Fermentative and nutritional traits of elephantgrass silage added with increasing proportions of coffee hulls

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ABSTRACT. This trial was carried out to evaluate the effects of coffee hulls inclusion (0%, 5%, 10%, 15%, and 20%; natural basis) on fermentation and nutritional traits of elephantgrass silage. A completely randomized design with four replications was used to compare treatments average, while plastic bags were used as experimental silos. Coffee hulls inclusion increased DM contents linearly and changed the fiber compounds profile. Including 10% of coffee hulls increased the contents of silage lactate and reduced acetate contents. DM digestibility and ruminal degradability of the silages decreased with the inclusion of more than 10% of coffee hulls. The amounts from 5% to 10% of coffee hulls were considered best levels to make elephantgrass silage with adequate fermentation pattern and nutritional quality.

Key words: ADF, ruminal degradability, *in vitro* DM disappearance, NDF, *Pennisetum purpureum*.

RESUMO. Características fermentativas e nutricionais da silagem de capim elefante com a inclusão de casca de café. O objetivo deste trabalho foi o de avaliar os efeitos da inclusão de casca de café (0%, 5%, 10%, 15% e 20% na matéria natural) nas características fermentativas e nutricionais da silagem de capim-elefante usando sacos plásticos como silos. O delineamento experimental utilizado foi o inteiramente casualizado, com quatro repetições. A inclusão da casca de café aumentou os teores de matéria seca (MS) das silagens linearmente e alterou os componentes da fibra. A inclusão de 10% de casca de café aumentou os teores de lactato e diminuiu os de acetato das silagens. A digestibilidade e a degradabilidade da MS das silagens diminuíram com a inclusão de casca de café acima de 10%. A inclusão de 5% a 10% de casca de café ao capim proporcionou silagens com melhor padrão fermentativo e qualidade nutricional.

Palavras-chave: degradabilidade ruminal, digestibilidade "*in vitro*" da MS, FDA, FDN, *Pennisetum purpureum*.

Introduction

The main problem for more than 150 milions of bovine in Brazilian herds (IBGE, 1998) is the quantitative and qualitative shortage of herbage during the dry season. To overcome that, farmers could use roughage dry matter (DM) surplus in the rainy season, making grass silage to be used in the dry season, resulting in a better pasture management.

Traditionally, conserved forages have been used only to meet the maitenance requeriments of beef cattle although, when properly ensiled, grasses encompass potentially higher rates of liveweight gain, achieving 0.8 - 1.0kg of daily gain in beef cattle fed on grass silage alone (McIlmoyle and Steen, 1979).

Elephantgrass (*Pennisetum purpureum* Schum.) is one of the most important fodder plants in tropical regions. Due to its high dry matter production in the rainy season, under good soil fertility and proper management, it is frequentely used in cut and carry systems (Lavezzo, 1985). Silage seems to be the most suitable alternative to conserve it, as haymaking due to the great stem proportion impairs adequate moisture reduction. However, low DM contents and reduced amounts of water soluble carbohydrates, together with a high buffering capacity, are considered limiting factors to a successful fermentation when ensiling (Vilela, 1998).

The use of feedstuffs containing high DM contents, such as hay and straw, during ensiling, decreased DM losses and undesirable fermentation products associated with silage spoilage, while increased voluntary DM intake in cattle (Lavezzo, 1985).

Brazil is the largest coffee producer in the world. Coffee hulls is an unvoidable crop residue, representing roughly 50% of the coffee grain weight before its processing (Caielli, 1984). Brazilian coffee hulls production reaches 1,650,000 Mg yearly (AEC, 1996), which can be available to use in ruminant feeding, without additional costs.

Silage quality can be estimated through relative proportions of main organic acids produced by fermentation (Woolford, 1984). Lactate production rate is also an important factor to inhibit the growth of undesirable bacteria and to reduce fermentation losses (McDonald *et al*., 1991).

