3}$ $m^3$ containing "Bunsen" valves. We evaluated two microbial inoculants with different doses of inoculation, which resulted in treatments: T1 - control (without inoculation), T2: inoculant Silomax Centurium Matsuda at the recommended dose of $5x10^4$ CFU/g; T3: inoculant Sil All C4 (Alltech Brazil) the adjusted dose $5x10^4$ CFU/g (similar to T2), T4: inoculant Sil All C4 (Alltech Brazil) on minimum recommended dose of 9.45 $x10^4$ CFU/g; T5: inoculant Sil All C4 (Alltech Brazil) on average recommended dose of 1.42 $x10^5$ CFU/g and T6: inoculant Sil All C4 (Alltech Brazil) on maximum recommended dose of 1.89 $x10^5$ CFU/g. The composition of enzyme-microbial inoculant Sill All C4 (Alltech Brazil) consists of the *Lactobacillus plantarum, Pediococcus acidilactici*, *Lactobacillus salivarius* and *Enterococcus faecium* bacteria and the amylase, cellulase, xylanase e hemicellulolytic enzymes. The microbial inoculant SiloMax Centurium Matsuda was composed of *Lactobacillus plantarum*, *Pediococcus pentosaceus* and sucrose. Adopted was specific mass average for all treatments 637.74 ± 4.90 kg MN/m³. Compaction occurred with the aid of a wooden bat. The mini silos were sealed with plastic tape and stored the shade for a total period of 365 days. For quantitative evaluation of the effluent produced was placed in the bottom of the silos previously dried sand, stored in little bag made of non-woven fabric (TNT). The measurement of the effluent production was performed by means of the difference weight of the whole silo and TNT little bag with sand, before and after fermentation, relative to the amount of green mass of silage sample. The loss of the MS due to the gas production was determined by the difference between the gross weight of DM silage and opening in relation to the amount of dry silage, discounting the total weight of the whole ensiled the total weight of the silage on opening. The loss of total DM was determined by the difference between the gross weight of DM silage and opening in relation to the amount of dry silage.
The experiment was conducted according to a completely randomized design with four replications for each treatment, which were: control (without inoculation), treatment with the

recommended dose of the microbial inoculant and treatments with adjusted, minimum, average and maximum dose enzyme-microbial inoculant. Performed was the analysis of variance (PROC GLM - SAS), and treatment comparisons performed through the partition sum of the square treatments of the orthogonal contrasts: 5 -1 -1 -1 -1 -1, 1 0 -1 0 0 0, 0 1 0 -1 0 0, 0 1 0 0 -1 0, 0 1 0 0 0 -1. For all statistical evaluations was considering 5% probability of type I error.

**Results and Discussion** In Table 1 are presents the mean values for losses effluent (LEFF), loss of gases (LGAS) and loss of total dry matter (LTDM). The LEFF silages were not influenced (P>0.05) for inoculant doses, being similar to the values observed for the control treatment. This was expected, because the inoculation did not affect the dry matter (DM) of silage to levels that would influence the LEFF, as shown in Table 1. Already the LGAS and LTDM were lower (P<0.01) for inoculant treatments compared to the control treatment. Higher yields of gases are associated with undesirable fermentation promoted by bacteria, such as enterobacteria and bacteria of the genus *Clostridium* sp., and occur more frequently in materials with low moisture and soluble carbohydrates, such as grasses unconventional. Treatment with microbial and enzyme-microbial inoculant tends to increase the desirable bacteria population during the fermentation process, increasing competition with undesirable bacteria, which allows to reduce the production of $CO_2$. Penteado et al. (2006) also observed a decrease in losses by gas silage Mombasa at different regrowth ages with added enzyme-microbial inoculant, resulting in 1.30% loss for gas in MS. In relation to LTDM, it was observed highest values for silage without inoculant regarding the other silages treated, due to the greater amount of gas loss observed for this treatment.

**Table 1** Mean values of LEFF (% DM), LGAS (% DM) and LTDM (%) of grass silage Piata (*B. brizantha*) with different doses of inoculants

| Item | C[1] | RD[2] | AD[3] | MD[4] | ARD[5] | MRD[6] | CV (%) | Contrast *P*-value 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DM[7] | 22.78 | 23.35 | 22.74 | 22.46 | 22.36 | 22.98 | 2.79 | 0.9955 | 0.1919 | 0.0641 | 0.0420 | 0.4216 |
| LEFF | 4.14 | 3.93 | 4.36 | 4.86 | 5.22 | 3.54 | 11.80 | 0.6214 | 0.5140 | 0.1624 | 0.0589 | 0.5642 |
| LGAS | 14.99 | 8.73 | 5.37 | 6.21 | 6.64 | 4.84 | 20.91 | <0.0001 | 0.1066 | 0.2194 | 0.3042 | 0.0649 |
| LTDM | 18.53 | 12.37 | 9.54 | 10.84 | 11.57 | 8.26 | 13.66 | 0.0002 | 0.2184 | 0.5003 | 0.7216 | 0.0799 |

[1]Control (without inoculation), [2] Recommended dose (Silomax Matsuda), [3]Adjusted dose (Sill All C4), [4]Minimum recommended dose (Sill All C4), [5]Average recommended dose (Sill All C4), [6]Maximum recommended dose (Sill All C4), [7]percent (%). Comparisons considering 5% probability of type I erro.

**Conclusion** The addition of enzyme-microbial and microbial inoculant at different inoculation doses reduces losses gases and loss of total dry matter grass silage Piata.

**Chemical composition of *Brachiaria brizantha* cv. Piatã silage with different additives**

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**Introdution** The possibility of using the grass as silage, especially the family of *Brachiaria sp.*, should be studied more intensely because Brazil has large areas of pasture implanted with these species. But, the ensilability of these unconventional grasses can be compromised due to the characteristic of the plant at the time of ensiling, as low dry matter, soluble carbohydrate and high buffering capacity, affecting the fermentation process. The use of additives in the process of ensiling grass unconventional would be an alternative to improve these characteristics. However, there are few studies in the literature with the use of additives for these grasses. Within the context it was used *Brachiaria brizantha* cv. Piatã aiming to evaluate the chemical composition of the silage with different additives.

**Materials and Methods** The experiment was conducted at the Laboratory of Animal Nutrition and Forage UFMT/ICAA, at Sinop, Mato Grosso, in partnership with Embrapa Agrossilvipastoril between the months of May 2012 to November 2012. We used 20 PVC silos with 0.1 m diameter and 0.35 m in height, with a volume of $2.75 \times 10^{-3}$ $m^3$, fitted with "Bunsen" valves. We evaluated five additives in ensiling of Piatã palisade grass, resulting in treatments: T1 – control (no additive), T2 – microbial inoculant Silomax Centurium (Matsuda), T3 – enzyme-microbial inoculant Sil All C4 (Alltech Brazil), T4 – corn meal (10% fresh matter) and T5 – crude glycerin (10% fresh matter). The composition of the enzyme-microbial inoculant Sil All C4 consists of homofermentative bacteria (*L. plantarum*, *P. acidilactici* and *L. salivarius*) and heterofermentative bacteria (*E. faecium*), and the presence of enzymes (amylase, cellulase, xylanase and hemicellulolytic) with inoculation rate for lactic bacteria total of $1.89 \times 10^{10}$ cfu/g for heterofermentative $2.10 \times 10^{9}$ cfu/g. The inoculant Silomax Centurium consists *L. plantarum*, *P. pentosaceus* and sucrose with inoculation rate of $2.5 \times 10^{10}$ cfu/g. The inoculum dose was applied as recommended by the manufacturer. Glycerin was acquired company Fiagril S/A as a byproduct of the manufacture of biodiesel. Glycerin and corn meal containing 89% dry matter (DM). Compaction occurred with the aid of a wooden bat and adopted was specific mass average for all treatments 636.93 kg ± 11 kg de MN/m³.We determined the contents of dry matter (DM), mineral matter (MM), crude protein (CP) (N x 6.25), ether extract (EE), neutral detergent insoluble protein (NDIP) and acid detergent insoluble protein (ADIP), non-fiber carbohydrates (NFC) and hemicellulose as Silva & Queiroz (2002). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) was determined according to Van Soest described by Silva (2002), using α-amylase-term heat stable. The experiment was performed according to a completely randomized design with four replications for each treatment, and comparisons of treatment means performed using the Tukey test at 5% of probability of type I error.

**Results and Discussion** The contents of DM, MM, CP, EE, NDF, ADF, NFC, NDIP, ADIP and hemicellulose are presented in Table 1. The DM content of the inoculant treatments were not significantly changed compared to control. The addition of 10% corn meal and glycerin in natural matter increased the DM content of the silage, possibly due to high DM content of the additives used. The inclusion of inoculant, microbial and enzymatic and corn meal gave higher CP, as it controls the moisture content, soluble carbohydrates and providing desirable microorganisms, with lower occurrence of proteolysis. With the exception of the addition of corn, the inclusion of other additives did not change in NDF silage compared to control. For the treatment with enzyme-microbial inoculant, the values of ADF and hemicellulose are the same as inoculant treatment and the control treatment. This can be possibly explained by the absence of enzyme activity present in the enzyme-microbial inoculant to promote solubilization of cell wall constituents (Coan et al., 2005). For values NDIP and ADIP, treatment with glycerol resulted in higher values of these compounds, possibly the percentage of glycerol additive may have affected the outcome of a particular analysis, as well as the values of ADF.

**Table 1** Average levels of DM, MM, CP, EE, NDF, ADF, NFC, NDIP, ADIP and hemicellulose in *Brachiaria brizantha* cv. Piatã silages treated with different additives.

| Item | Treatments | | | | | CV[7] (%) |
|---|---|---|---|---|---|---|
| | Control | SiloMax[3] | Sil-All C4[4] | Corn meal[5] | Glycerin[6] | |
| DM (%) | 23.88c | 23.39c | 23.24c | 27.74a | 25.65b | 2.47 |
| MM[1] | 7.22b | 8.15b | 8.38b | 7.06b | 9.45a | 6.85 |
| CP[1] | 10.07b | 11.40a | 11.56a | 11.75a | 9.91b | 4.01 |
| EE[1] | 1.97b | 1.53b | 2.05b | 3.31a | 3.24a | 23.68 |
| NDF[1] | 62.48a | 62.89a | 63.36a | 44.90b | 60.11a | 7.14 |
| ADF[1] | 22.02bc | 23.37bc | 24.86b | 20.52c | 29.07a | 7.35 |
| FCN[1] | 18.26b | 16.04b | 14.66b | 32.98a | 17.29b | 20.10 |
| NDIP[2] | 13.04bc | 17.21b | 13.47bc | 10.62c | 29.89a | 17.53 |
| ADIP[2] | 2.16b | 2.73b | 2.50b | 2.10b | 5.70a | 20.88 |
| Hemicelulose[1] | 40.46a | 39.52a | 38.5a | 24.38b | 31.04ab | 12.84 |

[1] % dry matter; [2] % crude protein; [3]microbial inoculant; [4]enzyme-microbial inoculant; [5]10% fresh matter; [6]crude glycerin (10% fresh matter); [7] Coefficient of variation.
Means followed by the same letter in the line do not differ by Tukey test (α = 5%).

**Conclusion** Recommends the inclusion of 10% of corn meal as fed *Brachiaria brizantha* cv. Piata, it promotes better fermentation and nutritive value, and lower dry matter losses.

# Losses in ensiling process of *Brachiaria brizantha* cv. Piatã with different additives

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**Introduction** The Piatã palisade grass was released in 2007 after 16 years of evaluations by EMBRAPA and partners, with support from the Association for Research Funding Tropical Forage Improvement (Unipasto) (Valle et al., 2007). The possibility of using the grass as silage, especially the family of *Brachiarias sp*., should be studied more intensely because Brazil has large areas of pasture implanted with these species. However, requiring the use of appropriate technologies in feed production, mainly for the use of unconventional forage as silage. Within this context, the objective was to evaluate the losses in silage fermentation of *Brachiaria brizantha* cv. Piatã with different additives.

**Materials and Methods** The experiment was conducted at the Laboratory of Animal Nutrition and Forage UFMT/ICAA, Sinop, Mato Grosso, in partnership with Embrapa Agrossilvipastoril between the months of May 2012 to November 2012. We used 20 PVC silos with 0.1 m diameter and 0.35 m in height, with a volume of 2.75 x $10^{-3}$ $m^3$, fitted with "Bunsen" valves. We evaluated five additives in ensiling of Piatã palisade grass, resulting in treatments: T1 – control (no additive), T2 – inoculant Silomax Centurium (Matsuda), T3 – enzyme-microbial inoculant Sil All C4 (Alltech Brazil), T4 – corn meal (10% fresh matter) and T5 – crude glycerin (10% fresh matter). The composition of the enzyme-microbial inoculant Sil All C4 consists of homofermentative bacteria (*L. plantarum*, *P. acidilactici* and *L. salivarius*) and heterofermentative bacteria (*E. faecium*), and the presence of enzymes (amylase, cellulase, xylanase and hemicellulolytic) with inoculation rate for lactic bacteria total of 1.89 x $10^{10}$ cfu/g for heterofermentative 2.10 x $10^{9}$ cfu/g. The inoculant Silomax Centurium consisted of *L. plantarum*, *P. pentosaceus* and sucrose with inoculation rate of 2.5 x $10^{10}$ cfu/g. The inoculum dose was applied as recommended by the manufacturer. Glycerin was acquired from the company Fiagril S/A as a byproduct of the manufacture of biodiesel. Glycerin and corn meal containing 89% dry matter (DM). Compaction occurred with the aid of a wooden bat and adopted was specific mass average for all treatments 636.93 kg ± 11 kg de MN/m³. For quantitative evaluation of effluent production, dried sand stored in a bag made of non-woven fabric (TNT) was placed in the bottom of the silos. The measurement of the effluent production was performed by means of the difference weight of the whole silo and TNT little bag with sand, before and after fermentation, relative to the amount of green mass of silage sample. Gas losses was determined by weight difference and the losses of total DM was determined by the difference between the gross weight of DM silage and opening in relation to the amount of dry silage. The experiment was performed according to a completely randomized design with four replications for each treatment, and comparisons of treatment means performed using the Tukey test at 5% of probability of type I error.

