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Evaluation of the quality of the silage obtained from the uniformization pruning in intensive silvopastoral systems

Evaluación de la calidad del ensilado obtenido de la poda de uniformización en sistemas silvopastorales intensivos

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ABSTRACT

Keywords:

Silage,
Uniformization pruning,
Silvopastoral systems,
Proximal analysis.

The objective of the present work was to evaluate the nutritional composition of the silage made from the material collected from the uniformization pruning in an intensive SSP with buttercup. (*Tithonia diversifolia*) y tilo (*Sambucus nigra*), and mixed in different proportions with sugar cane (*Saccharum officinarum*) and King grass (*Pennisetum hybridum*), using a commercial additive of lactic acid bacteria and ruiminal content (*rumination*). Six treatments were evaluated with five repetitions and a weight of 10 kg per treatment, distributed as follows: T1: 25% T. diversifolia + 25% S. nigra + 50% S. officinarum with commercial additive (BTCac), T2: T1 with ruiminal content (BTCru), T3: 25% T. diversifolia + 25% S. nigra + 50% + P. hybridum with commercial additive (BTPac), T4: T3 with ruiminal content (BTPru) T5: 25% T. diversifolia + 25% S. nigra + 25% S. officinarum + 25% P. hybridum with commercial additive (BTCPac), T6: T5 with ruiminal content (BTCPru). With the obtained data an asymmetric factorial design of two levels was carried out, the analyzed variables were: dry matter (MS), ash (CEN), crude protein (PC), neutral detergent fiber (NDF), lignin (LIG) processed by NIRS , through agreement U of A - DaryCaby and pH. The CEN presented significant difference ($p < 0.05$) between treatments BTCac (11.92%), BTCru (11.62%) and BTCPac (14.76%), BTCPru (14.80%), BTPac (14 , 66%), BTPru (13.86%), but not between additives or interaction between treatment and additives, the NDF presented significant difference ($p = 0.0375$) among additives (58.08% and 60.39% commercial and ruiminal content respectively), but not between treatments or interaction between additive and treatments, lignin (LIG) presented a significant difference ($p < 0.05$) between treatments BTCac (5.1%) and BTCPru (7.5%)), BTPac (7.6%), BTPru (6.8%), and interaction between additive and treatments and there was no significant difference between treatments, the pH presented a significant difference ($p < 0.05$) between treatments BTCac (4.1), BTCru (4.2) and BTCPac (4.7), BTCPru (4.6), BTPac (4.6), BTPru (4.8), and there was no difference between additives or interaction between additive and treatments, the MS and Pc did not present a significant difference among treatments, or interaction between additive and treatments, with averages of 16.5% and 10.7% respectively.

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RESUMEN

Palabras clave:

Ensilaje,
podas de formación,
sistemas silvopastoriles,
análisis proximal.