Butyrate is produced in silages by clostridia fermentation pathway under anaerobiosis, forage high moisture content (>70%) and higher pH levels (>5.0) (Pitt, 1990). This clostridia undesirable fermentation consumes lactate (elevating pH) and carbohydrates, catabolises aminoacids and produces a wide range of unpalatable substances, such as butyrate and ammonia, reducing the DM voluntare intake (McDonald *et al*., 1991; Pitt, 1990). To prevent clostridia bacteria growth, Bolsen (1995) recommends lowering pH under 4.6 in wet silages.

The objective of this trial was to evaluate the effects of 0%, 5%, 10%, 15% and 20% of coffee hulls on fermentation and nutritional characteristics of elephantgrass silage.

Material and methods

The experiment was carried out at Universidade Estadual do Sudoeste da Bahia, in *Vitória da Conquista*, State of *Bahia*, Brazil, in 1998, using elephantgrass cv. Cameroon chopped about 3.0cm following the recommendation of Lavezzo (1985).

The results of elephantgrass and coffee hulls chemical analysis at the ensiling moment are shown in the Table 1.

Table 1. Chemical analysis of elephantgrass and coffee hulls used in the experiment (expressed in g/kg DM, ecxept DM that are expressed in g DM/kg NM).

Components	Elephantgrass	Coffee hulls
DM	130	873
CP	148	85
NDF	685	638
ADF	392	508
Hemicellulose	293	130

Elephantgrass was harvested with high levels of moisture (87%) and crude protein (14.8%). Conversely, coffee hulls as a lignocellulosic byproduct is rich in ADF, with high content of lignin, which may decrease silage nutrititional value (Garcia *et al*., 2000).

Coffee hulls were previously submitted to measurements of its water absorption ratio and density, according to the methodologies described by Ginger-Reverdin (2000). The results were 2237g/kg/DM and 309 g for each liter, respectively, which appears to be satisfactory for absorbing water and increasing silage density. Furthermore, despite of its low nutritional value (Caielli, 1984), it could be used as considerable part of ruminant diets (Garcia *et al*., 2000).

Chopped grass and 0, 5, 10, 15 and 20% of coffee hulls were weighed and mixed up in the proportion of each treatment, totalizing 5kg of the mixture. They were then ensiled in polietilene bags, using hand-compacting to maximize the air take-out. The bags were stored under environment temperature until the opening, at the 90th day after ensiling.

Sensorial analysis was made immediately after each silo opening, when the color, the presence of yeasts and molds, odor, moisture content and silage texture were observed. Those traits were ranked according the scale of Meyer *et al*. (1989), with a maximum score of 30 points. Sensorial analysis results of experimental silages ranged from 22.2 to 24.5 points, whereas in pure elephantgrass silages an excessive moisture content was observed.

Additionally, yeasts colonies, related to oxygen presence, were also observed near to the bag opening during sensorial analysis of silages. Oxigen left in the silo during its closure or even its infiltration after that are difficult to avoid when using plastic silos.

Silages were sampled to determine pH in water, imersing 10g of fresh silage inside a becker with 30ml of destilated water for 30 minutes before reading in pHmeter (Digimed DM 20). A second sample (400g) was taken and used to extract 200ml of silage juice in a hydraulic prense to mensure the pH and the titratable acidity (Silva, 1998). A 5-ml silage juice sample was taken, treated with 1ml of metaphosphoric acid (25%) and frozen for further analysis of organic acids. Lactate, acetate, propionate, and butyrate contents were determined following the methodology described by Wilson (1971). Another sample (500 g divided in two trays) was dried in an air forced-dryer oven at 60±5ºC for 72 hours. After grinding, the samples were analysed to determine DM contents (105ºC), crude protein (CP) (Kjeldahl method), NDF, ADF, and ash according the methodologies described by Silva (1998). Hemicellulose was estimated by subtracting ADF from the NDF contents.

The "in vitro" DM disappearance (IVDMD) was determined by modified Tilley and Terry (1963)

two-stage technique. In the first stage, forage was incubated in ruminal fluid, simulating ruminal digestion of cell contents and structural carbohydrates, and, in the second stage, extraction with neutral detergent solution was performed, simulating true digestion (Sollenberger and Cherney, 1995).