**Results and Discussion** The values of effluent losses, gas losses and dry matter loss, in percent, can be seen in Table 1. For treatment with microbial additive and enzyme-microbial, the effluent losses was not significant compared to the control treatment. When added glycerin silage effluent losses were higher (5.42%), due to its liquid form submission. The lowest values were found with the addition of corn meal (1.67%), it has the function to absorb humidity. The DM content is also relevant to the effluent losses, since the higher the DM content of silage, the lower the moisture content contained on and therefore the lower the effluent losses. These losses are not favorable during the fermentation, because the liquid formed has highly digestible compounds such as soluble carbohydrates, organic acids, minerals and nitrogen compounds soluble reducing the nutritional value of silage (McDonald et al., 1991). Gas losses for treatments with corn meal and enzyme-microbial inoculant were within the limits considered acceptable for silage (1-2% of the total DM losses), since this type of loss is considered inevitable during the ensiling process (McDonald et al. 1991). The values for the total DM losses (%) are dependent on the effluent losses and gas, consequently, higher values of effluent and gas will directly influence the DM loss.

**Table 1** Averages of effluent losses, gas losses and dry matter loss occurred in *Brachiaria brizantha* cv. Piatã silages treated with different additives.

| Item | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Control | Silomax | Sil-All C4 | Corn meal | Glycerin | CV[3] (%) |
| Effluent losses[1] | 3.56b | 3.43b | 3.93b | 1.67c | 5.42a | 14.33 |
| Gas losses[2] | 9.62a | 4.65b | 1.42b | 1.54b | 5.10b | 41.52 |
| Dry matter losses[2] | 12.67ab | 7.96bc | 4.21cd | 3.22d | 10.41b | 26.16 |

[1] % fresh matter; [2] % dry matter; [3] Coefficient of variation.
Means followed by the same letter in the line do not differ by Tukey test ($\alpha = 5\%$).

**Conclusion** Recommends the inclusion of 10% of corn meal as fed *Brachiaria brizantha* cv. Piata, it promotes lower dry matter losses.

## Microbial populations in buffel grass silages added with corn bran

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**Introduction** The process of conservation through grass silage involves the losses of nutritive value due to chemical changes that occur due microbial development and plant enzymatic processes. Several factors affect the fermentative profile and hence the quality silage, among which may be mentioned the original contents of dry matter and soluble carbohydrates and initial number lactic acid bacteria. According to Pereira et al. (2007) the quantification of the number of microorganisms present in the plant and during fermentative process is fundamental to understand the aspects related to the pattern of silage fermentation. Thus, the aim of this research was to quantify the microbial populations of buffelgrass silage added with corn bran.

**Materials and Methods** It was used a pasture of buffel grass (*Cenchrus ciliaris* cv. Biloela) already implanted 28 years ago, at the Pendência Experimental Station, which belongs to the State Company for Agricultural Research of Paraíba. It was used 5 x 5 factorial combination (five levels of corn bran x five fermentation periods), in a completely randomized design with three replications. The levels of corn bran used were 0, 50, 100, 150, 200 g/kg, added based in the natural matter of bran and of grass and the fermentation periods evaluated were 1, 3, 7, 15 and 30 days. At the start of the experiment, conducted a uniformity cut height of 10 cm from the soil and a fertilized with 50 kg/ha of nitrogen as ammonium sulfate. The grass was harvested when had 50 cm of height, with the aid of costal mower, to the 10 cm of soil, and then, chopped in a forage machine stationary previously regulate for the size particles of 2.0 cm. The corn bran was added to the chopped material according with the percentage of each treatment. The material was ensiled in PVC tubes provided with Bulsen valve to exhaust the gas and amount known of sand in the bottom of the silo to capture the effluent. The microbial populations were quantified using selective culture media for each microbial group: Rogosa Agar (Difco) for enumeration of lactic acid bacteria (LAB), Brilliant Green Bile Agar (Difco) for enumeration of enterobacteria, and Potato Dextrose Agar (Difco) for enumeration molds and yeasts. The microbial group enumeration was performed from a 10 g sample silage of each repetition per treatment in different fermentation periods, to which were added 90 mL phosphate buffer and homogenized in industrial blender for 1 minute to obtain a $10^{-1}$ dilution. After that, successive dilutions were performed in order, aiming to obtain dilutions ranging from $10^{-1}$ to $10^{-9}$, once 30 and 300 colony forming units (cfu) were considered to be counted reliable.

**Results and Discussions** The LAB populations in buffel grass silages remained high independently of fermentation periods and levels of corn bran (Table 1). The LAB population showed dominant over other microbial groups reaching 9.69 log cfu/g in seventh day of fermentation. This behavior may be occurred due adequate concentrations of soluble carbohydrates, the mean substrate used in fermentation of these bacteria. For the enterobacteria populations was observed there was reduced development of this microbial group, coming to disappear in fifteenth day of fermentation for all levels of corn bran, except of the 200 g/kg of inclusion. However, on the 28th day of fermentation the populations of this microbial group were detected again in silages treated with 50 and 150 g/kg of corn bran. This behavior is excepted because these microorganisms possess the ability to protect themselves when find under adverse conditions (Pereira et al., 2007). The greater development of LAB and consequent acidification of silage may be associated with reduced growth of enterobacteria. The yeasts and molds populations were present in greater number from the seventh day of fermentation, with a stabilizing tendency between 15th and 30th. This increase from the seventh day of fermentation may be occurred by a major acidification of silage, because greater of lactic acid by LAB, and permanence sufficient concentrations soluble carbohydrates, resulting in a favor environmental for the development of yeasts. The stabilization of molds and yeasts populations from the 15th day of fermentation may be related to the reduction in residual soluble carbohydrates, limiting the development of these microorganisms.

**Table 1** Enumeration of lactic acid bacteria (LAB), enterobacteria and molds and yeasts (MY) in buffel grass silage added with corn bran (CB) and throughout the fermentation period (days)

| Levels CB (g/kg) | Fermentation period (days) | | | | |
|---|---|---|---|---|---|
| | 1 | 3 | 7 | 15 | 30 |
| | LAB (log cfu/g forage) | | | | |
| 0 | 6.34 | 8.36 | 8.70 | 9.29 | 8.34 |
| 50 | 7.44 | 8.84 | 8.39 | 8.97 | 8.01 |
| 100 | 7.57 | 8.53 | 8.81 | 9.13 | 7.55 |
| 150 | 8.06 | 8.25 | 7.78 | 8.41 | 8.58 |
| 200 | 5.09 | 8.44 | 9.69 | 7.68 | 9.37 |
| | ENT (log cfu/g forage) | | | | |
| 0 | 4.16 | 4.21 | ND[3] | ND | 2.04 |
| 50 | 2.59 | 3.30 | ND | ND | ND |
| 100 | 2.31 | 3.50 | 3.25 | ND | 3.27 |
| 150 | ND | 3.89 | 3.89 | ND | ND |
| 200 | ND | 1.99 | 4.26 | 3.43 | 2.49 |
| | MY (log cfu/g forage) | | | | |
| 0 | 5.02 | 5.87 | 5.65 | 5.62 | 5.59 |
| 50 | 3.53 | 5.74 | 5.51 | 6.48 | 6.06 |
| 100 | 4.43 | 4.68 | 6.63 | 6.28 | 6.19 |
| 150 | 2.90 | 5.31 | 6.78 | 6.06 | 5.78 |
| 200 | 4.40 | 5.50 | 8.68 | 6.21 | 5.86 |

**Conclusions** The added of corn bran does not affect the development of microbial population in the ensilage process of buffel grass. The quantification of microbial populations in buffel grass silages are suitable for a good fermentation.

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**Enumeration of fungi and evaluation of losses in buffel grass hay ammoniated with urea**

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**Introduction** Forage availability in semiarid region during the year is desuniform and low production during the dry season, leading to feed shortages in this period of the year. An alternative to solve the problem of seasonality of forage is haymaking, which consists of conservation of nutritional value of forage through rapid dehydration. Allied haymaking, some researchers have used additives in order to improve in the conservation process, as well as the quality of the stored material. The use of urea reduces the growth of microorganisms in hay and can improve the quality of low quality forages, its nutritional value and intake by animals. Another important characteristic of urea is its fungal activity, which provides a reduction in deterioration of hay stored. Thus, the objective was to quantify the population of fungi and to evaluate the losses of buffel grass hay ammoniated with urea.

**Materials and Methods** It was used a pasture of buffel grass (*Cenchrus ciliaris* cv. Biloela) already implanted 28 years ago, at the Pendência Experimental Station, which belongs to the State Company for Agricultural Research of Paraíba. We used a completely randomized design with five treatments and four replications. The treatments consisting by urea levels (0, 5, 10, 20, 40 g/kg) were added the hay bales based in the dry matter. At the start of the experiment, conducted a uniformity cut height of 10 cm from the soil and a fertilized with 50 kg/ha of nitrogen in the form of ammonium sulfate. The grass was harvested when reached 50 cm of height, with the aid of costal mower, to the 10 cm of soil. Subsequently, the material was baled with the aid of a baler wood with dimensions of 25x40x40 cm, height, length and width, respectively. After the confection of the bales, they were weighed and then preceded to treatment with the respective urea levels. The amount of urea by treatment was diluted in 450 mL of water, with the aim of increasing the moisture content of the forage from 150 to 250 g/kg. The application was made through sprinklers, prioritizing the homogeneous distribution in order to ensure that all the material had contact with the solution. Immediately after application, the bales were covered with polyethylene bags sealed with adhesive tape and preventing entry of air. After 60 days of storage proceeded to removal of the bag and the bales were exposed to air for about 4 hours to eliminate ammonia unreacted with the hay. Past four o'clock the bales were weighed again for subsequent calculation of losses. Dry matter recovery storage (DMRs) was calculated by equation bellow:

DMRs (g/kg) = FMas*DMas / FMbs*DMbs * 100, wherein:

FMas = forage mass after storage (kg);

DMas = dry matter after storage (g/kg);

FMbs = forage mass before storage (kg);

DMbs = dry matter before storage (g/kg);

The pH determination was performed according to methodology described by Bolsen et al. (1992). The enumeration of molds and yeasts was performed from a 10 g sample of hay added 90 mL phosphate buffer and homogenized in industrial blender for 1 minute to obtain a $10^{-1}$ dilution. After that, successive dilutions were performed in order to obtain dilutions ranging from $10^{-1}$ to $10^{-7}$. It was used culture media Potato Dextrose Agar, added of 10g/kg tartaric acid at 100 g/kg, after sterilization, for enumeration of molds and yeasts after incubation for 3-7 days at room temperature. The plating was performed in duplicate in sterile Petri dishes. It was considered counted reliable plates with values between 30 and 300 colony forming units (cfu). Data of dry matter recovery and pH were submitted to analysis of variance and regression, using the statistical analyses program SISVAR (Ferreira, 2008).

**Results and Discussion** There was no adjustment of linear models for DMRs and pH values (Table 1), with addition of urea levels in buffel grass hay. It is observe that, except the urea level of 10 g/kg, the urea inclusion reduced in absolute values when compared to the non-ammoniated hay, demonstrating that the ammoniation is not reduced losses during storage. The losses during storage may occur due continuation cellular respiration. It was observed quadratic effect for pH, with highest value observed at urea level 5 g/kg (8.88), reducing the other urea levels. The probable explanation for this fact is that ammonia is a weak base with high buffering capacity and does not act as direct pH modifier, so that the increase addition of urea does not necessarily observed pH increase. The addition of urea levels was effective in reduced molds and yeasts populations, reducing from 6.50 log cfu/g in the hay without addition of urea to 3.65 cfu/g when added 40 g/kg of urea hay demonstrating the fungistatic effect of ammoniation. It was observed higher reduction in the number of molds and yeasts in buffel grass hay, in the levels of inclusion of 20 and 40 g/kg of urea. Almeida et al. (2006), found that addition of 20 g/kg of urea was sufficient to inhibit the growth of fungi in Bahia grass hay (*Paspalum notatum*).

**Table 1** Mean values of dry matter recovery storage (DMRs), pH and molds and yeasts enumeration (MY) in buffel grass hay ammoniated with urea

| Levels of urea (g/kg DM) | DMRs (g/kg) | pH | MY (log cfu/g forage) |
|---|---|---|---|
| 0 | 928.6 | 8.24 | 6.50 |
| 5 | 862.4 | 8.88 | 5.45 |
| 10 | 932.1 | 8.02 | 5.85 |
| 20 | 872.7 | 8.04 | 3.78 |
| 40 | 884.3 | 7.96 | 3.65 |
| CV (%) | 5.16 | 4.34 | - |

CV: Coefficient of variation

**Conclusions** The application of urea has no benefit in related to the losses, however is effective in to reduce molds and yeasts population in storage of buffel grass hay.

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# Sugarcane vinasse as additive for whole-plant corn ensiling

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**Introduction** The additives applied during the ensiling process seek to reduce storage losses and maintain as much as possible the nutritional value of silage. The additives improve the fermentation process through different mechanisms, these include: limit respiration and proteolysis by enzymes of plants, manipulating fermentation and inhibiting the activity of microorganisms such as yeasts and molds and reducing losses due to effluents. The biofuels industry obtained ethanol from fermentation of sugarcane by the action of yeast, producing a residue called vinasse. The vinasse is a mixture of water and organic and inorganic compounds, is characterized by having an acid pH (4.0), high moisture content (82%), a protein content of 7% and high concentrations of organic matter (94 %) (Fernandez et al, 2009). These characteristics, together with its high production and high biochemical oxygen demand suggest that this product can be used as an acidifier and improve the fermentation process during ensiling. The aim of this study was to evaluate the sugarcane vinasse as acidifier in the corn silage production.

**Materials and Methods** Whole plants of corn (*Zea mays*) (ICA-109) were chopped and ensiled in laboratory silos fabricated with PVC tubes (10 cm diameter and 40 cm long). The treatments were: Three levels of vinasse inclusion (3, 6 and 9% of fresh matter) diluted in water at three different concentrations (10, 20 and 30% v/v), for a total of 9 treatments with five replicates each. The vinasse was added by aspersion onto the forage. The silos were opened after 100 days, in the solid fraction were determined the concentrations of dry matter (DM), crude protein (CP), ash, calcium, phosphorus, neutral detergent fiber (NDF) and acid detergent fiber (ADF). On the liquid fraction were determined concentrations of volatile fatty acids (VFA) by gas chromatography, ammonia nitrogen ($N\text{-}NH_3$) and pH with potentiometer (FAO, 2011). Data were analyzed by a 3 x 3 factorial arrangement and Tukey test ($\alpha = 0.05$) was used for comparison of treatment means.

