EVALUATION OF SUGAR CANE BAGASSE SUBJECTED TO HAYING AND ENSILING[1]

Avaliação do bagaço de cana-de-açúcar submetido à fenação e à ensilagem

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ABSTRACT

This work aimed to evaluate sugar cane bagasse from cachaça production, subjected to hay-making and ensiling. The experiment was conduced at Universidade Federal de Lavras, MG, using the completely random delineation (CRD), with seven treatment and three repetitions. The treatments were constituted of *in natura* sugar cane bagasse (INB), manually hayed and baled sugar cane bagasse, mechanically hayed and baled, manually baled INB and mechanically baled INB, whole ensiled INB and chopped ensiled INB. Bromatological composition, tampon capacity (TC), pH values and total sugar rate of the INB were evaluated. For the ensilage, there were used cistern silos and for the baling, manual and mechanical balers. The bagasse was baled *in natura*, or after reaching 89% rate of DM, according to the treatments. The evaluated characteristics were dry matter rate (DM), crude protein (CP), fiber in neutral detergent (FND), fiber in acid detergent (FAD). The results went through variance analyses and the averages were compared by the Scott – Knott test (P<0.05). The INB presented rates of 51.70% of DM; 2% of CP; 79.43% of FND; 48.78% of FAD and 16.4% of total sugar in the MS. The sugar cane bagasse presented low TC and the silage presented satisfactory pH for good conservation. The dehydration followed by the manual baling provided a decrease in the cell wall components, revealing itself as the best bagasse conservation method.

Index terms: Hay, silage, sub-product.

RESUMO

Neste trabalho, objetivou-se avaliar o bagaço de cana-de-açúcar proveniente da produção de cachaça, submetido à fenação e à ensilagem. O experimento foi conduzido na Universidade Federal de Lavras, MG, utilizando-se o delineamento inteiramente casualizado (DIC), com sete tratamentos e três repetições. Os tratamentos foram constituídos por bagaço de cana *in natura* (BIN), bagaço de cana fenado e enfardado manualmente, bagaço de cana fenado e enfardado mecanicamente, BIN enfardado manualmente, BIN enfardado mecanicamente, BIN ensilado inteiro e BIN ensilado picado. Foram avaliadas a composição bromatológica, capacidade tampão (CT), valores de pH e os teores de açúcares totais do BIN. Para a ensilagem foram utilizados silos cisternas e para o enfardamento, enfardadoras manual e mecânica. O bagaço foi enfardado *in natura*, ou após atingir teor de 89% de MS, conforme os tratamentos. As características avaliadas foram os teores de matéria seca (MS), proteína bruta (PB), fibra em detergente neutro (FDN) e fibra em detergente ácido (FDA). Os resultados foram submetidos à análise de variância e as médias foram comparadas pelo teste de Scott-Knott (P<0,05). O BIN apresentou teores de 51,70% de MS; 2% de PB; 79,43% de FDN; 48,78% de FDA e 16,4% de açúcares totais na MS. O bagaço de cana apresentou baixa CT e as silagens apresentaram pH satisfatório para boa conservação. A desidratação seguida do enfardamento manual proporcionou diminuição nos componentes da parede celular, revelando-se o melhor método de conservação do bagaço.

Termos para indexação: Feno, silagem, sub-produto.

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INTRODUCTION

The “firewater” industry creates and abundant offering of sub-products, such as the sugar cane bagasse, in which the surplus is preoccupying, because in uses a lot of space and pollutes, and its utilization aggregate environmental, economical and structural benefits. The sugar cane harvest coincides with the forage scarcity period and the usage of the exceeding bagasse in an alternative of cheap fodder that may contribute to the profit increase of the property, giving an appropriated destination for the bagasse and minimizing the environmental pollution. However, the low stability of bagasse demands processes for its conservation for over two or three months. According to Rodrigues & Peixoto (1983), the use of bagasse as fodder for ruminants, both *in natura*, hayed of

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ensiled, may solve the stocking problem of this residue and the low forage availability in seasons of the year when forage is scarce.

The forage preservation as silage has as base the conservation process in acid means, in a fast pH decrease that leads to a proteolytic activity reduction, measured by enzymes from the plant itself, and makes unwanted anaerobic microorganism's growth to cease, especially enterobacteriaceae and clostridium (Muck & Bolsen, 1991). The pH is influenced by the sugar/protein ratio of forage (Soest, 1994). When working with forage containing high rates of sugar and low rates of protein, the tampon power is low and pH stability usually occurs before the 10th day of ensilage. (McDonald et al., 1991). According to Giger – Reverdin et al. (2002), quoted by Nussio et al. (2002), the tampon power is influenced by the protein and amid contents, by absorption of water capacity and by intrinsic osmotic pressure of the sample.