Samples of ruminal degradability were estimated using two Hostein cows surgically fitted with ruminal cannulae, collecting bags at 6, 12, 24, 48, and 72 hours after incubation in the rumen. Soluble fraction was quantified by washing the bags under running water during five minutes. The calculations were made using the equations described by Orskov and McDonald (1979), assuming a digest a passage rate of 0.02/h.

A completely randomized design with four replications was used. Data were analysed using SAS (1996) GLM procedure. Treatments were compared using regression.

Results and discussion

Both water and silage juice pH had a quadratic behaviour with the coffee hulls inclusion (Figure 1).

The pH decrease varied according to the technique used. Silages pH measured in the juice were even lower (3.3% in media) than the ones obtained in water.

Titratable acidity had a cubic behaviour with a tendency to stabilize when the coffee hulls proportion was above 10%. Titratable acidity seemed to be more sensitive to reflect smaller changes in silage acidity than the pH measurements.

The elephantgrass silage pH levels observed without coffee hull addition approached the value of 4,5 reported by Tosi *et al*. (1995) in silages of dwarf elephantgrass harvested 72 days after its last cut, added or not 40% of corn cobs. The inclusion of 10, 15, and 20% of coffee hulls decreased pH values close to 3.8, which was also observed by these authors, when testing molasses (4%) as silage additive.

Treated silages pH varied between 3.8 to 4.2. This pH range is considered satisfactory to guarantee the forage preservation in the silo (Lavezzo, 1985).

According to McDonald *et al*. (1991), grass silage dry matter contents of 200g/kg NM are normaly accepted as a lower limit to decrease pH close to 4.0 and then preserve ensiled herbage satisfactorily. However, when herbage is too wet (150g DM/kg NM), even lowering its pH to 4.0 would not be enough to inhibit clostridial growth (McDonald *et al*., 1991). Therefore, pH and DM interaction should also be considered to control undesirable silage fermentation.

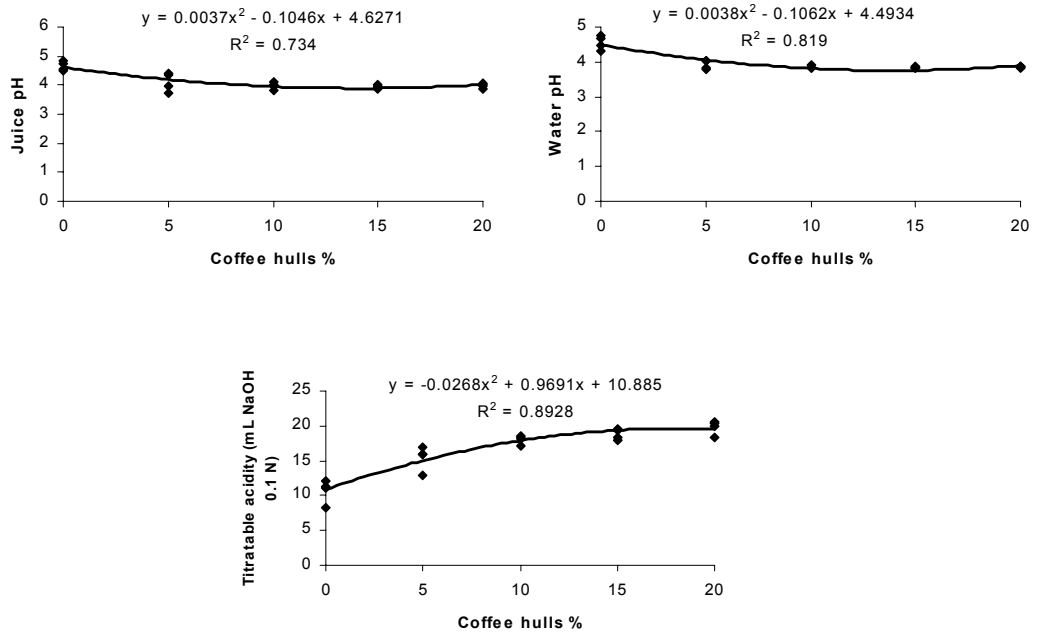

Figure 1. Juice and water pH, and titratable acidity of elephantgrass silages with inclusion of different proportions of coffee hulls