**Results and Discussion** The silages had pH values between 3.5 and 3.6, indicating that an adequate fermentation process occurred. The $N\text{-}NH_3$ concentrations in silages were not altered by the treatments. The values for this variable were between 0.7 and 0.9%, indicating that limited proteolysis occurred during fermentation. The propionic and butyric acids were not detected in the silage. The acetic acid concentration was not affected by the treatment ($P>0.05$). The treatments had no effect on DM content of silages ($P>0.05$). The NDF and ADF concentrations in the silages decreased with the increased participation of vinasse in the treatment ($P<0.05$). However, the hemicellulose content was unchanged by the treatment, demonstrating that the vinasse promoted hydrolysis of cellulose during the fermentation process. The protein percentage was equivalent between treatments. The calcium and phosphorus concentration presented the same trend observed for the protein. The sugarcane vinasse has high amounts of potassium and other minerals for this reason the ash content increased as the level of participation of vinasse was increasing in the silage.

**Table 1** Chemical composition and fermentation profile of silages

| | Percentage of inclusion | | | | | | | | | Efects[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | | 6 | | | 9 | | | | | |
| Concentration, % | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | Inc. | Conc. | Inc. x Conc. |
| DM, % | 17.6 | 18.9 | 17.4 | 17.2 | 17.4 | 18.3 | 17.0 | 18.3 | 19.2 | ns | ns | ns |
| NDF, % DM | 60.8 | 59.9 | 56.7 | 56.8 | 56.8 | 58.2 | 59.8 | 55.4 | 54.8 | 0.02 | ns | ns |
| ADF, % DM | 32.9 | 33.3 | 29.7 | 29.5 | 29.2 | 29.9 | 30.2 | 26.6 | 27.3 | 0.01 | ns | 0.01 |
| Hemicellulose, % DM | 27.8 | 26.6 | 27.0 | 27.3 | 29.6 | 28.3 | 29.5 | 28.8 | 27.5 | ns | ns | ns |
| Crude protein, % DM | 8.2 | 8.5 | 7.3 | 9.2 | 7.4 | 8.4 | 8.9 | 8.4 | 8.6 | ns | ns | ns |
| Ash, % DM | 7.8 | 6.6 | 7.3 | 8.1 | 7.7 | 8.4 | 8.2 | 8.4 | 7.9 | 0.01 | ns | ns |
| Calcium, % DM | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.4 | 0.4 | 0.5 | ns | ns | ns |
| Phosphorus, % DM | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | ns | ns | ns |
| *Fermentation profile* | | | | | | | | | | | | |
| pH | 3.5 | 3.6 | 3.6 | 3.5 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | ns | 0.01 | ns |
| N-NH3, % total N | 0.8 | 0.9 | 0.9 | 0.7 | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | ns | 0.08 | ns |
| Acetic acid, %  DM | 6.5 | 9.8 | 9.5 | 9.9 | 9.4 | 6.1 | 16.5 | 9.4 | 7.8 | ns | ns | ns |
| Propionic acid, % DM | - | - | - | - | - | - | - | - | - | - | - | - |
| Butyric acid, % DM | - | - | - | - | - | - | - | - | - | - | - | - |

[1] Inc. = inclusion; Conc. = concentration; Inc. x Conc. = interaction inclusion x concentration; ns = non significative

**Conclusion** The vinasse inclusion did not have the expected effect on the pH values in the silage. The high potassium, calcium and nitrogen levels in the vinasse could act as buffer during fermentation process, reducing the acidifying power of vinasse.

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**_In vitro_ gas production of corn silages inoculated with _Lactobacillus buchneri_ CNCM I-4323 associated with three ruminal fluids**

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**Introduction** Silages resultant from homofermentation generally presents low aerobic stability. Therefore, inoculants containing heterofermentative lactic acid bacteria (LAB), such as *Lactobacillus buchneri* are used to improve the aerobic stability of the silage by producing high levels of acetic acid (inhibits action of yeasts and molds). This strategy should result in an improvement of silage quality. According to Weinberg et al. (2003), LAB can survive in ruminal fluid and improve animal performance. In this sense, the technique of *in vitro* gas production can be used to evaluate the feed quality and if really these LAB are surviving in ruminal conditions. Thus, our aim was to evaluate the influence of *L. buchneri* CNCM I-4323 inoculation associated with three ruminal fluids on *in vitro* gas production of corn silages.

**Material and Methods** A corn hybrid Impacto Víptera (Syngenta) was sown on 2011, harvested at 279 g/kg of dry matter (DM) on 2012 using a Premium Flex forage harvester. Forages were chopped to achieve a theoretical length averaging 10 mm and ensiled without (control) or with $1x10^5$ cfu of *Lactobacillus buchneri* CNCM I-4323 per gram of fresh forage. Inoculant was dissolved in water (0.7 L/t) and then applied with spray mounted on the fresh forage under constant mixing. The similar amount of water was applied in control silage. Eight silos were filled with 350 kg of corn forage each (remained closed for 229 days). After opening the silos, an *in vitro* assay was performed incubating wet samples (1 g) in a water bath at 39°C in serum bottles (115 mL) with 60 mL buffered rumen fluid, according to Maurício et al. (1999). Rumen fluid was collected from 6 rumen-cannulated sheep in the morning, before feeding. The rumen fluid was filtered through four layers of cheesecloth into pre-warmed thermal-flasks, homogenized and mixed with solution media. The sheep were fed with 70% of corn silage and 30% concentrate, on DM basis. Three different ruminal fluids were used. Two animals fed control silage (Control); two animals fed inoculated silage ($1x10^5$ cfu of *L. buchneri*) (*L. buchneri*); and two animals fed control silage and a daily-dose of *L. buchneri* was applied directly into the rumen ($1x10^7$ cfu of *L. buchneri*/g of silage provided) (rumen applied). Accumulated headspace gas pressure measurements were made using a needle attached to a pressure transducer connected to a visual display (readings after 3, 6, 9, 12, 24 and 48 h post-inoculation). Relative gas production was calculated by dividing the gas production at a given time by the gas production for that bottle at 48 h. Experiment was conducted in a completely randomized design with a 2 x 3 factorial arrangement with eight replicates. All data was analyzed as mixed model with repeated measures in the time using MIXED procedure of SAS (v. 9.0). Differences among means were tested using the LSMEANS statement with the PDIFF option. Significance was declared at 5%.

**Results and Discussion** Gas production in the corn silage inoculated with *L. buchneri* was greatest mainly when incubated with control rumen fluid (Table 1). Gas production technique considers the conversion of all the main rich sources of metabolizable energy, such as pectins, starch, cellulose and hemicellulose into gases. Thus, these results can be explaining by higher non-structural carbohydrates content in the inoculated silage (58.6 *vs*. 55.2 g/kg of

DM in control silage). According to Nsereko et al. (2008), some strains of *L. buchneri* can produce the acid ferulic enzymes that act on the fiber content (reduce or alter the structure). The LAB can survive in ruminal conditions (Weinberg et al., 2003), thus, perhaps the *L. buchneri* can change the profile ruminal microorganisms profiles and improve the utilization efficiency of the silage. In relation to relative gas production, we found values among 75 to 82% of the total gas production after 24 h of incubation.

**Table 1** Gas production of corn silages inoculated with *Lactobacillus buchneri* associated with three ruminal fluids in various times of fermentation (hours).

| Treatments | 3 | 6 | 9 | 12 | 24 | 48 |
|---|---|---|---|---|---|---|
| Gas production, mL/g of organic matter | | | | | | |
| Control silage | | | | | | |
| Control | 30.02 | 44.96 | 64.72 | 85.20 | 161.45 | 211.15 |
| *L. buchneri* | 38.36 | 48.18 | 66.76 | 87.21 | 151.98 | 192.11 |
| Rumen applied | 31.40 | 50.56 | 69.45 | 84.82 | 168.10 | 213.99 |
| Inoculated silage | | | | | | |
| Control | 30.58 | 44.82 | 66.92 | 90.66 | 176.71 | 225.56 |
| *L. buchneri* | 33.08 | 53.77 | 74.91 | 94.08 | 178.09 | 220.18 |
| Rumen applied | 34.68 | 53.89 | 79.36 | 91.75 | 175.69 | 213.01 |
| SEM[1] | 0.526 | 0.593 | 0.640 | 0.740 | 0.908 | 0.803 |
| P-value | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Relative gas production | | | | | | |
| Control silage | | | | | | |
| Control | 0.13 | 0.20 | 0.29 | 0.39 | 0.75 | - |
| *L. buchneri* | 0.18 | 0.23 | 0.33 | 0.43 | 0.76 | - |
| Rumen applied | 0.15 | 0.24 | 0.34 | 0.41 | 0.80 | - |
| Inoculated silage | | | | | | |
| Control | 0.13 | 0.19 | 0.29 | 0.40 | 0.78 | - |
| *L. buchneri* | 0.15 | 0.24 | 0.34 | 0.43 | 0.82 | - |
| Rumen applied | 0.16 | 0.25 | 0.36 | 0.42 | 0.81 | - |
| SEM[1] | 0.003 | 0.002 | 0.003 | 0.004 | 0.005 | - |
| P-value | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | - |

SEM = standard error of the mean.

**Conclusions** Corn silage inoculated with *L. buchneri* present higher gas production. *L. buchneri* applied directly in ruminal fluid increases the gas production in the control silage.

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**End products of *in vitro* fermentation of corn silages inoculated with *Lactobacillus buchneri* CNCM I-4323 associated with three ruminal fluids**

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**Introduction** Silages resultant from homofermentation generally presents low aerobic stability. Therefore, inoculants containing heterofermentative lactic acid bacteria (LAB), such as *Lactobacillus buchneri* are used to improve the aerobic stability of the silage by producing high levels of acetic acid (inhibits action of yeasts and molds). This strategy should result in improve of silage quality. According to Weinberg et al. (2003), LAB can survive in ruminal fluid (*in vitro* conditions) and improve animal performance. Thus, the objective of this trial was to evaluate the influence of *L. buchneri* CNCM I-4323 inoculation in corn silage associated with three ruminal fluids on the end products of *in vitro* fermentation.

**Material and Methods** A corn hybrid Impacto Víptera (Syngenta) was sown on 2011, harvested at 279 g/kg of dry matter (DM) on 2012 using a Premium Flex forage harvester. Forages were chopped to achieve a theoretical length averaging 10 mm and ensiled without (control) or with $1x10^5$ cfu of *Lactobacillus buchneri* CNCM I-4323 per gram of fresh forage. Inoculant was dissolved in water (0.7 L/t) and then applied with spray mounted on the fresh forage under constant mixing. The similar amount of water was applied in control silage. Eight silos were filled with 350 kg of corn forage each (remained closed for 229 days). After opening the silos, an *in vitro* assay was performed incubating wet samples (1 g) in a water bath at 39°C in serum bottles (115 mL) with 60 mL buffered rumen fluid, according to Maurício et al. (1999). In this assay, rumen fluid was collected from 6 rumen-cannulated sheep in the morning, before feeding; the rumen fluid was filtered through four layers of cheesecloth into pre-warmed thermal-flasks, homogenized and mixed with solution media. The sheep were fed with 70% of corn silage and 30% concentrate, on DM basis. Three different ruminal fluids were used. Two animals fed control silage (Control); two animals fed inoculated silage ($1x10^5$ cfu of *L. buchneri*) (*L. buchneri*); and two animals fed control silage and daily-a dose of *L. buchneri* was applied directly into the rumen ($1x10^7$ cfu of *L. buchneri*/g of silage provided) (Rumen applied). At 9 and 48 h, the serum bottles were opened and pH values and volatile fatty acids (VFA) were analyzed. The VFA were determined by gas chromatograph. Experiment was conducted in a completely randomized design with a 2 x 3 factorial arrangement with eight replicates. All data were analyzed as mixed model with repeated measures in the time using MIXED procedure of SAS (v. 9.0). Differences among means were tested using the LSMEANS statement with the PDIFF option, and significance was declared at 5% and tendencies between 5 and 10%.

**Results and Discussion** We observed higher production of total VFA in the corn silage inoculated with *L. buchneri* mainly when incubated with control and *L. buchneri* rumen fluid after 48 h of incubation. As a result, pH values decreased in these treatments as well as when it was compared to the 9 h of incubation. The inoculation in the ensilage resulted in higher production of propionic acid after 48 h of incubation when compared to control silage, and consequently, lower acetate: propionate ratio was observed (Table 1). Even with these challenges, the commercial inoculant produced significant shifts in pH values and *in vitro* end fermentation products, indicating that it had affected the final outcome of silage fermentation. Incubation of control silage with ruminal fluid from animals fed with inoculated corn silage promotes higher acetic acid production.

**Table 1** End products of *in vitro* incubation (9 and 48 h) of corn silages inoculated with *Lactobacillus buchneri* associated with three ruminal fluids.

| Treatments | pH | Acetate | Propionate | Butyrate | AC:P ratio | Total VFA |
|---|---|---|---|---|---|---|
| 9 h | | | | | | |
| Control silage | | | | | | |
| Control | 6.64 | 35.30 | 13.29 | 4.16 | 3.52 | 53.97 |
| *L. buchneri* | 6.62 | 44.57 | 15.09 | 7.08 | 3.10 | 69.99 |
| Rumen applied | 6.62 | 39.59 | 13.38 | 5.68 | 3.28 | 62.28 |
| Inoculated silage | | | | | | |
| Control | 6.60 | 40.74 | 13.19 | 6.06 | 3.51 | 63.33 |
| *L. buchneri* | 6.59 | 40.78 | 14.00 | 6.92 | 3.15 | 64.07 |
| Rumen applied | 6.59 | 41.10 | 13.80 | 5.20 | 3.57 | 61.83 |
| 48 h | | | | | | |
| Control silage | | | | | | |
| Control | 6.59 | 48.94 | 16.62 | 8.76 | 3.06 | 79.45 |
| *L. buchneri* | 6.59 | 60.10 | 18.74 | 11.40 | 3.00 | 92.29 |
| Rumen applied | 6.56 | 56.21 | 18.63 | 10.35 | 3.08 | 102.25 |
| Inoculated silage | | | | | | |
| Control | 6.58 | 67.50 | 19.66 | 11.94 | 3.10 | 115.44 |
| *L. buchneri* | 6.52 | 64.17 | 21.43 | 13.39 | 3.00 | 122.03 |
| Rumen applied | 6.55 | 62.94 | 18.70 | 9.78 | 3.06 | 105.28 |
| SEM | 0.008 | 3.382 | 0.708 | 0.664 | 0.052 | 6.612 |
| Silage (S) | <0.0001 | 0.0006 | 0.0133 | 0.0047 | 0.0467 | <0.0001 |
| Ruminal fluid (RF) | <0.0001 | 0.0713 | 0.0005 | <0.0001 | <0.0001 | 0.0306 |
| S x RF | 0.0099 | 0.0065 | 0.3082 | 0.0014 | 0.1618 | 0.0036 |
| Time | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

SEM = Standard error of the mean; AC:P = acetate: propionate ratio.

**Conclusions** *Lactobacillus buchneri* inoculated in corn silage increased the volatile fatty acids production in an *in vitro* condition.