Rodrigues & Peixoto (1983) evaluated the sugar cane bagasse in its natural state and in the silage form and observed that ensilage promoted a reduction from 2.56 to 2% in the crude protein rate (CP) of *in natura* bagasse for silage. The rates of fiber in neutral detergent (FND) increased from 75.59 to 78.29% and of fiber in acid detergent (FAD) decreased form 52.87 to 49.75%. The lignin and ashes increased from 8.52 to 10.33% and from 1.94 to 4.68%, respectively, when comparing *in natura* bagasse to ensiled bagasse.

This work was conduced, aiming to evaluate the sugar cane bagasse from alembic cachaça subjected to haying and ensiling.

MATERIAL AND METHODS

The experiment was carried out from July 2004 to June 2005, in the facilities from Animal Husbandry department at Universidade Federal de Lavras, Minas Gerais. The sugar cane bagasse was originated from Bocaina alembic, located in the city of Lavras, MG, the utilized sugar cane variety was the BR-825336, with 15 months of age.

A completely random delineation was used, with seven treatments and three repetitions. The experimental units consisted of cistern silos and bales of bagasse. The treatments consisted of sugar cane *in natura* bagasse (INB); whole ensiled INB; chopped ensiled INB; whole hayed sugar cane bagasse and baled manually (89% of DM); whole hayed sugar cane bagasse and baled mechanically (89% of DM; manually baled INB and mechanically baled INB.

Samples were taken from the *in natura* sugar cane bagasse before ensilage of baling, which were pre dried in forced ventilation hothouses at temperature of 60°C until constant weight. Another INB part was frozen in plastic bags to determine of tampon capacity (TC) by the Playne & McDonald method (1966). The pre dried samples were crushed using stationary Thomas – Wiley mill, with a sieve of 1mm opening in the mesh. The rates of dry matter (DM) and crude protein (CP) were determined according to AOAC (1975); fiber in neutral detergent (FND) and fiber in acid detergent (FAD), according to Soest et al (1991). The bromatological analyses were made in the Animal Research Laboratory of the Animal Husbandry Department at UFLA. Also total sugar rates were determined by the Antrona method (Dische, 1962), in the Vegetal Products Analyses Laboratory of the Food Science Department at UFLA. For the material stocking and silage obtaining there were used six cistern type silos, covered with masonry with capacity for 500kf of forage. The bagasse was use whole or chopped in particles of approximately 5cm, according to the treatments. For the chopping an ensilage machine Liebeck L12 was used, with a power demand of 20/25 HP and with eight blades. The ensiled mass compression was done by feet and the silos sealing, with plastic sheets, covered with dirt. For the baling of the whole *in natura* or dehydrate in the sun (89% of dry matter) bagasse, vertical manual baler and mechanical baler Nogueira AP-41-n were used. The monitoring of DM rate from the material spread over a cemented platform using a microwave oven. When the wanted DM rate was reached, the material was baled.

The silos remained closed from October 2004 to February 2005 and, after the opening, the pH levels of the silage in the top, middle and low part of the silos was determined. To determine the pH levels, 9g of sample immersed into 60ml of distilled water, was used, with posterior potentiometer reading. Also samples were taken from the silages, in the middle portion of the silos, to do the pre drying at 60°C, in air circulating hothouses.

The bales remained stocked in a shed during the same period as the silages, and samples were taken to do the pre drying in air circulating hothouse.

The pre dried samples, both in silage and baled bagasse, were chopped in a stationary mill with a sieve of 1mm opening in the mesh. The studied variables were the same as the INB, except total sugar. The results were subjected to variance analyses and the contrast between the treatment averages were compared by the Scott-Knott test ($P<0.005$), using the SISVAR software (Ferreira, 2000).

RESULTS AND DISCUSSION

An average concentration of 16.4% of total sugar in the dry matter of *in natura* bagasse was determined, with sucrose as the main sugar. According to Woolford (1972), the minimum carbohydrate capable of guarantee adequate fermentation in the ensiled mass in around 6 – 8 %, while Catchpoole & Henzel (1971) stipulated 13- 16% as being the minimum values for grass ensilage. Based on the presented sugar rates, sugar cane bagasse can be considered adequate to silage production.