Increased elephantgrass silage DM contents were obtained due to the elevation of the coffee hulls proportion (Figure 2). Increasing the DM contents of high moisture silage could prevent environmental damages caused by the effluent's polluent (Haigh, 1997; Wright, 1997), and to decrease handling and storage costs (Rotz *et al*, 1993).

Higher DM contents of silages with 15% and 20% of coffee hulls were close to the Haigh (1990) recommended levels (above 250g DM/kg NM), in order to have an optimum DM content to guarantee adequate silage preservation.

During ensiling elephantgrass showed 148g/kg DM of CP, while after silo opening its CP content decreased to 92,2g/kg DM. This CP decrease occurred in all five treatments, but was more intense where elephantgrass silage was not added with coffee hulls. Probably, plant proteases and microrganims breaked down the true protein in ammonia, which was lost by volatilization in the temperature used in the oven (Dewar and McDonald, 1961).

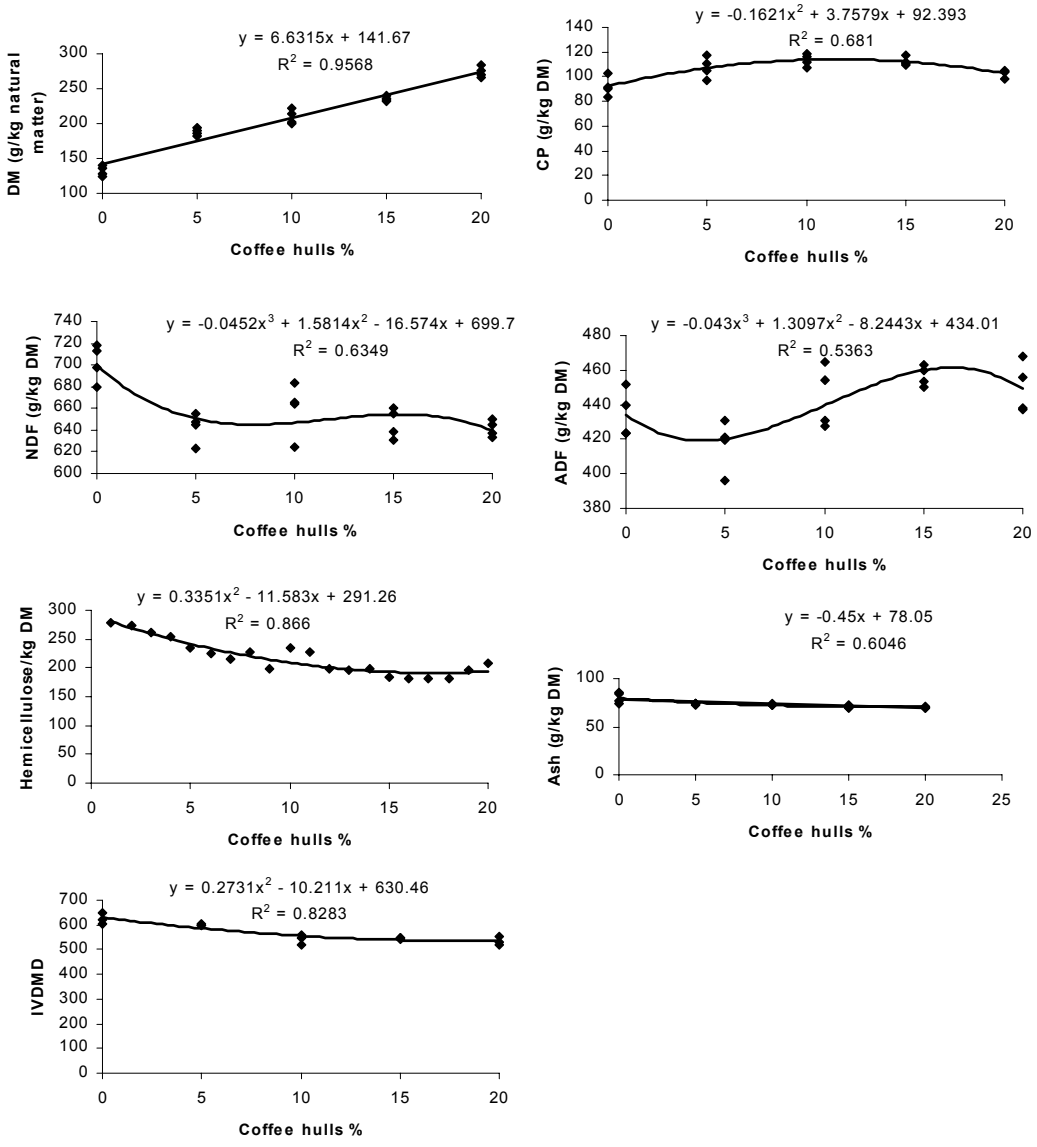

Figure 2. Chemical analysis, and "*in vitro*" dry matter disappearance (IVDMD) of elephantgrass silage with different proportions (in natural matter, NM) of coffee hulls