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**Production of green biomass and dry biomass of silage made from wheat (cv. BRS Umbu) subjected to a regime of cuts in Guarapuava - PR**

R. Carletto[1], M. Neumann[2], J.S. Maculan[3], B. Fianco[4], T.L. Dalmagro[5] and L.K. Cescon[6]

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**Introduction** The use of silages of wheat plants is not traditional in Brazil, however, occur in regions where adverse weather during the winter season, the cultivated off-seasons corn becomes unavailable, being lost if they occur early frosts. Keeping this in view, the use of winter cereals is being preferred by farmers searching for making silage in the winter, as the wheat in many situations has good nutritional values (Bumbieris Jr. et al., 2011) . The use of wheat for dual purpose, both for grain production and yield of silage or grazing animals is presented as an alternative for avoiding large expanses of territorial idle. The existing genotypes have long vegetative period, with good capacity to forage and short reproductive phase, keeping productive stability in terms of yield and quality of grain (Wendt et al., 2006). To obtain whole plant silage winter cereal quality is recommended that the plants are harvested at mature grain in soft, allowing to obtain higher biomass volume, ensuring a good preservation of desirable nutrients route fermentation (Fontaneli and Fontaneli, 2009). In this work, we report results of different biomass yield green and dry matter of silage made from wheat cultivar BRS dual purpose umbu (EMBRAPA), in a regime of cuts in the region of Guarapuava - PR.

**Material and methods** The experiment was conducted at the Center for Animal Production (NUPRAN), Department of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO), in Guarapuava - PR, located in the subtropical zone of Paraná, in the geographical coordinates 25º23'02" south latitude and 51°29'43" west longitude. The planting was realized on May 13, 2011. The fertilizer used was 400 kg $ha^{-1}$ of 04-20-20 chemical fertilizer formula. Besides the basic fertilization, were realized 2 split applications of urea, totaling 280 kg $ha^{-1}$ N. The experimental design was a randomized block design with three treatments (without cut – just one harvest for silage; with one cut – one forage harvest and one silage harvest; with two cuts - two forage harvest and one for silage) and five replications, totaling 15 plots, each plot contained an area of 15 m², with planting carried out on spacing 17 cm between rows, sowing rate of 220 seeds / m² and planting depth of 4 cm. Cultural practices were carried out during the experiment, such as herbicide-based *metyl metsulfuron* (Ally® commercial product: 6.6 g $ha^{-1}$), based insecticide of *Thiamethoxam* + *lambdacyhalothrin* (commercial product ENGEO pleno®: 150 ml . $ha^{-1}$) and the base fungicide *Epoxiconazole* + *pyraclostrobin* (Opera® commercial product: 1 $l.ha^{-1}$). Were harvested when the plants were 30 cm high, lowering it to 8 cm of soil. Each plot had an area of 8 m² evaluated, discarding the borders. With the collected material was estimated production of green biomass per hectare and production of dry biomass, by drying in an oven at 55 °C until the samples reach a constant weight. Data were subjected to analysis of variance and means were compared by Tukey test at 5% probability.

**Results and discussion** Table 1 described the yield of green biomass and dry biomass production of silage made from wheat plants cv. BRS umbu that were submitted to three different management systems (without, with one cut and two cuts). It is evident that the management where we got higher productivity (P <0.05) the system was that there was no cut forage, yielding higher values of green biomass and dry biomass note also that the largest number of cut occurs decrease of the yield both green biomass as dry biomass similar results were found by (Meinerz et al., 2011), where wheat BRS umbu regime without cuts totaled 10,577 kg $ha^{-1}$ of dry biomass. On the other hand, Fontaneli et al. (2009) obtained lower values, equivalent to 6,017 kg $ha^{-1}$ of dry biomass for wheat BRS umbu when silages were made from plants that have been cut.

**Table 1** Production of green biomass and dry biomass at the time of silage production wheat BRS umbu under different management systems

| | Biomass yield, $kg.ha^{-1}$ | |
|---|---|---|
| Treatment | Green | Dry |
| Without cut | 21913 a | 10927 a |
| With one cut | 14625 b | 7989 b |
| With two cuts | 5294 c | 3364 c |
| Average | 13944 | 7476 |
| CV % | 9.24 | 11.94 |
| Probability | < 0.0001 | < 0.0001 |

**Conclusion** With this study it can be concluded that the cultivar studied has great productive potential regarding both the production of green biomass as dry biomass, observing differences in production occurs when the management of cuts aimed at the utilization of forage.

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## Composition of wheat plants (cv. BRS Umbu) destined for silage production, subjected to regimes of cuts in Guarapuava – PR

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**Introduction** Brazil has no tradition in the production of silage from wheat plants, however, in the south of the country, where there are adverse weather during the winter, as excessive rains and frosts, making the cultivation of winter maize unfeasible. Keeping this in view, the use of winter cereals is being seen as an alternative for making silage in the winter, since in many situations the wheat has good weather resistance and nutritional values (Bumbieris Jr. et al., 2011). It is possible to obtain stocks of forage winter cereals, considering that species such as wheat is able to produce about 1.5 to 2.5 times more than non-grain grass silages in temperate regions; some studies show values higher than 10 t ha$^{-1}$ of dry matter (DM). All winter cereals can pass through the ensilage process, but some species without arista are preferred, such as wheat, which also has good value grain / stem-leaf (Lamat, 2005). In this work, we report results of the botanical composition of wheat cultivar BRS dual purpose Umbu (EMBRAPA), subjected to regimes of cuts in the region of Guarapuava - PR.

**Material and Methods** The experiment was conducted at the Center for Animal Production (NUPRAN), Department of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO), in Guarapuava - PR, located in the subtropical zone of Paraná, in the geographical coordinates 25°23'02" south latitude and 51°29'43" west longitude. The planting was realized on May 13, 2011. The fertilizer used was 400 kg ha$^{-1}$ of 04-20-20 chemical fertilizer formula. Besides the basic fertilization, were realized 2 split applications of urea, totaling 280 kg ha$^{-1}$ N. The experimental design was a randomized block design with 3 treatments (without cut – just one harvest for silage; with one cut – one forage harvest and one silage harvest; with two cuts - two forage harvest and one for silage) and 5 replicates, totaling 15 plots, each plot contained an area of 15 m², with planting done in 17 cm spacing between rows, sowing rate of 220 seeds/m² and planting depth of 4 cm. Cultural practices were carried out during the experiment, such as herbicide-based *metyl metsulfuron* (Ally® commercial product: 6.6 g ha$^{1}$), based insecticide of *Thiamethoxam* + *lambdacyhalothrin* (commercial product ENGEO Pleno®: 150 ml.ha$^{-1}$) and the base fungicide *Epoxiconazole* + *pyraclostrobin* (Opera® commercial product: 1l.ha$^{-1}$). Were harvested when the plants were 30 cm high, lowering it to 8 cm of soil. Each plot had an area of 8 m² evaluated, discarding the borders. With the collected material was estimated production of green biomass per hectare and yield of dry biomass for assessment is used to forced air oven at 55 °C until reaching constant weight of the samples. Assessment of plant composition was made by manual separation of the components stem, leaf and ear. Data were subjected to analysis of variance and means were compared by Tukey test at 5% probability.

**Results and Discussion** Table 1 is described the composition and physical structure of wheat plants BRS Umbu when silage production for both treatments. It is possible observe that the occurrence of cuts increased (P <0.05) the presence of ear in silage, reducing the participation of stems and leaves, possibly providing a silage of higher energy value. Meinerz et al. (2011) obtained similar results for wheat cultivars dual purpose, where obtained 16.6% of the leaf blade, stem 42.7% and 40.7% of ears + grains.

**Table 1** Composition and physical structure of the plant at the time of silage production wheat BRS Umbu under different management systems.

| | Participation in the physical structure of the plant,% DM | | |
|---|---|---|---|
| Treatment | Leaf | Stem | Cob |
| Without cut | 37.6 a | 9.6 c | 52.8 b |
| With one cut | 40.2 a | 17.2 a | 42.6 c |
| With two cuts | 28.0 b | 12.6 b | 59.4 a |
| Average | 35.3 | 13.1 | 51.6 |
| CV%. | 10.07 | 11.87 | 5.28 |
| Probability | 0.0015 | 0.0002 | < 0.0001 |

Means followed by lower case letters in columns differ by Tukey test at 5%.

**Conclusion** Concluding with this work that the wheat BRS Umbu presents great potential for the production of silage at the time of silage production is evident the high percentage of ears, also showing that the regime of cuts significantly changed the percentage of ears, reducing participation of stems and leaves.

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**Aerobic stability of high-moisture corn silages inoculated with lactic acid bacteria and rehydrated with water or acid whey**

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**Introduction** The fermentation of high-moisture corn (HMC) is often restricted because of its relatively low moisture and fermentable sugar contents, and the accumulation of total acids produced is quite low. As result, there is low aerobic stability after opening of the silos. However, this can be minimized using different strategies, as lactic acid bacteria (LAB) application or acid whey application (main sub-product formed in the dairy plants from manufacture of cheese). The acid whey can be not discarded in rivers or ponds because promote serious damages for the environment, increasing the biochemical oxygen demand (Gheri et al., 2003). This product has been used like fertilizer in agricultural systems and in the animal feeding, and has potential to use in the ensiling process. Our aim was to evaluate the aerobic stability of HMC silages inoculated with lactic acid bacteria and rehydrated with water or acid whey.

**Material and Methods** We used the AG-4051 cultivar in this study. The corn was harvested to ensiling when the grains presented 14% of humidity. The following treatments were applied to the corn: control (untreated); inoculated with Maize All® (*Enterococcus faecium* and *L. plantarum*, 1 x $10^{10}$ cfu per gram of product, *P. acidilactici*, 1 x $10^9$ cfu per gram of product, amylolitic and cellulolytic enzymes (1.5%), and proteolytic enzymes (2.0%)); rehydration with water or acid whey until reaches 30, 35 or 40% of humidity. The application rate of the inoculant was determined in accordance with the instructions from the manufacturer. Thus, the experiment was conducted in a completely randomized design, with four replicates in a factorial arrangement 3 (rehydration with three different humidity levels) x 2 (silage inoculated or not) x 2 (liquid used in the rehydration). As experimental silos were used PVC tubes with capacity of 4 L. After 30 days of ensiling, the silos were opened, the silage was homogenized and placed in a covered shed and cemented at environment temperature to determine the aerobic stability. We used 4 kg of silage in each replicate in this assay. Temperature of the silage was measured each six hour by a thermometer placed in the center of the mass during the aerobic exposure by 3 days. The ambient temperature was measured by a thermometer distributed near the experimental silos. The aerobic stability was defined as the number of hours that the temperature of the silage remained stable before rising more than 2ºC above the ambient temperature (Taylor and Kung Jr., 2002). During the aerobic exposure, the silages were sampled to determine the pH values. Data were subjected to ANOVA by SISVAR program, and the differences between the means were determined using Tukey test. Significant differences were declared at 5%.

**Results and Discussion** We observed lower temperatures ($P$ = 0.0017) and pH values ($P$ = 0.0003) when the HMC silages were rehydrated just until 30% of humidity, independent of the liquid used or inoculant application (Table 1). Soluble sugars are an energy source for yeasts in aerobic and anaerobic conditions, and are fermented into ethanol, mainly in silages with low-moisture (Kung Jr. et al., 2007). However, the profile of organic acids was similarly among the treatments in this work, and the acetic acid concentration ranged of 0.1 to 0.2%

(DM basis). Thus, the moisture in this case it is more important to control the action of spoilage microorganisms. There was increase in the temperature of the HMC silages during the aerobic exposure (Figure 1). This result occurs because of the action of spoilage microorganisms, which are undesirable and inevitable after the silo opening (Woolford, 1990).

**Table 1** Characteristics of HMC silages inoculated with LAB and rehydrated with water or acid whey in different levels of humidity during the period of aerobic exposure.

| | Treatments | | |
|---|---|---|---|
| Item | 30% | 35% | 40% |
| | | Temperature (ºC) | |
| Water | 23.21$^{Ab}$ | 27.74$^{Aa}$ | 28.50$^{Aa}$ |
| Acid whey | 23.64$^{Ab}$ | 25.49$^{Ba}$ | 26.12$^{Ba}$ |
| Inoculant | | | |
| Control | 23.70$^{Ab}$ | 26.71$^{Aa}$ | 26.99$^{Ba}$ |
| Maize All | 23.15$^{Ac}$ | 26.24$^{Ab}$ | 27.91$^{Aa}$ |
| | | pH | |
| Water | 4.11$^{Ac}$ | 4.56$^{Ab}$ | 5.13$^{Aa}$ |
| Acid whey | 4.06$^{Ab}$ | 4.37$^{Aa}$ | 4.43$^{Ba}$ |
| Inoculant | | | |
| Control | 4.06$^{Ab}$ | 4.53$^{Aa}$ | 4.66$^{Ba}$ |
| Maize All | 4.10$^{Ac}$ | 4.40$^{Ab}$ | 4.90$^{Aa}$ |

Means followed by same letter (uppercase in the column and lowercase on the line) do not differ by Tukey test.

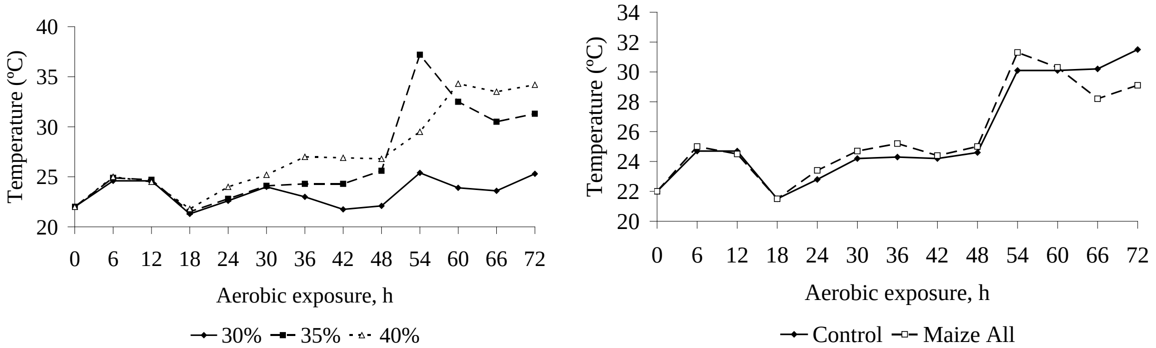


**Figure 1** Temperature of HMC silages rehydrated with water or acid whey at different levels of humidity during the period of aerobic exposure.