The conservation manner influenced significantly (P<0.05) the rates of DM, CP, FND and FAD in the bagasse. The results for the determination of DM, CP, FND and FAD in the *in natura* sugar cane bagasse, baled, hayed and baled and ensiled SCB are found on Table 1.

The rates of 51.70% of DM in NB of this study was higher than the ones obtained by Carvalho et al (2005, 2006), equal to 30.8 and 40.11% of DM, respectively. There was no statistic difference between the DM of INB rates (51.70%) and the chopped bagasse silage (48.43%), although the difference of 3.27 percentage unities (Table 1), that may be attributed to, especially, the loss or transformation of soluble carbohydrate during fermentation. In the whole bagasse silage, the DM rate in comparison to the INB and 7.46 percentage units in comparison to the chopped bagasse silage. The biggest difficulty on whole material compression may have contributed to a higher loss, because of the higher quantity of residual oxygen. Besides the DM losses being higher in silages produced with whole material, there was also a big loss of forage in these silos. Approximately 25 to 305 of ensiled mass were lost because of fungi occurrence, especially in top portion of the silos, causing degradation of the stored material.

In the bagasse bale evaluation done after five months of storage, it was observed that the dehydration did not alter the rate of DM in the baled bagasse, because there was no difference between the bagasse baled hayed and baled *in natura*. The sugar cane bagasse is a material which easily dehydrates, because it was necessary less than 8 hours of sun exposition to reach the DM rate of 89% and, even after baling, with bales exposed t air, the dehydration process was still constant. The DM rate also increased in the baled bagasse after dehydration, and the DM rates obtained after storage were, respectively, 98.02 and 96.19% for hayed bagasse, baled mechanically and manually. The crushing by mill, causing dilacerations of tissues, and low density of bagasse may have contributed for an easement in the material drying. There was no statistic difference, between manual and mechanical baling related to DM rates. Because bagasse is a crude material and with long fibers, it was more difficult to balance the mechanical baler and in the bale confection.

The *in natura* bagasse presented a rate of 2% of CP in the DM. Evangelista (2001) obtained a concentration of 2.4% of CP and Pires et al. (2004), of 1.8% when evaluating sugar cane bagasse from alembic. The ensilage promoted increase in the CP rates both related to *in natura* bagasse and hayed and bailed, not presenting difference between the silages with whole and crushed bagasse. The CP rates were higher in silages when comparing to the other treatments, which may be a consequence of soluble carbohydrate loss through cell breathing and fermenting processes. The forage gets the higher rates of wall cell components, which causes the effect of concentration and the increase in the CP percentage of silage DM. Inverse results were obtained by Rodrigues & Peixoto (1983) with ensilage, promoting CP reduction from 2.56% and 2.0% of *in natura* bagasse for silage. There was no dehydration effect and or baling effect in the rates of CP from the bagasse, which values vary from 1.90 and 1.96% in DM. Considering that for normal ruminant bacterial activity are necessary 6 – 8% of CP (Mertens, 1994) the CP rates of the bagasse are far from the minimum necessary, leading to the necessity of nitrogenous supplementation, the same that occurs when using fresh sugar cane in feeding ruminants.

The conservation forms of sugar cane bagasse promoted a difference (P<0.05) in the rate of FND and FAD.

The FND rate registered in INB (79.43% of DM) is very close to the obtained by Evangelista (2001), which was 78.5%, is lower than the one obtained by Pires et al. (2004), 94.3%, both evaluating alembic bagasse. Rodrigues & Peixoto (1983) analyzed the sugar cane bagasse from mill of an alcohol distillery and obtained rate of 75.59% of FND. The sugar cane bagasse that was hayed and manually baled presented a lower FND rate, 71.49% in DM, corresponding to a decrease of 7.49 percentage units related to INB. This result is controversial, because, according to Reis et al. (2001), during the forage drying occurs a decrease in the soluble carbohydrate contents and the concentration of CP, FAD and FND and lignin may increase proportionally, because the results are expressed in percentage. The bagasse dehydration until it reaches the DM rate of 89% was fats and, consequently, the losses were minimized.

There was no statistic difference between the FND rates presented by the *in natura* bagasse (79.43%), *in natura* bagasse manually baled (82.38%) and chopped and ensiled sugar cane bagasse (82.88%), although noticing an increase tendency in this fraction with the material conservation. Rodrigues & Peixoto (1983) evaluated sugar cane bagasse silage and concluded that in all treatments silages presented higher concentration of fiber contents and decrease in the DM rates in proportion to the original material, before ensilage. These authors observed that ensilage promoted increase from 75.59 to 78.2% in the FND rate *in natura* sugar cane bagasse for silage.