El objetivo del presente trabajo fue evaluar la composición nutricional del ensilaje elaborado a partir del material recolectado de las podas de uniformización en un SSP intensivo con botón de oro (*Tithonia diversifolia*) y tilo (*Sambucus nigra*) y mezclado en diferentes proporciones con caña de azúcar (*Saccharum officinarum*) y king grass (*Pennisetum hybridum*) utilizando un aditivo comercial de bacterias acidolácticas y contenido ruiminal (*ruminaza*). Se evaluaron seis tratamientos con cinco repeticiones y un peso de 10 kg por tratamiento, distribuidos de la siguiente manera: T1: 25% botón + 25% tilo + 50% caña con aditivo comercial (BTCac), T2: T1 con ruminaza (BTCru), T3: 25% botón + 25% tilo + 50% + King grass con aditivo comercial (BTPac), T4: T3 con ruminaza (BTPru) T5: 25% botón + 25% tilo + 25% caña + 25% king grass con aditivo comercial (BTCPac), T6: T5 con ruminaza (BTCPru). Con los datos obtenidos se realizó un diseño factorial asimétrico de dos niveles, las variables analizadas fueron: Materia Seca (MS), Ceniza (CEN), Proteína cruda (PC), fibra detergente neutra (FDN), Lignina (LIG) procesados por NIRS, a través del convenio U de A – DaryCaby y pH. La CEN presentó diferencia significativa ($p<0,05$) entre los tratamientos BTCac (11,92%), BTCru (11,62%) y BTCPac (14,76%), BTCPru (14,80%), BTPac (14,66%), BTPru (13,86%), pero no entre aditivos ni interacción entre el tratamiento y los aditivos la FDN presentó diferencia significativa ($p=0,0375$) entre aditivos (58,08% y 60,39% comercial y ruminaza respectivamente), pero no entre tratamientos ni interacción entre el aditivo y los tratamientos, la lignina (LIG) presentó diferencia significativa ($p<0,05$) entre los tratamientos BTCac (5,1%) y BTCPru (7,5%), BTPac (7,6%), BTPru (6,8%), e interacción entre el aditivo y los tratamientos y no hubo diferencia significativa entre tratamientos, el pH se presentó diferencia significativa ($p<0,05$) entre los tratamientos BTCac (4,1), BTCru (4,2) y BTCPac (4,7), BTCPru (4,6), BTPac (4,6), BTPru (4,8), y no hubo diferencia entre aditivos ni interacción entre el aditivo y los tratamientos, la MS y Pc no presentaron diferencia significativa entre tratamientos, ni interacción entre el aditivo y los tratamientos, con medias de 16,5 % y 10,7% respectivamente.

Introduction

Livestock production in Colombia uses monoculture grazing of grasses to feed cattle; This makes that production system dependent on high amounts of external inputs such as balanced food, fertilizers, agrochemicals, fuels, etc.

Colombia is a country with an exuberant biological diversity, in which you can find numerous species of trees and shrubs (native or introduced) such as T divesifolia and S. nigra. These are adapted to tropical conditions and have a high potential used as feed for cattle due to their agronomic characteristics and nutritional composition, which can exceed the contributions made by foreign grasses.

Taking this into account, the establishment of silvopastoral systems (SSP) proposed as a strategy to intensify livestock production sustainably, taking advantage of the benefits provided by tree and shrub species such as contribution to the reduction of maintenance and fertilizer costs. These obtain products such as poles, wood, firewood, fruits and foliage that animals consume, reduces the impact of trampling, reduces erosion, increases moisture retention, promotes the return of wildlife, increases carbon deposits, reduces emissions of methane because they contribute to improving the efficiency of metabolic processes in the rumen of cattle, among others [1], [2].

Several tasks are contemplated in the establishment and management of the (SSP), among these are the uniformization prunings that aim to homogenize the plants for the beginning of grazing or when these are too tall and the animal does not reach or is not comfortable consuming it [3]. The product is most of the time delivered to the ground as green manure [4].

In tropical conditions, it is difficult to maintain a constant forage production specifically due to the marked difference between the rainy and dry season, which makes it necessary to create food reserves for use in times of drought [5]. The uniformization prunings generated during the establishment of the SSP can be an essential food to preserve it through the silage technique mixed with other plant sources as a mechanism to improve its initial condition offered to animals in times of food scarcity.

Silage seeks to maintain the initial nutritional characteristics of the material to be preserved, for this, strategies such as inoculation with lactic acid bacteria (LAB) are used to improve lactic fermentation, but the effects of said inoculants on the quality of the silage and the productive performance of the animals are not clear [6].

The objective of this work was to evaluate the nutritional composition of the silage made from the material collected from the uniformization pruning from an intensive browsing SSP with the species of the buttercup (*Tithonia diversifolia*) and linden (*Sambucus nigra*). These species mix in different proportions with sugar cane (*Saccharum officinarum*) and King Grass (*Pennisetum hybridum*) using commercial additive of lactic acid bacteria and rumination.