**Conclusions** The HMC silages inoculated or not with lactic acid bacteria and rehydrated with water or acid whey present characteristics similarly during the period of aerobic exposure.

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**Fermentative losses of maize silage added with natamycin and *Lactobacillus buchneri***

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**Introduction** During the ensiling process, microorganisms such as yeasts and bacteria might lead to biochemical losses as gases. It may also occur due to plant cell respiration. Effluent production may also be responsible for substantial water soluble carbohydrates (WSC), protein and organic acid losses. Under anaerobiosis, viable yeasts metabolize WSC into ethanol and carbon dioxide, mostly when small amounts of oxygen are available (McDonald et al., 1991). It reduces the concentration of available substrates for lactic acid bacteria, thus decreasing their efficiency on acid production and pH lowering. Natamycin is an antifungal compound utilized for yeasts and molds control in foods, such as cheeses and salami. Recently, Schmidt et al. (2012) verified positive effect of natamycin on reduction of greenhouse gases emission from maize silages. This trial aimed to evaluate the effect of adding natamicyn and *Lactobacillus buchneri* to maize silages on dry matter and gases losses through fermentation.

**Materials and Methods** The trial was carried out at Centro de Pesquisas em Forragicultura (CPFOR) of Universidade Federal do Parana. Maize was harvested by self propelled chopper at a theoretical particle length of 12 mm. Four treatments were applied (wet basis): Control – no addititves (C); (LB) - *Lactobacillus buchneri* ($5x10^4$ cfu $g^{-1}$); (NA) - Natamicyn (8 g $t^{-1}$); (NLB) - *Lactobacillus buchneri* plus natamicyn at the same dosages. All treatments were diluted in distilled water (4 L $t^{-1}$). Forage was ensiled in 20-liter experimental silos provided with Bunsen valves for gases outflow. A plastic platform was placed in the bottom of each silo, and covered with a nylon mesh fabric and a cotton sheet. This device was used to collect the effluent. The silos were filled with 12.5 kg of forage, assuring 600 kg $m^{-3}$. Silos were sealed and stored for a 90-day period in a closed room. The silos were weighted for gravimetric determination of dry matter, gases and effluent losses, as stated by Jobim et al. (2007). Silages were sampled for assessing pH and dry matter. Experimental design was completely randomized with four replicates. Data were analyzed by ANOVA and means of treatment were compared by Tukey test at a probability of 0.05 with STATISTIX program (9.0).

**Results and Discussion** Fermentative losses, dry matter content and pH means are shown in Table 1. Control treatment showed the highest dry matter content among the treatments ($P<0.05$). The NLB treatment resulted in the lowest pH mean (3.76), which was different ($P<0.05$) from NA and control treatments. The acid production of *L. buchneri* during fermentation was probably enhanced when combined with natamycin, which is able to reduce yeasts population. Hondrodimou et al. (2011) assert that natamycin reduced competition for nutrients between two groups of microorganisms and improves fermentative process, thus lowering silage pH.

Effluent production did not differ among treatments and the values were quite low, probably due to the proper DM content. The NLB treatment caused the lowest dry matter losses (DML) among treatments. This effect was related to the lowest pH and the inhibition of yeasts growth. Siqueira et al. (2007) verified increase in dry matter recovery and decrease on gases production when chemical additives were combined with *L. buchneri* at ensiling process.

**Table 1** The pH, dry matter and fermentative losses of maize silages

| | Treatments[1] | | | | | |
|---|---|---|---|---|---|---|
| Variable[2] | C | NA | LB | NLB | Mean | SEM |
| Dry matter, % | 36.9[a] | 31.1[c] | 31.7[c] | 33.1[b] | 33.2 | 0.59 |
| pH | 3.85[b] | 3.85[b] | 3.83[ab] | 3.76[a] | 3.8 | 0.01 |
| DML % | 6.89[b] | 7.06[b] | 8.88 [b] | 2.10 [a] | 6.2 | 0.70 |
| Gases % DM | 6.75[b] | 6.85[b] | 8.71 [b] | 1.95 [a] | 6.1 | 0.69 |
| Effluent, kg $t^{-1}$ of fresh matter | 1.43 | 2.2 | 1.87 | 1.54 | 1.8 | 0.13 |

[1]C, control; NA, Natamycin; LB, *Lactobacillus buchneri*; NLB, Natamycin + *L. buchneri*.
[2]DML, Dry matter losses; SEM, Standard error of the mean.
Different lower case letters within a line differ by Tukey test (P<0.05).

**Conclusion** The combination of natamicyn and *Lactobacillus buchneri* promoted decrease of pH and lower dry matter losses and gases production of maize silage during fermentation.

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# Effect of natamycin and *Lactobacillus buchneri* on yeast counting of maize silages during aerobic degradation

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**Introduction** According to Adesogan and Queiroz (2009) yeasts are the main microorganism to start aerobic degradation of silages, due to its affinity to lactate and glucose. Reich and Kung Jr. (2010) found high acetic acid concentrations and lower yeast counts in silages added with *Lactobacillus buchneri* when compared to control treatments. Natamycin is an antifungal compound used to avoid yeasts and molds in foods, such as cheeses and salami. Recently, Schmidt et al. (2012) verified positive effect of natamycin added to maize silages decreasing gases losses. This trial aimed to evaluate pH and yeast counting of maize silages added with natamycin and *Lactobacillus buchneri*.

**Materials and Methods** The trial was carried out at the Centro de Pesquisas em Forragicultura (CPFOR) of Federal University of Parana. Maize was harvested by self propelled chopper at a theoretical particle length of 12 mm. Four treatments were applied: Control – no additives (C); *Lactobacillus buchneri* at $5x10^4$ cfu $g^{-1}$ fresh matter (LB); Natamycin at 8 g $t^{-1}$ fresh matter (NA); and *Lactobacillus buchneri* plus natamycin at the same dosages (NLB). Forage was ensiled in 20-liter experimental silos provided with Bunsen valves for gases outflow. Each silo was filled with 12.5 kg of fresh forage, assuring 600 kg $m^{-3}$. Silos were sealed and stored for 90 days. After opening, samples were collected for pH evaluation and silages were exposed to air at 23±1ºC. For yeast counting, silages were sampled at days 0, 3 and 5 of aerobic exposure (D0, D3 and D5, respectively). Preparation for counting procedure was made by adding 25 g of silage to 225 mL of NaCl solution at 8.5%. The mixture was stirred and filtered, and 2 mL samples were taken for serial dilutions ranging from $10^{-1}$ to $10^{-7}$. Diluted samples were seeded in triplicate on Sabouraud agar added with tartaric acid at 10% (resulting pH of 4.5) by Pour Plate method. The plates were BOD incubated at 26 ºC. From 72 to 144 hours after incubation yeast colonies were counted. Mean values of triplicates were transformed by base 10 logarithm and expressed in colonies forming units per gram of silage (cfu $g^{-1}$). Experimental design was completely randomized with four replicates. Data were analyzed by ANOVA and means of treatments were compared by Tukey test at a probability of 0.05 using STATISTIX (9.0).

**Results and Discussion** Means of pH and yeast counts are shown in Table 1. The NLB treatment showed the lowest pH (3.76), which was different from NA and control treatments ($P<0.05$). On day zero, NLB showed lower yeast counting than NA and control treatments ($P<0.05$). Natamycin decreased yeast population and might have enhanced *L. buchneri* fermentation, thus reducing pH and yeast counting of exposed silages. This effect was also verified by Hondrodimou et al. (2011) during lactic fermentation of olives added with natamycin.

On day 3, NLB yeast count was only different from control silage (P<0.05). Schmidt et al. (2012) observed decreased greenhouse gases emission from maize silages added with natamycin, when compared with untreated silages, which was explained by natamycin effect of controlling yeasts growth. In this trial, NA treatment was not effective for avoiding yeast growth, but promoted synergistic effect when added to LB. After five days of aerobic exposure NA showed higher yeast count than control and NLB treatments.

**Table 1** pH and yeast population of maize silage aerobically exposed (log cfu $g^{-1}$ of fresh matter).

| | Treatments[1] | | | | | |
|---|---|---|---|---|---|---|
| Variable[2] | C | NA | LB | NLB | Mean | SEM |
| D0 | 2.95[a] | 2.23[a] | 1.92[ab] | 0.26[b] | 1.84 | 0.31 |
| D3 | 7.67[a] | 6.63[ab] | 6.47[ab] | 5.99[b] | 6.69 | 0.23 |
| D5 | 6.85[b] | 8.74[a] | 7.78[ab] | 6.32[b] | 7.42 | 0.29 |
| pH | 3.85[a] | 3.85[a] | 3.83[ab] | 3.76[b] | 3.8 | 0.01 |

[1]C, Control; NA, Natamycin; LB, *Lactobacillus buchneri*; NLB, Natamycin + *L. buchneri*. Different lower case letters within a line differ by Tukey test (P<0.05). [2]$Log_{10}$ (yeast count) on days 0, 3 and 5 after silo opening.

**Conclusion** The combination of natamycin and *Lactobacillus buchneri* promoted decrease of maize silages pH and inhibit yeast growth after the silo opening until the third day of air exposure.

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# Aerobic stability of silage black oat *(Avena strigosa Schreb.)* in different densities and particle sizes

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**Introduction** Many factors are important in the fermentation process to ensure quality silage. Among them, the oxygen removal is of great importance in order to provide a rapid production of lactic acid and pH drop to maintain the material conservation (Kung Jr., 2001). The silage density has influence on this aspect, since higher densities decrease the porosity of the silage. Yet, the smallest particle size favors compression and provides a greater surface area for contact with microorganisms. This study was carried out with the purpose of evaluating the effect of different densities and particle sizes in the aerobic stability of black oat *(Avena strigosa Schreb.)* silage.

**Materials and methods** The field experiment was conducted at the State University of Maringa Experimental Farm of Iguatemi, located in the Northwest of Paraná. The aerobic stability of the black oat (Avena strigosa Schreb) silage was evaluated in a factorial scheme (3X3), being three particle sizes: 5, 8 and 12 mm and three densities: 550, 600 and 650 $kg/m^3$. At the time of ensiling the commercial inoculant based on *Lactobacillus plantarum, Pediococcus acidilactici, cellulase and sucrase (Lallemand®)* was used in all treatments. The silos were opened after 90 days of ensiling and uncompressed samples were taken to assess the aerobic stability as described by Kung Jr. et al. (2000). Temperature measurements were taken at 8 h and 16 h with the use of a Gulterm 1001digital thermometer and the pH reading was done at 8 h with digital potentiometer according to Cherney & Cherney (2003).

**Results and discussion** Over the time of exposure to air there was an increase in the pH for all silages at all densities, which is an indicative of deteriorative microorganisms' activity (Table 1). According to Kung Jr. (2001), yeasts are the main microorganisms that initiate aerobic deterioration, using lactic acid for metabolism. The microbiological activity causes silage warming and increases silage pH, allowing bacteria previously inhibited by the acidity to develop and continue with the process of aerobic deterioration.

It was found that the silage with average particle size of 12 mm showed lower pH values to time exposure to air. It was also observed that these silages tend to have lower temperatures, showing high aerobic stability (Table 2).

The silage with 8 mm particle size showed a break in stability with 42 hours of exposure to air, t is observed that in these treatments there was a time and peak of higher temperature that can be related to a higher fermentation standard of silages, which generated a higher substrate concentration and thus higher microbial activity.

**Table 1** Average values for oat silages pH in different densities and particle sizes during 192 hours of exposure to air

| Time (h) | 550 kg/m³ | | | 600 kg/m³ | | | 650 kg/m³ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 mm | 8 mm | 12 mm | 5 mm | 8 mm | 12 mm | 5 mm | 8 mm | 12 mm | Average | VC(%) |
| 0 | 4.13a | 4.22ab | 4.31b | 4.12a | 4.18a | 4.28a | 4.10a | 4.16a | 4.23a | 4.19 | 2.2 |
| 18 | 4.07a | 4.21ab | 4.34b | 4.05a | 4.21a | 4.38b | 4.04a | 4.15ab | 4.27b | 4.19 | 2.1 |
| 42 | 4.21a | 4.31a | 4.38a | 4.06a | 4.29b | 4.46b | 4.10a | 4.31b | 4.38b | 4.28 | 2.54 |
| 66 | 4.21a | 4.53b | 4.43ab | 4.12a | 4.54b | 4.58b | 4.15a | 5.03b | 4.47a | 4.46 | 4.28 |
| 90 | 5.26a | 5.18a | 4.47a | 4.97a | 5.72a | 4.50a | 5.97ab | 7.03b | 4.43a | 5.28 | 17.89 |
| 114 | 6.93b | 6.54ab | 4.66a | 6.63b | 7.31b | 4.39a | 6.28ab | 7.87b | 5.35a | 6.22 | 19.34 |
| 138 | 8.31b | 7.89b | 5.33a | 7.44b | 8.15b | 4.58a | 7.60b | 8.80b | 5.64a | 7.08 | 14.59 |
| 162 | 8.43b | 8.26b | 6.35a | 8.56b | 8.54b | 4.78a | 8.57b | 8.75b | 6.92a | 7.69 | 10.69 |
| 186 | 8.87a | 8.51a | 7.99a | 8.83b | 9.06b | 5.61a | 8.99b | 9.06b | 7.49a | 8.27 | 6.42 |

Averages followed by different lowercase letters in the column differ at 5% error by Tukey test.

**Table 2** Changes in temperature of the oat silage during the 98 hours of exposure to air

| | 550 kg/m³ | | | 600 kg/m³ | | | 650 kg/m³ | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 mm | 8 mm | 12 mm | 5 mm | 8 mm | 12 mm | 5 mm | 8 mm | 12 mm |
| Temperature peak (°C) | 30 | 30 | 28 | 28 | 32 | 29 | 33 | 33 | 29 |
| Time to reach maximum temperature (h) | 74 | 74 | 26 | 74 | 74 | 26 | 74 | 74 | 26 |
| Aerobic stability (h)[1] | 50 | 42 | 50 | 66 | 42 | 46 | 50 | 42 | 90 |

[1]Time (hours) to break aerobic stability (2 °C above ambient temperature).

**Conclusion** There was no clear effect of the density of ensiling on the aerobic stability of silages. The silages of average particle size of 12 mm showed smaller changes in pH during exposure to air.

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# Agronomic evaluation of corn hybrids in 2012/2013 harvest in Guarapuava - PR

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**Introduction** In Brazil, the most used crop for making silage is corn, because it is easy for cultivation, high dry matter yield, high nutritional value and have great acceptance by ruminants (Oliveira et al., 2007). There are a large number of corn hybrid varieties for silage production in the market, so it is important to evaluate the agronomic performance of the regions indicated (Lupatini et al., 2004). The aim of this study was to compare the plant height, corn-cob height, number of leaves per plant, the production of green biomass, the production of dry biomass and grain yield from the different hybrids evaluated for silage.