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For FAD rates of sugar cane bagasse, occurred an elevation of 48.78% in INB up to 54.68% of mechanically baled INB (Table 1). The FAD rate obtained for INB is lower than the obtained by Pires et al. (2004), of 62.7% and by Evangelista (2001), of 59.0% in DM, both evaluating bagasse from alembic. A FAD concentration of 38.34% was registered by Carvalho et al. (2006), when evaluating sugar cane bagasse acquired in cachaça producing plants. The haying followed by manual baling promoted a decrease in the FAD rate to 45.06% in DM, with this treatment presenting the lowest FAD rate.

The ensilage promoted increase in the FAD rate in proportion to INB. In studies conduced by Rodrigues & Peixoto (1983), the results were inverse, since ensilage promoted a decrease from 52.87 to 49.75% in the FAD rate of *in natura* bagasse for its silage.

There was no difference between the silage of whole and chopped bagasse FAD values, which presented similar rates to the ones obtained with mechanically baled bagasse. Also there was no dehydration effect of the bagasse when the baling was done by a mechanical baler. The manually baled INB presented FDA rate similar to the obtained with lower INB than the ones obtained with the other treatments.

Analyzing the data presented on table 1, it is possible to affirm that haying followed by manual baling was the best conservation method, because it provided a decrease in the FND and FAD rate in proportion to INB.

The values of tampon capacity of the bagasse and of the pH of silages are presented on Table 2.

The sugar cane bagasse, both chopped an whole, presented lower values of tampon power, with 2.15 and 2.41meqHCl/100g DM (Table 2), showing itself slightly higher on whole bagasse. The smaller tampon power of bagasse was expected in ratio of total sugar rate (16.4% in DM), the low protein rate (2.0%) and increased the DM rate (51.70%).

It is possible to observe, on table 2, that basically there was no variance of pH as for the collect location on the chopped sugar cane bagasse silage profile, which varies from 3.7 and 3.85. It is important that the pH of silage situate itself in the range considered ideal for adequate conservation of ensiled material, which, according to Lavezzo (1985) is from 3.8 to 4.2. Although, the superficial silage of the silos with whole bagasse presented pH higher than the ones taken from the middle and bottom of silos. This fact suggests that there was presence of agents that influenced the increase of superficial pH, such as water and air. It has to be outlined that in the higher layer of these silos the forage presented almost entirely degraded, indicative factor of harmful microorganism development.

Table 1 – Rates of dry matter (DM, crude protein (CP), insoluble fiber in neutral detergent (FND) and insoluble fiber in acid detergent (FAD) in the sugar cane bagasse (SCB) subjected to different forms of processing and conservation.

Treatment	DM	CP	FND	FAD
	%	% in DM		
In natura SCB (INB)	51.70 b	2.00 b	79.43 b	48.78 b
Chopped and ensiled INB	48.43 b	2.53 a	82.88 b	52.43 a
Whole ensiled INB	40.97 c	2.65 a	88.13 a	51.19 a
Mechanically baled INB	97.04 a	1.94 b	87.45 a	54.68 a
Manually baled INB	93.68 a	1.96 b	82.38 b	48.64 b
Hayed and mechanically baled SCB	98.02 a	1.94 b	85.99 a	52.81 a
Hayed and manually baled SCB	96.18 a	1.90 b	71.49 c	45.60 c
CV (%)	4.29	4.30	2.65	2.98

Averages followed by the same letters in the columns do not differ statistically up to the level of 5% by the Scott Knott test.

Table 2 – Tampon capacity (TC) of bagasse before ensilage and pH of silage in three different points of sampling in the silo.

	TC*	pH*		
Bagasse/silage	meq.HCl/ 100 g DM	Higher layer	Medium layer	Low layer
Chopped INB	2.15	3.85	3.80	3.70
Whole INB	2.41	7.00	3.90	4.00

* statistic analyses of the data were not done.

CONCLUSIONS

The chopped bagasse ensilage has shown efficiency in the material conversion during the period of 5 months, presented, in ratio to *in natura* bagasse, similar rates of DM and FND and higher rates of CP.

The haying did not promote differences in the DM rates of baled bagasse after five months of storage.

The dehydration followed by manual baling promoted a decrease of cell wall components, proving to be the best method for bagasse conservation

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