Materials and methods

Origin of plant material

The plant material used to make the silos was obtained from a browsing silvopastoral system established at the SENA Center for Renewable Natural Resources La Salada. It is located in the Municipality of Caldas Antioquia, Km 6 via la Pintada (6°02'57.6"N 75°37'30.6"W), at 1900 masl, with an average temperature of 18 ° C, a rainfall of 3800 mm / year, and a relative humidity of 85%, sandy clay loam soil, pH = 5.74 moderately acid. The establishment of the SSP system was carried out in June 2016, in an area of 1 ha-1, composed of three strata: 1- arboreal stratum composed of alder trees (*Alnus acuminata).* These were planted at a distance of 10 m between rows and 4 m between trees, 2- shrub stratum composed of buttercup plants (*Tithonia diversifolia*) planted in rows every 3 and continuously between plants and linden (*Sambucus nigra*) sown in rows every 3 meters and 50 cm between plants and 3- a herbaceous layer composed of star grass (*Cynodon nlemfuensis*).

Cutting, transport and chopping of the material

After four months, a radical pruning was carried out, from the primary stems at a height between 70-80 cm from the ground to the button and linden plants. This material was used to make the silage. King Grass and sugarcane were harvested at an age of 2.5 months and 11 months respectively. The cutting and transport of the forage to the processing area was carried out manually and there it was fractionated in a pasture pick with an approximate particle size of between 2 and 2.5 cm. Samples collected from King grass, forage cane and button and linden pruning were used to determine the initial nutritional composition through the near infrared spectroscopy (NIRS) technique, in the animal nutrition laboratory of the Universidad de Antioquia and in the Eurofins Agro NL laboratory (Holland) through the U of A agreement – DaryCaB.

Preparation of additives

Ruminal enzyme extract (*ruminasse*) and a commercial product are used as an additive for the production of silage, the latter composed of lactic acid bacteria. (*Lactobacillus Plantarum, Lactobacillus Brevis, Pediococcus Acidilactici y Streptococcus Diacetylactis*), The dose used was 1g dissolved in half a liter of water without chlorine at room temperature, shaking it slightly, for each 10 kg silo.

Rumination was obtained from cattle slaughtered in a processing plant, it was transported to the place where the test was prepared in an anaerobic environment,1kg (solid and liquid phase) was used for each 10 kg silo.

Silage preparation

Six treatments were evaluated: T1: 25% button + 25% linden + 50% cane with commercial additive (BTCac), T2: T1 with rumination (BTCru), T3: 25% button + 25% linden + 50% + king grass with commercial additive (BTPac), T4:

T3 with ruminased (BTPru) T5: 25% button + 25% linden + 25% cane + 25% king grass with commercial additive (BTCPac), T6: T5 with ruminased (BTCPru). After having the material in the processing area, it was weighed and mixed, adding the inoculum according to the indicated treatment, it was packed in six-gauge silage bags, compacted manually and each silo was wrapped in a plastic film, storing it later, in a place protected from humidity and sun, for a period of 31 days. 5 repetitions were carried out for each treatment, when opening each treatment, the pH measurement was performed with a potentiometer. For the analysis of the data obtained, a 2-level asymmetric factorial design was carried out. The statistic used for the modeling of the results was the following:

$$y_{ijk} = \mu + \tau_i + t_k + (\tau^* t)_{ik} + \varepsilon_{ijk} \quad (1)$$

Where:

yijk: Observation ijk

μ: General Average.

τi: Treatment effect.

tk: Additive effect

(τ*t) ik: Effect of the treatment - additive interaction

εijk: Random error with mean 0 and variance.

The variables analyzed were: Dry Matter (DM), Ash (CEN), Crude Protein (PC), neutral detergent fiber (NDF), Lignin (LIG) and pH.

Results and Discussion

The initial nutritional composition of the materials used to make the silage is presented in table I.

Table I. Nutritional quality of the species used to make the silage

	Tithonia diversifolia	*Sambucus nigra*	*Saccharum officinarum*	*Pennisetum hybridum*
MS %	15,28	19,73	27,33	20,85
Ceniza %	14,17	13,80	8,20	12,50
PC (%)	16,77	15,70	11,43	6,97
FDN (%)	47,67	45,00	65,47	72,20
Lignina (%)	6,07	6,20	1,00	4,56

Source: The authors. MS: dry matter, CP: crude protein, soluble CP: soluble crude protein, NDF: neutral detergent fiber.