**Material and methods** The experiment was conducted in the premises of the Animal Production Center (NUPRAN), at Agricultural and Environmental Sciences Department of the Midwest State University (UNICENTRO) in Guarapuava, PR, evaluating the following variables: height of the first corn-cob insertion, number of senescent leaves, green biomass production, dry biomass and grain yield from the following corn hybrids: SG YG 6030, PRO LG 6036, LG 6038 PRO, BRAS 3010, PL 6880 and PL 1335. Final production of green biomass, dry matter and grain as plant height, corn-cob height of insert and senescent leaf number was determined on the silage production time (dough stage R4). The experiment was conducted according to a completely randomized design with four replications, and six treatments (SG 6030 YG, LG PRO 6036, PRO 6038 LG, BRAS 3010, PL 6880 and PL 1335). The collected data for each parameter were submitted to analysis of variance with average comparison at the significance level of 5% by Tukey test, through SAS (1993).

**Results and discussion** Table 1 shows the mean values of plant height, height of corn-cob insert, number of senescent leaves, production of green biomass, dry biomass and grain yield of corn hybrids evaluated during 2012/2013 harvest in Guarapuava – PR. From the collected data it is evident that there was no statistical difference in plant height, corn-cob height of insert and number of leaves per plant on the different hybrids. But when comparing the variables: biomass production, dry biomass and grain yield an statistical difference is evidenced, and the hybrids LG PRO 6038, PRO 6036 LG and SG 6030 YG reached the highest averages, which were superior from the other tested materials.

Gralak (2011) had an plant height average of 2.4 meters and corn-cob height average of 1.43 meters, the dry matter yield average of 18383 kg $ha^{-1}$, green biomass average production of 68680 $kg.ha^{-1}$ and grain yield average of 10104 kg $ha^{-1}$ this values were lower than those found in this work, emphasizing that the experiments region was the same in both works. Neumann (2006), in an experiment with hybrid P-30S40, located in Guarapuava PR in 2004/2005 crop year also showed values lower than those obtained in this study.

**Table 1** Mean values of plant height, first corn-cob height, number of senescent leaves, production of green biomass, dry biomass and grain yield of evaluated corn hybrids (Crop 2012/2013, Guarapuava-PR).

| Hybrids | Plant height (m) | Corn-cob height (m) | Number of senescent leaves | Green biomass production (kgha$^{-1}$) | Dry biomass production (kgha$^{-1}$) | Grain production R6 (kg.ha$^{-1}$) |
|---|---|---|---|---|---|---|
| LG 6038 PRO | 2.57 a | 1.46 a | 3.00 a | 87588 a | 29457 a | 12360 a |
| LG 6036 PRO | 2.54 a | 1.49 a | 3.25 a | 85888 a | 28089 a | 11426 a |
| SG 6030 YG | 2.59 a | 1.57 a | 2.75 a | 79663 a | 25609 a | 11405 a |
| BRAS 3010 | 2.40 a | 1.38 a | 3.17 a | 68748 b | 21721 b | 9117 b |
| PL 6880 | 2.46 a | 1.48 a | 2.17 a | 70688 b | 23456 b | 8338 b |
| PL 1335 | 2.46 a | 1.39 a | 3.17 a | 65780 b | 22171 b | 9498 b |
| Average | 2.51 | 1.46 | 2.93 | 76392 | 25084 | 10357 |
| P>F | 0.1309 | 0.3840 | 0.2179 | 0.0075 | 0.0170 | 0.0501 |
| CV, % | 4.13 | 9.23 | 21.94 | 10.98 | 12.75 | 18.01 |

Means in the same section followed by different letters for each variable differ by Tukey test at 5%.
CV: Coefficient of variation.

**Conclusion** The highest values of plant height, corn-cob height and number of leaves per plant were statistically similar among the six hybrids, but the production of dry matter, green biomass and grain were higher in three specific hybrids: PRO LG6038, LG PRO 6036 and SG 6030 YG.

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## Agronomic evaluation of different corn hybrids cultivated at different location at the time of silage production

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**Introduction** Corn is considered the default culture for silage due to tradition, high productivity and good nutritional value. Thus it becomes an alternative to forage feed essential in the production chain of cattle (Neumann, 2006). The aim of this study was to evaluate the plant height, ear height, number of leaves per plant at different altitude at the time of planting silage.

**Material and methods** The study was coordinated by the Center for Animal Production (NUPRAN) Sector of Agricultural and Environmental Sciences of the State University Midwest (UNICENTRO) in Guarapuava, PR, and evaluated three variables: plant height, ear high and number of leaves per plant of six corn simple (P1630H, P2530, AS1555PRO, 30R50H, 30F53H and X40B143H) associated with two cultivation sites (Location A: located at latitude S25°34’513” longitude W51°41’576”, Location B: located at latitude S25°42'480" longitude W51°56'795"). Corn plants of different treatments were taken at 20 cm in the reproductive stage of hard grain (R5) to obtain the data. The data collected for each parameter were subjected to analysis of variance with comparison of means at the significance level of 5% by Tukey test, through the SAS (1993).

**Results and Discussion** Table 1 shows the means for plant height, cob insertion and number of leaves per plant of different corn hybrids cultivated at different regions at the time of silage production on the 2012/2013 harvest in the region or the major region of Guarapuava - PR. According to the data we realized that for the variables of plant height and ear height of region B was the one that had the highest average, and for the number of leaves showed no statistical difference between the regions. The hybrid that had the best average when measured at plant height was X40B143H, and in relation to ear height obtained the highest value and was statistically equal to hybrid 30R50H. The latter, together with P1630H presented a higher number of leaves per plant.

Oliboni (2009) conducted their experiment in the same region with 81 hybrids between them: parents, crosses and witnesses, obtained values of average plant height of 2.4 meters and ear height of high 1.38 meters, and similar values to the present work. Neumann (2006) obtained an average height of 2.43 m and height of plant average ear high 1.42 meters using the hybrid P-30S40, also located in Guarapuava, the harvest of 2004/2005.

**Table 1** Averages for plant height, ear insertion height and number of leaves per plant of different corn hybrids cultivated at different regions at the time of silage production (Crop 2012/2013, Guarapuava-PR).

| Local | Hybrids | | | | | | Average |
|---|---|---|---|---|---|---|---|
| Cultivation | P1630H | P2530 | AS1555PRO | 30R50H | 30F53H | X40B143H | |
| | | | | Plant height, m | | | |
| A | 2.44 | 2.44 | 2.25 | 2.50 | 2.24 | 2.63 | 2.42 b |
| B | 2.57 | 2.46 | 2.35 | 2.64 | 2.36 | 2.78 | 2.53 a |
| Average | 2.51BC | 2.45C | 2.30D | 2.57B | 2.30D | 2.71A | |
| | | | | Ear height, m | | | |
| A | 1.06 | 1.21 | 1.05 | 1,38 | 1.17 | 1.35 | 1.20 b |
| B | 1.19 | 1.23 | 1.21 | 1,57 | 1.29 | 1.56 | 1.34 a |
| Average | 1.13C | 1.22B | 1.13C | 1,48A | 1.23B | 1.46A | |
| | | | | Number of leaves per plant | | | |
| A | 4.1 | 2.7 | 2.3 | 5.2 | 2.9 | 3.2 | 3.4 a |
| B | 5.2 | 2.8 | 2.6 | 4.1 | 3.1 | 3.3 | 3.5 a |
| Average | 4.7A | 2.8B | 2.5B | 4.7A | 3.0B | 3.3B | |

Means followed by lower case letters in the column differ by F test at 5%.
Means followed by capital letters in the line differ by Tukey test at 5%.

**Conclusion** The cultivation site B had the highest mean values of plant height and ear height in relation to the number of leaves, the two places (A and B) did not differ in value. Comparing hybrids, which had the highest plant height was X40B143H, the height of insertion of X40B143H and 30R50H were the largest and the hybrids that obtained the highest number of leaves were the P1630H and 30R50H.

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## An evaluation of the effects of silage digestibility on the performance of, and concentrate sparing effect of, finishing beef cattle, lactating dairy cows, pregnant ewes and finishing lambs

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**Introduction** Digestibility is the most important factor influencing the feed value of grass silage (Keady et al., 2000). Grass silage forms the basal forage for finishing beef cattle, lactating dairy cows, pregnant ewes and finishing lambs during the indoor feeding period in many regions world wide. The aims of this study were to determine the effects of silage digestibility on the performance of, and the concentrate requirements of, finishing beef cattle, lactating dairy cows, finishing lambs and pregnant ewes.

**Materials and methods** Data from 76 comparisons (34, 23, 10 and 9 comparisons involving finishing beef cattle, lactating dairy cows, finishing lambs and pregnant ewes respectively) in which grass silages differing in digestibility were offered as the sole forage, supplemented with differing levels of concentrate were used in the current study. Where not available, the digestible organic matter digestibility (D-value) of the grass silages was determined from dry matter digestibility using the equations of Keady et al (2001). Silage composition, silage and concentrate intakes, and animal performance data from the 79 comparisons are presented by Keady et al (2013). The data was categorised according to the source and least squares procedures were used to fit a model with source as a fixed effect and the proportion of the forage in the diet as a covariate; the linearity of the effect of forage proportion was tested in all cases by fitting a quadratic term but this was not significant in any case.

**Results and Discussion** The effects of silage D-value on food intake and animal performance are presented in Table 1. The mean response to an increase of 10 g/kg in D-value was 0.33 kg/day, 23.8 g/day and 9.3 g/day of milk yield of dairy cows, carcass gain of beef cattle and carcass gain of finishing lambs, respectively. The response to silage D-value varied significantly with forage:concentrate ratio of the diet. Whilst the response to silage D-value declines as concentrate feed level increased, it was still significant when concentrate accounted for 60% of total DM intake. In studies involving pregnant ewes, the silages were offered *ad libitum* for up to 14 weeks of mid and late pregnancy. The mean response to each 10 g/kg increase in silage D-value was an increase in ewe weight post lambing of 1.3 ± 0.08 kg and an extra 52.3 ± 11.41 g in lamb birth weight. When the 9 comparisons involving pregnant ewes were analysed for the effect of concentrate input (mean of 16.6 kg DM) in late pregnancy (as a proxy for the proportion of forage in the diet) there was no evidence of any association. The regression equations describing the effects of silage digestibility and concentrate feed level on animal performance are presented in Table 2. There was no interaction ($P>0.05$) between silage D-value and concentrate feed level, or for any quadratic effects, for the response of the performance of lactating dairy cows, finishing lambs or pregnant ewes. Each increase of 5 units in silage D-value enables the yields of milk and of fat + protein from dairy cows, carcass gain by finishing lambs and lamb birth weight to be maintained whilst concentrate DM feed level was reduced by 2.35 kg/d, 2.80 kg/d 0.30 kg/d and 19.2 kg during late pregnancy, respectively. For finishing beef cattle there was a significant interaction between silage D-value and concentrate feed level; as silage D-value increased the effect of increased concentrate feed level on concentrate sparing affect declined (Table 3).

**Conclusions** Each 10 g/kg increase in D-value increases carcass gain of finishing beef cattle and lambs, and milk yield of dairy cows by 23.8 g/d, 9.3 g/d and 0.33 kg/d, respectively. Whilst the response to silage digestibility declines as the proportion of the concentrate in the diet increases, the response to silage digestibility is still significant when concentrate accounts for 60% of feed DM intake. Assuming that silage D-value declines by 33 g/kg per week delay in harvest (Keady et al 2013) on extra 1.55 kg/d, 0.20 kg/d and 12.7 kg (in late pregnancy) of concentrate DM is required to maintain milk yield of dairy cows, carcass gain of lambs and lamb birth weight for each 1 week delay in harvest. For beef cattle offered 670 or 710g/kg, D-value silage supplement with 4 kg concentrate, each week delay in harvest requires an additional 1.5 and 1.97 kg/d concentrate DM to maintain carcass gain.

**Table 1** Responses in animal performance to a change of 10 g/kg in silage D-value

| Animal type | Performance trait | Forage: concentrate ratio 100:0 | 80:20 | 60:40 | 40:60 |
|---|---|---|---|---|---|
| Lactating dairy cows | Milk yield (kg/day) | - | 0.58 ± 0.144 | 0.37 ± 0.050 | 0.16 ± 0.100 |
| | Fat (g/kg) | - | -0.01±0.220 | -0.07 ± 0.076 | -0.13 ± 0.152 |
| | Protein (g/kg) | - | 0.14 ± 0.093 | 0.06 ± 0.032 | 0.26 ± 0.065 |
| | Fat +Protein yield (kg) | - | 0.037±0.0101 | 0.026±0.0035 | 0.015±0.0070 |
| | DM intake (kg/day) | - | 0.33 ± 0.277 | 0.20‡ ± 0.096 | 0.07 ± 0.192 |
| Finishing beef cattle | Carcass gain (kg/day) | 35 ± 4.0 | 26 ± 2.5 | 17 ± 2.9 | 8 ± 4.8 |
| | DM intake (kg/day) | 0.12 ± 0.010 | 0.09 ± 0.006 | 0.07 ± 0.014 | 0.04 ± 0.024 |
| Finishing lambs | Carcass gain (g/day) | 16 ± 2.3 | 13 ± 1.3 | 9 ± 0.9 | 6 ± 1.5 |
| | DM intake (kg/day) | 0.08 ± 0.007 | 0.07 ± 0.004 | 0.05 ± 0.003 | 0.03 ± 0.005 |

Responses in bold are significantly different from zero ($P<0.05$), ‡ $P=0.057$

**Table 2** Relationships between animal performance, silage D-value and concentrate level

| **Animal type‡** | **Performance trait** | **Constant** | **D-value†** | **Conc§** | **D-value *Conc** | **Conc$^2$** | **$R^2$** | **Sig¶** |
|---|---|---|---|---|---|---|---|---|
| DC | Milk yield (kg/d) | 4.85 | +0.260 (0.0462) | +0.554 (0.1265) | | | 0.61 | *** |
| | Fat & Protein (kg/d) | -0.034 | +0.023 (0.0036) | +0.041 (0.0098) | | | 0.64 | *** |
| BC | Carcass gain (kg/d) | -1.90 | +0.033 (0.0037) | +0.333 (0.0661) | -0.0036 (0.00100) | -0.0038 (0.00199) | 0.75 | *** |
| FL | Carcass gain (g/d) | -632 | +8.6 (1.21) | +142.4 (13.60) | | | 0.91 | *** |
| PE | Lamb BW (kg) | 0.73 | +0.050 (0.0115) | +0.013 (0.0120) | | | 0.67 | *** |

‡DC = dairy cows; BC = beef cattle; FL = finishing lambs; PE = pregnant ewes.
†In units of 10 g/kg; §Concentrate dry matter (kg/d); ¶Significance of the regression equation

**Table 3** Effect of an increase in silage D-value (+50 g/kg) on concentrate sparing effect of beef cattle offered silages differing in D-value and supplemented with different levels of concentrate

| | Concentrate DM (kg/d) | | |
|---|---|---|---|
| D-value (DMD) | 2 | 4 | 6 |
| 670 (711) | 1.67 | 1.50 | 1.21 |
| 690 (731) | 1.85 | 1.70 | 1.44 |
| 710 (751) | 2.07 | 1.97 | 1.77 |
| 730 (771) | 2.35 | 2.34 | 2.32 |

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## Degradability of wheat silages and corn silages with or without the gene B*t* (*Bacillus thuringiensis*)

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**Introduction** Roughage degradability in the rumen can influence animal performance due to effects on intake, differences in rumen fermentation and digesta kinetics. The objective was to evaluate DM degradability in wheat silages, with or without bacterial inoculant (*Lactobacillus plantarum* and *Pediococcus acidilactici*), and in conventional corn silages or genetic modified corn (*Bacillus thuringiensis*).