The CP contents of elephantgrass silage had a quadratic behaviour. The NDF and ADF were better ajusted in cubic equation. Lower pH levels increase chemical hidrolysis of some polysacharides, such as hemicellulose, which can reduce the fiber content of the ensiled forage (Bolsen, 1995). Lactic acid bacteria can only use soluble sugars as substrate and hemicellulose may be the source for a portion of the lactate and acetate produced during ensilage (Jaster, 1995). In this work, hemicellulose contents had a quadratic behaviour (Figure 2).

Hemicellulose also undergoes considerable breakdown (11% - 55%) by enzymatic action during the early stages of ensiling, which is gradually supressed by acid hidrolysis (Woolford, 1984).

The IVDMD had a quadratic behaviour (Figure 2). Faria *et al*. (1996) did not observe any reduction in IVDMD when 20% of elephantgrass hay was included to elephantgrass during ensiling . However, hay inclusion increased DM and CP contents.

Silage soluble fraction was not affected by coffee hull treatments (Figure 3). However, the insoluble, potentially degradable fraction decreased with the increase of coffee hull amounts, probably due to higher FDA of coffee hulls compared to elephantgrass. Ruminal degradability was higher in non treated elephantgrass silage and decreased with the increase of coffee hulls, similarly to the results observed by Ribeiro Filho (1998), while working with maximal 40% of coffee hulls (DM basis) in bovine diets.