Table II shows the average values of the nutrients in each of the treatments evaluated according to the type of additive.

Table II. Nutritional quality of the silage of plant material mixtures according to the additive used

TTO	MS	CEN (%)	PC (%)	FDN (%)	LIG (%)	pH
BTCac	17,74	11,92^{a}	11,84	56,68	5,1^{a}	4,1^{b}
BTCPac	16,80	14,76^{b}	10,76	57,40	6,3^{abc}	4,7^{a}
BTPac	14,18	14,60^{b}	9,20	60,18	7,6^{c}	4,6^{a}
BTCru	18,57	11,62^{a}	13,07	61,12	6,1^{ab}	4,2^{b}
BTCPru	15,40	14,80^{b}	9,24	59,66	7,5^{bc}	4,6^{a}
BTPru	16,60	13,86^{b}	10,10	60,40	6,8^{bc}	4,8^{a}
Prom	**16,54**	**13,59**	**10,7**	**59,24**	**6,56**	**4,5**

Source: The authors. Means with different letters within each column differ significantly (P <0.05). dry matter (DM), ash (CEN), crude protein (PC), neutral detergent fiber (NDF) and Lignin (LIG).

Dry material

This variable did not present a significant difference between treatments, or between additives, or interaction between treatment and additive, with a general average of 16.54%, a value that is below that reported by Hidalgo et al [7], who is a nutritional evaluation and sensory silage of *Sorghum vulgare* and *Tithonia diversifolia*. In a proportion of 75% and 25%, respectively, they found a DM of 30%, this may be because the material in the present study was not subjected to a pre-drying process, in addition to the additives used (rumination and commercial inoculum of BAL), were prepared in a humid environment, which could have increased the humidity levels of the conserved material. On the contrary, Gastón [8] obtained a DM level of 12.7% in silage of leaves and non-woody stems of *Tithonia diversifolia* after 35 days of fermentation.

The ideal dry matter concentration in silage depends on the material to be conserved [9], some authors report that said value for tropical forages can be between 17 and 30% [10], [11], and this parameter can be improved by adding absorbent additives like straw, although there is a risk of diminishing the nutritional value by dilution [12].

Ashes

In this parameter, there was a statistical difference between treatments and not between additives and there was no treatment / additive interaction.

The treatments that differed were BTCPac, BTCPru, and BTPac BTPru from BTCac and BTCru, the latter two showing the lowest value (11.77% average). This could be due to the low initial ash content (8.20%) in the sugarcane, which is found to constitute 50% of the ensiled biomass. Ash values of 8% are reported by Suárez et al [13], in silages of the burnt bud of sugar cane (*Saccharum officinarum*) and matarratón (*Gliricidia sepium*), in proportions of 75/25% respectively. The values found in the present study being higher in all treatments (13.59% general average), likewise Carvajal and Cuesta [14], report values of 11.03% for silages of *Sambucus nigra* added with 5% cane molasses.

Crude protein

In this variable, there was no significant difference between treatments or between additives, or interaction between additive and treatment.

PC contents fluctuated between 9.20% and 13.07% and had a general average of 10.7%. This value is below that reported by Blanco at al [15], who found a protein content of 13.77%, for silage made from S. nigra, A. decurrens and A. satiava and molasses, using enzymatic extract from ruminal fluid as additive. This low value may be because some conserved materials such as grass Pennisetum hybridum in the initial state they had very low levels of protein (6.97%). In addition to biomass from the shrubs was an average 4.5 months old at the uniformization cut, taking into account that the effect of maturity in these species causes a decrease in nutritional quality.

However, some authors such as Suárez et al [13] obtained lower values than those reported in the present study (5.95%) when ensiling burnt bud of sugar cane (Saccharum officinarum) and matarratón (Gliricidia sepium), in proportions of 75/25% respectively.