**Material and Methods** The experiment was carried out at Central Western Paraná State University (UNICENTRO) and Maringá State University (UEM). The treatments were wheat silage (WS), wheat silage with bacterial inoculant (WSI), conventional corn silage (CCS) and genetically modified corn silage (GMCS). For *in situ* incubation, six bovines were used, rumen-fistulated, averaging 530 kg in weight, three of which were kept on wheat silage and three on corn silage. Incubation times lasted 0, 6, 12, 24, 48, 72 and 92 hours. The DM disappearance data were fit by non-linear regression, which predicts the potential degradability of diet items through the model proposed by Mehez and Orskov (1977). The Orskov and McDonald model (1979) was used to estimate effective degradability (ED). Statistical analysis was carried out by Bayesian inference. To compare the treatments, multiple comparisons were carried out between the *a posteriori* distributions of the parameters of interest averages. Treatments whose credible intervals for the average differences do not contemplate the value zero are regarded as different, at 5% significance.

**Results and Discussion** In the readily available DM fraction (a), GMCS silage showed the highest values ($P<0.05$). However, wheat silage inoculation provided lower disappearance of the readily available fraction (Table 1). Other studies, involving barley inoculation (Addah et al., 2011), did not observe an effect of the inoculation on the disappearance of the DM fraction (a). While evaluating corn hybrids with or without the modified gene, Trava (2013) observed that the hybrid with the modified gene showed lower reduction in the degradation of fraction (a), when compared to its counterpart without the modified gene.

With regard to the potentially degradable fraction (b), CCS showed higher values ($P<0.05$) than the other silages. Wheat silage inoculation did not influence the potentially degradable fraction. For their part, Addah et al. (2011) observed that the potentially degradable fraction was larger in barley silage than in corn silage. The higher the degradation percentage in fraction (b), the greater will the use potential of the fibrous fraction by ruminants be, resulting in a higher amount of energy available after rumen degradation (Bumbieris Jr. et al., 2011).

In this aspect, among the probable explanation for inoculation failures would be the specificity of the inoculant to the culture, competition from epiphytic flora, DM and soluble carbohydrate contents. Thus, the effect of the use of biological additives is conditioned both to biological viability of the inoculant, and to the intrinsic characteristics of the plant to be ensiled.

For the degradation rate (c), treatments GMCS and WSI showed the highest values compared to the others (P<0.05). Trava (2013) reported that silages of genetically modified corn hybrids showed greater differences between hybrids than the genetically modified one, which did not negatively affect the kinetics of DM degradation.

In effective degradability (ED), GMCS silage showed the highest degradation (P<0.05) compared to the other treatments. Wheat silage inoculation influenced (P<0.05) ED, in relation to the treatment without the added microbiological additive. The results of the present study indicate that adding the modified gene inoculant influenced the kinetics of DM disappearance in the rumen.

**Table 1** Values average and standard deviation of the soluble fraction (*a*), potentially degradable insoluble fraction (*b*), rate of disappearance of *b* (*c*) and effective degradability of dry matter (ED)

| Parameters | DM | | | |
|---|---|---|---|---|
| | WS[1] | WSI[2] | CCS[3] | GMCS[4] |
| *a* | 43.38[a] | 42.08[c] | 41.89[bc] | 46.69[a] |
| | (1.09) | (0.87) | (2.31) | (1.27) |
| *b* | 27.53[c] | 26.28[c] | 41.64[a] | 35.25[b] |
| | (1.90) | (1.06) | (7.08) | (1.76) |
| *c* (/h) | 0.03[b] | 0.04[a] | 0.03[b] | 0.04[a] |
| | (0.006) | (0.005) | (0.009) | (0.006) |
| ED (5%)[5] | 53.58[c] | 54.32[b] | 55.53[b] | 61.67[a] |
| | (0.58) | (0.44) | (1.18) | (0.64) |
| Standard deviation | 1.94 | 1.08 | 8.44 | 2.47 |

Different letters in the row indicate significant differences between treatment averages, through Bayesian comparisons at 95% credibility.

[1] WS = Wheat silage; [2] WSI= Wheat silage with inoculant; [3] CCS= Conventional corn silage; [4] GMCS= Genetically modified corn silage.

[5] Effective degradability calculated at ruminal particulate passage rate of 5%/h.

**Conclusions** The genetically modified hybrid showed greater DM degradability. Bacterial inoculation influenced effective DM degradability.

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**Influence of plant enzyme inactivation or sterilization on lipolysis in ensiled alfalfa**

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**Introduction** High intake of polyunsaturated fatty acids has been proved to increase their concentration in milk (Lawless et al., 1998) and, consequently be beneficial to human health (Simopoulos, 2001). Therefore, there is increasing interest in the changes of fatty acid composition in herbages and forages after ensiling. Like the extensive proteolysis in ensiled forage, especially in alfalfa silage, numerous studies have reported that lipolysis in silages is also a very extensive process (Van Ranst et al., 2009). It was proposed that lipolysis of forages during ensiling may be caused by both microbial and plant enzymes activation (Elgersma et al., 2003). However, whether the lipolysis during ensiling is mainly caused by microbial or plant lipases is still not clear. Hence, the objectives of the present work were to evaluate changes of fatty acid composition of alfalfa forage after ensiling; and to clarify the importance of microbial and plant enzymes activation on lipolysis of forages during ensiling.

**Materials and Methods** Third-cut alfalfa (*Medicago sativa*. L. cv. Forerunner) was randomly harvested at late bud to early bloom, leaving a stubble of 10 cm. Fresh forage samples were immediately taken into laboratory, chopped into about 1 to 2 cm length using a paper-cutter. Chopped forages from each experimental plot were then assigned to one of the following treatments: 1) untreated (sterilized water); 2) a commercial inoculants (LaLSiL Dry, manufactured by Lallemand, Montréal, Québec, Canada) after treatment of γ-ray irradiation at a dose of 25 kGy for 2 h; 3) LaLSil Dry after autoclaving treatment at 121 ºC, 115 MPa for 15 min. Before ensiling, DM contents of all treatments were adjusted to about 320 g/kg FW. Five mini-silos were made for each treatment by following the method described previously (Ding et al., 2013), and all mini silos were prepared in an aseptic operating board. Mini silos from each treatment were opened at 40 days of ensiling and immediately frozen (−80°C) in sealed plastic bags until further chemical analysis for fatty acid composition (Ding et al., 2013).

**Results and Discussion** The concentration of total fatty acid after ensiling decreased 43% in the control silage and 28% in the γ-ray treated silage, but did not change in the autoclave treated silage (Table 1). Among the major fatty acids (C16:0, C18:2n-6, C18:3n-3), a considerable increase ($P < 0.05$) was observed in proportion of C16:0 in the control silage as compared with fresh alfalfa; conversely, decreases in proportions of C18:2n-6 and C18:3n-3 occurred ($P < 0.05$). However, similar concentration of C16:0 in fresh forage, control silage and the silage treated with autoclave was observed. Besides C12:0, C14:0, C15:0, C18:0, cis-9 C18:1, C20:0, and C24:0, silage treated with γ-ray radiation at ensiling had smaller proportion of C16:0 and greater proportions of C18:2n-6 and C18:3n-3 ($P < 0.05$) than the control silage. Proportions of C16:0, C18:2n-6, C18:3n-3 and the other detected fatty acids (except for proportion of C15:0) did not differ between fresh forage and autoclave treated silage ($P > 0.05$). The above results indicate that the total fatty acid content and the $C_{18:3n-3}$ concentration in silage treated with plant enzymes inactivation plus inoculation of lactic acid bacteria was similar to that in fresh forage. Plant enzymes inactivation also inhibited the reduction of $C_{18:2n\text{-}6}$ and the increase of $C_{16:0}$ proportions during ensiling. Based on comparison of the total fatty acid contents in fresh alfalfa and in silages treated with γ-ray irradiation and autoclaving, it can be deduced that plant enzymes was the major contributor to the lipolysis during ensiling. The deduction can also be reflected by the changes in proportions of $C_{18:3n\text{-}3}$ in the above mentioned three treatments or by the $C_{18:3n\text{-}3}$ concentrations in these treatments.

**Table 1** Total fatty acid (FA) content (mg/g of DM), and FA composition (g/100 g of total FA) of fresh, wilted, and ensiled alfalfa after 40 d of ensiling without physical treatment and treated by γ-ray radiation or autoclave before ensiling

| | Forage before ensiling | | Silages | | | |
|---|---|---|---|---|---|---|
| | Fresh | Wilted | Control | γ-ray treated | Autoclave treated | SEM |
| Total FA | $29.57^{c}$ | $27.56^{c}$ | $16.82^{a}$ | $21.29^{b}$ | $29.20^{c}$ | 1.214 |
| $C_{12:0}$ | $0.07^{a}$ | $0.09^{ab}$ | $0.17^{c}$ | $0.12^{b}$ | $0.09^{ab}$ | 0.006 |
| $C_{14:0}$ | $0.19^{a}$ | $0.25^{b}$ | $0.40^{d}$ | $0.31^{c}$ | $0.21^{ab}$ | 0.012 |
| $C_{15:0}$ | $0.17^{ab}$ | $0.13^{a}$ | $0.37^{c}$ | $0.33^{c}$ | $0.23^{b}$ | 0.013 |
| $C_{16:0}$ | $18.65^{a}$ | $18.77^{a}$ | $31.57^{c}$ | $27.06^{b}$ | $20.28^{a}$ | 0.737 |
| $C_{16:1}$ | $1.04^{a}$ | $0.94^{a}$ | $1.55^{b}$ | $1.48^{b}$ | $1.06^{a}$ | 0.037 |
| $C_{18:0}$ | $2.91^{a}$ | $3.16^{a}$ | $5.08^{c}$ | $4.30^{b}$ | $3.22^{a}$ | 0.127 |
| $C_{18:1}$ *cis*-9 | $1.73^{b}$ | $1.10^{a}$ | $1.82^{b}$ | $1.64^{b}$ | $1.35^{a}$ | 0.044 |
| $C_{18:1}$ *trans*-11 | $0.06^{ab}$ | $0.00^{a}$ | $0.05^{ab}$ | $0.31^{c}$ | $0.14^{b}$ | 0.020 |
| $C_{18:2n\text{-}6}$ | $19.66^{c}$ | $17.71^{b}$ | $15.34^{a}$ | $16.56^{ab}$ | $17.34^{b}$ | 0.219 |
| $C_{18:2}$ *trans*-9, *trans*-15 | $0.00^{a}$ | $0.00^{a}$ | $2.41^{c}$ | $1.02^{b}$ | $0.75^{ab}$ | 0.154 |
| $C_{18:3n\text{-}3}$ | $54.53^{c}$ | $56.93^{d}$ | $37.85^{a}$ | $45.36^{b}$ | $53.92^{c}$ | 1.016 |
| $C_{20:0}$ | $0.29^{a}$ | $0.28^{a}$ | $0.63^{b}$ | $0.51^{b}$ | $0.33^{a}$ | 0.024 |
| $C_{22:0}$ | $0.50^{a}$ | $0.48^{a}$ | $0.86^{b}$ | $0.80^{b}$ | $0.46^{a}$ | 0.034 |
| $C_{24:0}$ | $0.20^{a}$ | $0.21^{a}$ | $1.88^{c}$ | $1.10^{b}$ | $0.57^{ab}$ | 0.109 |

[a-d]Within a row, means without a common superscript letter differ ($P < 0.05$).

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**Chemical composition of elephantgrass silage with cotton processing residue treated with urea**

Y.S. Luz[1], D.G. Quadros[2], A.P. Andrade[1], M.P. Figueiredo[1], F.E. Silva[2], G.S. Souza[2] and O. Fernandes Júnior[2]

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**Introduction** The elephantgrass (*Pennisetum purpureum* Schum.) has high dry matter production and is largely used small farms in Brazil. In order to reduce losses in the elephantgrass silage, water holding foods have been added to make the fermentative pattern better. Among them, the residues of agriculture production are interesting because they have high availability and low cost. The ammonization improved nutritive value of cotton residue processing, as was demonstrated by Quadros et al. (2012), with the reduction of the fiber and increase of crude protein. The objective of this work was to evaluate the chemical composition of elephantgrass silage with two proportions (5 and 10% DM) of cotton processing residue, ammoniated or not with urea (0, 4 and 8% DM).

**Materials and Methods** The experiment was conducted at the Bahia State University, Campus – IX, Barreiras, Bahia, Brazil, in the Laboratory of the Animal Production Research Center, in December 2011. It was used a completely randomized design with 7 treatments and 3 replicates. The treatments were: EG100 = elephantgrass (control); CR5 = 5% cotton residue; CR10 = 10% cotton residue; CR5 4U = 5% cotton residue treated with 4% urea; CR5 8U = 5% cotton residue treated with 8% urea; CR10 4U = 10% cotton residue treated with 4% urea, and CR10 8U = 10% cotton residue treated with 8% urea.