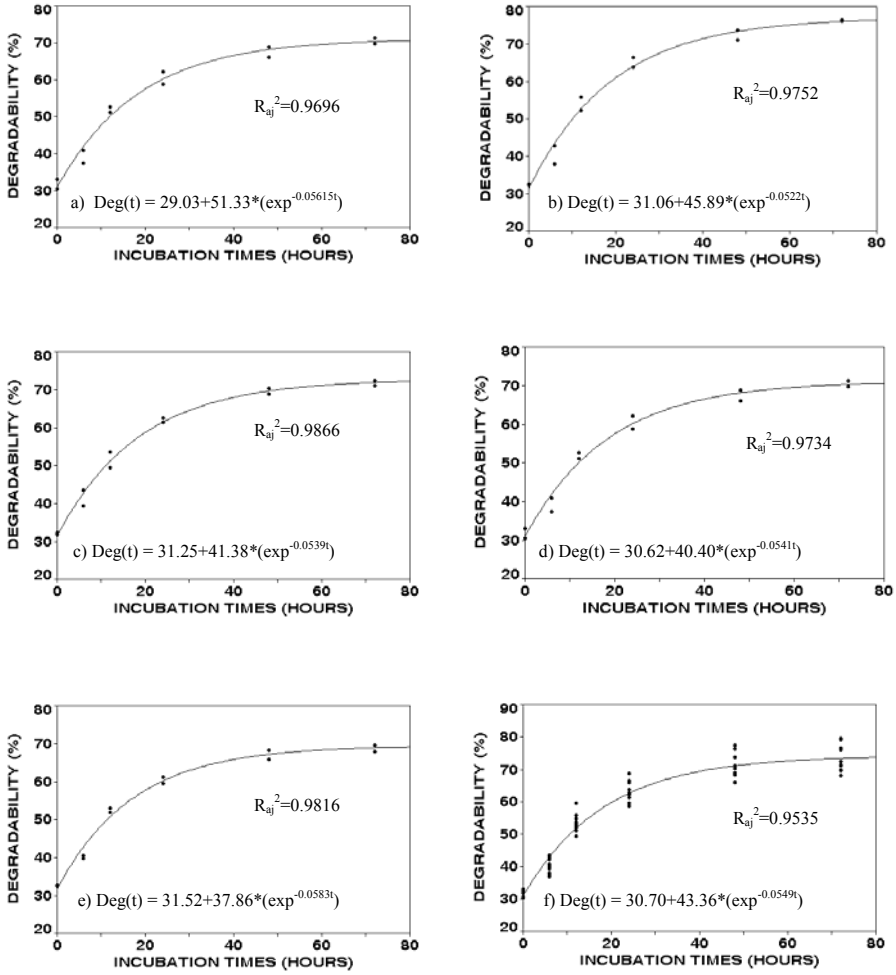

Figure 3. Ruminal degradability (Deg) of the pure elephantgrass silage (a) and with the inclusion of 5% (b), 10% (c), 15% (d), and 20% (e) of coffee hulls. The last graphic (f) represents the average of all treatments

Results of ruminal degradability observed in this paper were higher than the ones obtained by Pereira *et al*. (2000), when several nutritive additives were tested, related with corn and soybean processing plants by-products, in the elephantgrass ensiling, representing an average proportion of 18,8%, although a passage rate value of 0.05/h was used.

Lactate contents had a cubic behaviour (Figure 4) with higher values among 10 and 15% of coffee hulls. Those elephantgrass silage lactate contents (10% and 15% of coffee hulls) were similar to 75.6g/kg DM observed by Faria *et al*. (1996), when adding 20% of elephantgrass hay during ensiling.

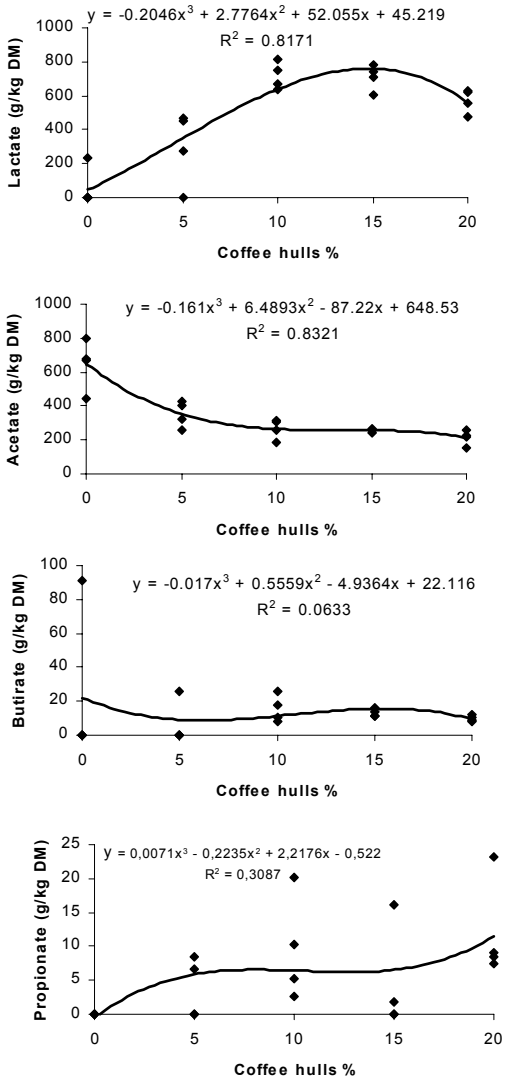

Figure 4. Contents of main organic acids in elephantgrass silage with inclusion of 0%, 5%, 10%, 15% and 20% of coffee hulls