Other factors that could be associated with levels of CP found are the collection of the material to be ensiled, so, rapid proteolysis begins. When the pH does not fall below 4.2 and the humidity conditions in the silage are high as in the present study, it is highly probable that the population of clostridium and the production of butyric acid will increase. Clostridium are proteolytic that degrade the protein to amino acids so that a decrease in this can be perceived in the ensiled material. This can be controlled by carrying out a rapid pre-drying process of the material [9], [12], or using additives such as formic acid, which can increase the amount of protein promoting an increase in the performance of the animals. This being attributed to the better balance of amino acids and the suppression of proteolysis by control of proteolytic bacteria and plant enzymes [16].

Neutral detergent fiber

In this variable, a significant difference was found between additives, but not between treatments or interaction between additive and treatment.

The general average was 59.24%, the lowest value was 56.68% in the BTCac treatment without statistical difference. This value is higher than that found in silages of Tithonia diversifolia and Pennisetum purpureum, (31,43 %) in a proportion of 20/80 respectively, using a commercial additive in a quantity of 4%, [17]. It is below that reported by Echeverria et al [18], who found in silage made from Olea pruning European, an NDF level of 66.87% at 110 days of fermentation.

The NDF values depend on the maturity of the crop, the genotype, the diversity of the soil, and the use of additives, in the case of this study the materials were of advanced age, which produced a high NDF value in the silage.

Lignin

This parameter presented a significant difference between treatments and additive treatment interaction, but there was no difference between additives. The treatments that differed were BTCac and BTCPru with values of 5.1% and 7.5% respectively and the treatments BTCac and BTPru and BTPac, with average values of 5.1%, 6.8% and 7.6 respectively.

The general average for this variable was 6.56%, a value that is below that reported by Echeverria et al [18], who found in silage made from prunings of European Olea, with 110 days of fermentation a value of 24,4%.

The lowest levels of lignin were present in the BTCac and BTCru treatments. In comparison with other grasses and legumes, sugarcane has a low level of lignin in the NDF, which may represent the low total levels of lignin in the treatment, although on the other hand, the negative effect of this phenolic compound on fiber digestibility can be more pronounced than in other plants [19]. The low nanoporosity of the cane, especially in the most lignified areas affects the composition of the cell wall, besides, the formation of a sclerenchyma ring in the stem cortex hinders the transformation of the particles, increasing the rumen retention time, which explains the greater physical effectiveness of FDN [9].

pH

This variable presented a significant difference between treatments and there was no difference between additives or additive treatment interaction. The treatments BTCac and BTCru showed a significant difference with BTCPac, BTCPru and BTPac, BTPru.

The general average was 4.5. The pH level in the present study is in the ideal range of 3.8 to 5.0 reported by Merry et al [20], which indicates an adequate fermentation of the forage mass. The average pH determined in the treatments with both additives is slightly above that found by Carvajal and Cuesta [14] with a pH of 4.28 in linden silage in 30 days of fermentation.

The decrease in the pH levels at the beginning of the ensilage process is essential to avoid the increase of proteolytic microorganisms. This level is largely promoted by the concentration of highly fermentable carbohydrates such as those provided by the cane and the microbiota present in the dough forage to be conserved [9], which is why the lower values in the treatments with 50% sugarcane can be explained.

Low pH levels in silage are generally associated with depressions in the intake and poor use of fiber, since at low pH in the rumen cellulolytic activity decreases, however, said pH is neutralized in the mouth by the action of the saliva at the time of consumption. [21].

Conclusions

Taking into account the results in the present study, the residues of the uniformization pruning generated in the establishment of silvopastoral systems, have a potential use mixed with materials such as sugarcane to be conserved through the silage technique to solve the deficiencies of forage in critical times. Rumination is presented as a material with potential for use as an additive in the conservation of forages because the action of this in the conservation of the material was similar to that of the commercial inoculum that has a high cost, on the contrary, rumination it is an item that is easily accessible and its commercial value is low.

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