The residue was gotten in regional cotton processing industry. The cotton residue was treated with 0, 4 and 8% urea (DM basis), and the urea was diluted with water to increase the moisture content to 30%. This treatment occurred during 28 days and after that the material was aerated for 72 hours before ensiling. It was used elephantgrass cv. Purple with 60 days of regrowth (15% DM). The grass was cut and chopped in particle sizes from 2 to 3 cm. After homogenization between the chopped material and the cotton residue, the forage mass was ensiled in mini silos, made with 20 L plastic buckets containing 4 kg of sand in the bottom to capture the effluent. The grass and the residue were mixed according to each treatment and compressed using feet, reaching an average density of 570 kg/m3. After 50 days, the silos were opened. At the opening of the silos samples were collected, dried in forced air circulation oven at a temperature of 50 º C for 72 hours. Then the samples were ground in a Wiley mill through 1 mm sieve. After that, the concentration of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), neutral detergent insoluble nitrogen in relation to the total nitrogen (NDIN/TN) and nitrogen acid detergent insoluble in relation to the total nitrogen (NDIN/TN) were determined, according Silva and Queiroz (2002). Data were subjected to analysis of variance and means were compared by Tukey test at 5% probability, using the statistical program ASSISTAT.

**Results and Discussion** The dry matter (DM) concentration of silages increased with the addition of the residue from 13.34% in control to 21.25% with the inclusion of 10% of CR (Table 1). Treatments showed an average increase of 37% compared to the control. The addition of CR influenced the dry matter content in the silage because of its high dry matter content (93%). The DM concentrations observed in this work were less than ideal for a good fermentation in elephant grass silages (25%) (Rezende et al., 2008).

The CP concentration did not differ (P>0.05). However NDF and ADF increased with the addition of CR, mainly in treatments with urea. The use of 10% of CR was effective for the reduction of NDF, and treatments with 5 to 10% of this residue were similar to treatment control for the ADF. This effect may have occurred by complexation of lignin with cell wall nitrogen supplied by the addition of urea (Rosa and Fadel, 2001). Also highlights the fact that the CR is rich in NDF (73.4%) (Quadros et al., 2012). It is observed that the levels of NDIN and ADIN showed significant increases for treatments that were ammoniated, meaning that 90% of total nitrogen is attached to the cell wall, made it unavailable for the rumen microorganisms action.

**Table 1** Chemical composition of elephantgrass silages with two proportions (5 and 10%) of residue of cotton processing, ammoniated with urea (0, 4 and 8%).

| Treatments | DM | CP | NDF | ADF | NDIN (%TN) | ADIN (%TN) |
|---|---|---|---|---|---|---|
| EG100% | 13.3c | 6.9a | 65.4cd | 39.7b | 19.0b | 6.5d |
| CR5% | 15.7b | 7.1a | 61.5de | 41.0b | 22.5b | 16.8cd |
| CR10% | 19.8a | 7.3a | 59.3e | 40.8b | 28.5b | 25.5bc |
| CR5% U4% | 16.7b | 6.6a | 72.2ab | 52.5a | 54.3a | 35.5ab |
| CR 5% U8% | 19.5a | 7.4a | 68.8bc | 51.4a | 56.8a | 44.4a |
| CR10% U4% | 16.6b | 7.8a | 72.8a | 53.1a | 49.2a | 38.0a |
| CR 10% U8% | 21.2a | 7.3a | 70.7ab | 50.7a | 52.6a | 41.7a |
| CV (%) | 3.6 | 8.0 | 2.1 | 2.7 | 13.9 | 13.2 |

Means followed by the same letter in the column do not differ according to Tukey test (P>0.05).

**Conclusions** The addition of residue of cotton processing ammoniated did not improve the chemical composition of elephantgrass silage. However, without urea treatment, the residue increased the content of dry matter without changing the components of the fiber and nitrogen of silages.

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**Influence of the dry matter content of grass on the silage acidification using inoculants**

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**Introduction** The acidification of the ensiled material is a key factor to eliminate the proliferation of undesirable microorganisms (Clostridia, Listeria, E. coli, etc.) and to stop the enzyme activity in the plant diminishing the respiration losses. The aim of the trial was to compare the influence of different DM contents on the pH lowering in grass silage using inoculants or not.

**Material and Methods** Timothy grass with different DM contents (15, 30 and 50%) was ensiled under laboratory conditions and inoculated as shown in Table 1.

**Table 1** Products used for the trial and their characteristics

| Product | Type of lactic acid bacteria | | Concentration (cfu/g) | |
|---|---|---|---|---|
| | homo-fermentative | hetero-fermentative | in the product (laboratory analysis) | in the silage (calculated) |
| A | X | - | $1.4 \times 10^{11}$ | $1.4 \times 10^{6}$ |
| A50% | X | - | $7.0 \times 10^{10}$ | $7.0 \times 10^{5}$ |
| B | X | - | $2.4 \times 10^{10}$ | $2.4 \times 10^{5}$ |
| C | X | - | $8.6 \times 10^{9}$ | $8.6 \times 10^{3}$ |
| D | X | X | $1.2 \times 10^{10}$ | $6.0 \times 10^{4}$ |
| F | X | - | $1.0 \times 10^{11}$ | $3.0 \times 10^{5}$ |

**Results and Discussion** As shown in Figure 1, the products A in a normal or half dosage, as well as product F, decreased the pH value already after 1 day of fermentation, independently of the DM content. Product B reached values very close to the products A and F. All those products decreased the pH value after 3 days to below 4, a desirable pH in order to stop the growth of, for example, Clostridia, which can markedly decrease the silage quality due to protein breakdown and production of butyric acid, making the silage less palatable for the animals, and diminishing this way the silage intake. The acidification using product D was slower and more influenced by the DM content, meaning the higher the DM content, the slower the pH decrease.

The acidification of grass silage using product C or no silage inoculant (Control treatment, CT) was similar: silages with 15 and 30% of DM decreased their pH value slowly, and with 50% was practically no acidification. The performance of product C could be related to the low inclusion rate ($8.6 \times 10^3$ cfu/g of silage) (Kung *et al.*, 2003). The retarded growth of lactic acid bacteria in silage with relatively high DM content is related to the higher osmolality of the plant fluids. In general, the inclusion of silage inoculants speeded out the fermentation and deepened the acidification. The growth of lactic acid bacteria showed a polynomial function with high coefficient of positive correlation ($R^2$=0.72). The maximal growth was reached with an approximated pH value of 4, showing the ability of lactic acid bacteria to decrease the pH value due to their lactic acid production and survive under relatively high medium acidity. Correlations between growth of lactic acid bacteria after 7 days of fermentation and the acidification on the grass silage were calculated but were very low due to the high dispersion of the values. Nevertheless it is possible to see tendencies which could be summarized as follow: a) the higher the DM content, the higher the pH values over the whole period; and b) the maximal growth of lactic bacteria is presented when the DM content was approx. 30%.

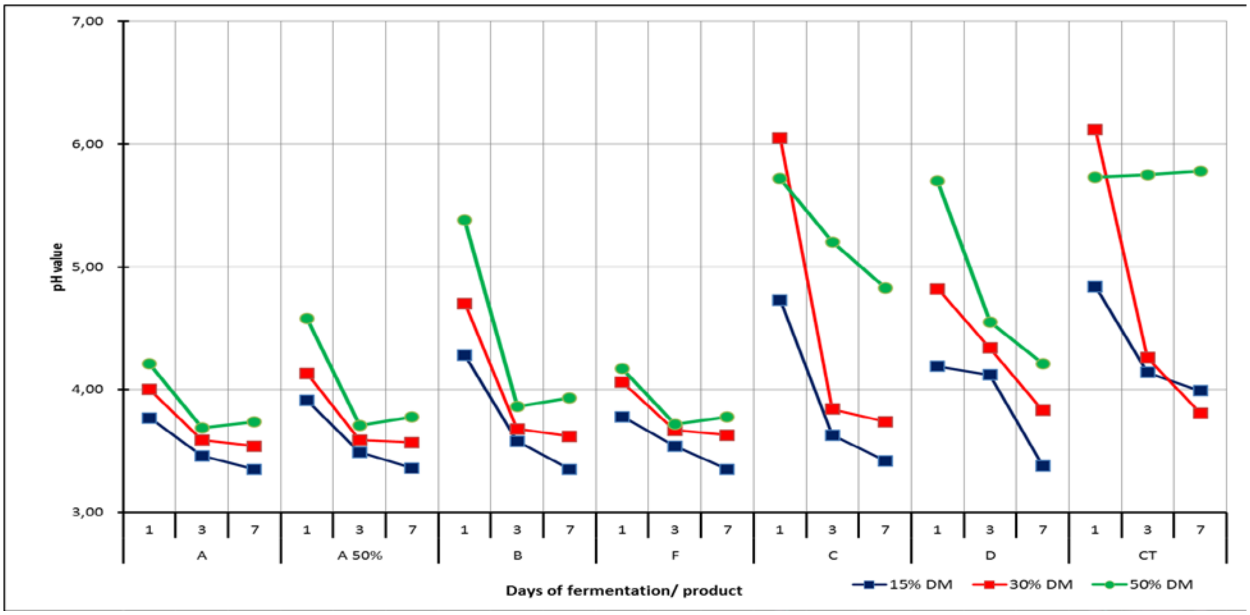


**Figure 1** Influence of different inoculants on the pH value after 1, 3 and 7 days and different dry matter content (15, 30 and 50%).

**Conclusions**

It can be concluded that the inclusion of silage inoculants allows to acidify the substrate markedly, especially in silages with relatively high DM content, the composition and the inoculation rate of each silage inoculant plays a decisive role on the final results, lactic acid bacteria can decrease the pH to relatively low values and their maximal growth was shown to be around 4, and the best acidification in grass silages was reached when the DM content was approx. 30%.

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**Fermentation kinetics of elephantgrass silage with proportions of cotton residue treated with urea**

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**Introduction** Elephantgrass is largely used on small farms being a strategic source of forage in the dry season of the year. In general, it is left to grow freely for just one cut, resulting in low quality of forage, affecting negatively the animal performance. Making silage seems to be the best way to conserve it, cutting three or four times during the rainy season. However, the high moisture content and the low amount of soluble carbohydrates limit the fermentation process. Dry additives have been added in elephantgrass ensiling to improve the pattern of fermentation (Quadros et al., 2003). In this context, the state of Bahia is the second largest producer of cotton in Brazil, releasing a huge amount of residue. The objectives of this work was to evaluate the fermentation kinetics of elephantgrass silage with two proportions (5 and 10% DM) of cotton processing residue (CR), ammoniated or not with urea (0, 4 and 8% DM).

**Materials and Methods** The experiment was conducted at the Bahia State University – Campus – IX - Barreiras, in the Laboratory of the Animal Production Research Center, in December 2011. We used a completely randomized design with 7 treatments and 3 replicates. The treatments were: EG100 = elephantgrass (control); CR5 = 5% cotton residue; CR10 = 10% cotton residue; CR5 4U = 5% cotton residue treated with 4% urea; CR5 8U = 5% cotton residue treated with 8% urea; CR10 4U = 10% cotton residue treated with 4% urea, and CR10 8U = 10% cotton residue treated with 8% urea. The residue was gotten in a regional cotton industry. The cotton processing residue was treated with 0, 4 and 8% urea (DM basis), and the urea was diluted with water to increase the moisture concentration to 30%. The treatment occurred for 28 days, and then the material was aerated for 72 hours before ensiling. The elephantgrass cv. Purple with 60 days of regrowth (15% DM) was cut and chopped in particle sizes of 2 to 3 cm. After homogenization between the chopped grass and the CR, the forage mass was ensiled in mini silos made with 20 L plastic buckets containing 4 kg of sand in the bottom to capture the effluent. The grass and the residue were mixed according to each treatment and compressed using feet, reaching an average density of 570 kg/m3. After 50 days, the silos were weighted and opened, measuring density, gas and effluent losses by gravimetric evaluation. After that, pH was measured using the methodology described by Silva and Queiroz (2002). Data were analyzed using ASSISTAT to analysis of variance and comparison of means, assuming significant differences among average values when P values were fewer than 5%. The pH of the silage increased significantly compared to the control.

**Results and Discussion** The pH of the silage increased significantly compared to the control. The use of urea in ammonization caused alkalinisation of the CR and increasing too much the silage pH decreasing the quality of fermentation (Table 1). The ideal pH for good silage starts at 3.8 to 4.2 (McDonald, 1991). According to these authors, grass silage dry matter contents of 20

% are normally accepted as a lower limit to decrease pH close to 4.0 and then preserve ensiled herbage satisfactorily. However, when herbage is too wet, even lowering its pH to 4.0 would not be enough to inhibit clostridia growth.

The addition of 10% ammoniated residue with 8% urea was effective in reducing effluent losses, differing from the other treatments were similar. Nevertheless, gas losses (range 2.16 to 3.31% DM) were higher than those observed for silage elephant pure (1.29% DM), which may be the high protein concentration of the CR, mainly ammoniated before ensiling, which might have favored the production of ammonia-N. Anyway the effluent losses of this work were high, causing damage to the silage fermentation, in addition loosing of important materials such as sugars, proteins, organic acids and minerals.

The results for the density of the material obtained a variation of 626.25 kg/m3 (control) to 504.52 kg/m3 (addition of 10% ammoniated residue with 8% urea). As the CR has lower density than the elephantgrass, that possibly affected reduce also the density of silage, with a variance because the addition of water and ammonization with urea in cotton processing residue.

**Table 1** Effluent and gases losses, recovery of dry matter, density and pH of silages with two proportions (5 and 10% of dry matter) of cotton processing residue, ammoniated with urea (0, 4 and 8% of dry matter).

| Treatments | Losses by effluent (kg/ton) | Losses by gas (%) | DM recovery (%) | Density (Kg/m$^3$) | pH |
|---|---|---|---|---|---|
| EG100% | 58.5 a | 1.3 e | 87.1 a | 626.2 a | 3.7 e |
| CR5% | 54.7 a | 3.0 abc | 70.4 cde | 571.4 abc | 3.8 de |
| CR10% | 55.8 a | 3.3 a | 66.8 e | 527.7 cd | 4.0 d |
| CR5% U4% | 54.2 a | 3.1 ab | 69.4 de | 599.2 ab | 5.1 c |
| CR 5% U8% | 54.7 a | 2.3 bcd | 76.9 bcd | 557.4 bcd | 5.2 bc |
| CR10% U4% | 53.8 a | 2.2 d | 78.3 b | 592.7 ab | 5.5 b |
| CR 10% U8% | 10.0 b | 2.3 cd | 77.3 bc | 504.5 d | 7.4 a |
| CV (%) | 8.28 | 11.21 | 3.70 | 3.81 | 1.97 |

[a–e]Means within a column with different superscripts differ ($P$<0.05).

**Conclusions** The chemical treatment with urea in cotton residue before the ensilage of elephantgrass did not result in improvements in the fermentation of elephant grass silage with increasing pH and low ability to reduce effluent losses and gases. However, the addition of untreated cotton residue without urea provides an increase in DM and desirable levels of pH of the silage.

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