Acetate, produced by enterobacterium, homofermentative (pyruvate fermentation pathway) and heterofermentative bacteria (McDonald *et al*., 1991), had a cubic behaviour. There was a tendency of the elephantgrass silage alone to show higher acetate contents than the silages with coffee hulls. Lactate decrease in silages with 15% to 20% of coffee hulls could be related to the lactate consumption by heterofermentative bacteria in the long storage period (90 days).

The butyrate contents were badly explained by regressions (R^2=0.06), due to the high value observed in one sample obtained in a pure elephantgrass silage. The reduction of butyrate amounts is considered an important biological response concerning silage preservation. Higher DM contents and lower pH values reached in treated silages allowed unfavorable conditions to clostridia development.

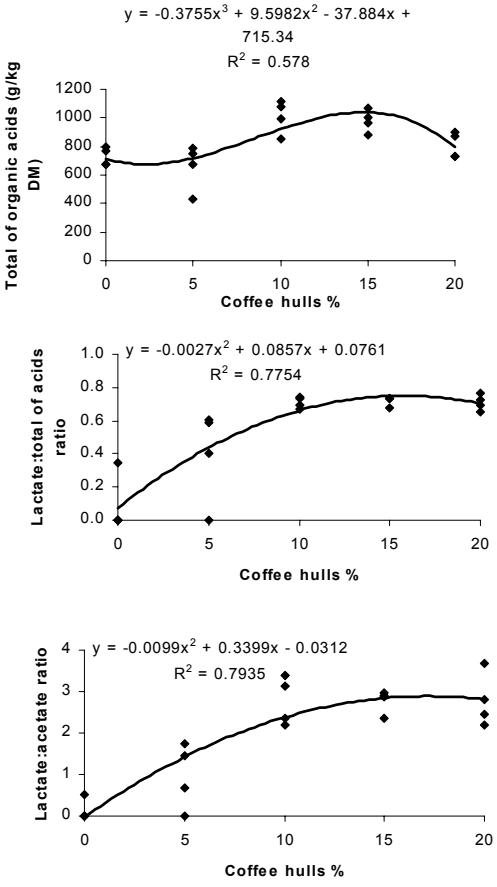

Figure 5. Total of main organic acids, lactate:total of acids ratio and lactate:acetate ratio of elephantgrass silage with 0%, 5%, 10%, 15% and 20% of coffee hulls.

The butyrate contents observed in this work (average 1.1g/kg DM) agreed with the data range described earlier (Tosi *et al*., 1989) when comparing 10% (2.1g/kg DM) and 20% (3.4g/kg DM) of sugarcane bagasse addition to elephantgrass at the ensiling moment with unwilted elephantgrass silage (1.05g/kg DM).

According to that, total amounts of organic acids were reduced with 5% of coffee hulls and increased with 10%, due to the changes in acids profile (Figure 5). Lactate production by 5% hulls-treated silage was sufficient to pH reduction, as lactic acid is an stronger acid than acetic.

The ratio of lactate in relation to total acids was low in untreated elephantgrass silages. It increased with the addition of 5%, stabilizing with 10%, 15% and 20% of coffee hulls. In well-preserved silage, at least 0.70 of the acids present are lactate (Pitt *et al*., 1985). The lactate/acetate ratio increased with the elevation of coffee hulls from 5 to 10%.

The inclusion of 5% to 10% of coffee hulls to the elephantgrass improved the fermentative pattern of the silages; however, it was observed a decrease on nutritional quality.

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Received on December 20, 2002.

Accepted on June 24, 2003.