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Effect of ensiling gliricidia with cassava on silage quality, growth performance, digestibility, ingestive behavior and carcass traits in lambs

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A R T I C L E I N F O

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A B S T R A C T

The objective of this study was to evaluate the effects of ensiling gliricidia (*Gliricidia sepium* Jacq.) with cassava on silage quality as well as the growth performance, digestibility, ingestive behavior and carcass traits in lambs. Gliricidia was ensiled with cassava leaves at varying proportions of inclusion (0, 200, 400 and 600 g/kg) for 75 days and fed as a total mixed ration (TMR) at 700 g/kg, while a concentrate mixture was fed at 300 g/kg to 32 castrated Santa Ines crossbred lambs with an average weight of 18.9 ± 2.0 kg. The pH, N-NH_3, density, butyric and acetic acid contents and dry matter losses (DML) of the gliricidia silages decreased linearly ($P < 0.05$) with cassava inclusion, but there was a linear increase ($P < 0.05$) in the contents of dry matter (DM), non-fibrous carbohydrates (NFC), total carbohydrates (TC), and lactic and propionic acids. Including cassava leaves in the gliricidia silage increased ($P < 0.05$) the intake (g/d) of DM, CP, EE, NDFap and NDFap (%BW) by the lambs, but there was no effect on the digestibility of DM, CP, EE, and NDFap or the time spent feeding, ruminating, idling and chewing. There was a slight tendency toward a quadratic increase in the NFC digestibility coefficient ($P = 0.084$). The inclusion of cassava leaves in the gliricidia silage linearly increased ($P < 0.05$) the final weight, total weight gain, average daily gain, and hot and cold carcass weights of the lambs, but there was no influence on the carcass traits ($P > 0.05$). However, the weights of the commercial cuts and non-carcass components linearly increased ($P < 0.05$) with the inclusion of 600 g/kg of cassava in the gliricidia silage. Therefore, it is recommended to combine gliricidia with 600 g/kg of cassava leaves to improve the fermentation pattern and chemical composition of gliricidia-cassava silage, and offering the silage in lamb diets increases the nutrient intake, performance, morphometric measurements and carcass and non-carcass components as well as the yields of

Abbreviations: ADF, acid detergent fiber; ADG, average daily gain; ADL, acid detergent lignin; CCI, carcass compactness index; CCW, cold carcass weight; CCY, cold carcass yield; CP, crude protein; DM, dry matter; DMI, dry matter intake; EE, ether extract; FCs, fibrous carbohydrates; EBW, empty body weight; EGTC, empty gastrointestinal tract content; HCW, hot carcass weight; HCY, hot carcass yield; LDA, *longissimus dorsi* area; NDF, Neutral detergent fiber; NDF_{ap}, NDF corrected for ash and protein; NFC, non-fibrous carbohydrate; "panelada", typical northeastern Brazilian food made from entrails; sheep "buchada", typical northeastern Brazilian food made from non-carcass components; SW, slaughter weight; SFT, subcutaneous fat thickness; TC, total carbohydrates; TWG, total weight gain

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both prime commercial cuts, such as the loin and ham, and typical foods, such as sheep "buchada".

1. Introduction

Conserving alternative feed in the form of silage is vital for feeding animals, especially in the dry season when forage availability is lower, but this practice usually results in decreased performance with lower-quality carcasses and reduced meat cut yields. However, the use of byproducts (Medeiros et al., 2015) and/or forage legumes (Silva et al., 2016) that are adapted to tropical climates and low rainfall can be a good alternative in silage production (Silva et al., 2016). Thus, ensiling is an important and efficient method for preserving forage and maintaining the quantity and quality of animal diets during periods of scarcity by providing valuable sources of energy and protein (Heinritz et al., 2012; Ferreira et al., 2016).

In this context, gliricidia (*Gliricidia sepium* Jacq.), a leguminous tree, yields high forage mass with good nutritional value, mainly in areas with deficient forage (Andrade et al., 2015). In addition, gliricidia has a low tannin content with a mean leaf concentration ranging from 6.0 to 9.0 g/kg DM (McSweeney et al., 2001; Vázquez et al., 2016), which is acceptable for sheep diets if it is not the only ingredient. However, the use of fresh or ensiled gliricidia may be limited by its strong odor caused by the release of volatile compounds (Silva et al., 2017) as well as its low dry matter content (270–300 g/kg DM) (Edvan et al., 2016; Ferreira et al., 2017).

As a result, the above-ground biomass of cassava (*Manihot esculenta* Crantz) stands out as a viable alternative feed for use in animal production in combination with gliricidia because cassava is adapted to adverse climatic conditions and exhibits high DM production, 32,000 kg/ha, depending on the type of management and its use, including as a feed source for animals in the form of silage or hay (Silva et al., 2016; Polyorach et al., 2016). However, the high crude protein (CP) content of cassava (205 g/kg DM on average) may lead to a buffering effect that may interfere with pH reduction to levels ideal for silage fermentation (Fernandes et al., 2016).

Therefore, the use of above-ground cassava biomass in combination with gliricidia can guarantee the efficiency of the silage under appropriate conditions, with a soluble carbohydrate content of the cassava between 120–150 g/kg DM as well as an increased buffering capacity (McDonald et al., 1991) and reduced losses in silage quality (Ferreira et al., 2017).

Thus, above-ground cassava biomass was ensiled with gliricidia to test the hypothesis that using this roughage combination could improve the fermentative profile and the nutritive value of feed as well as increase the performance, carcass characteristics and ingestive behavior of crossbred lambs.

2. Materials and methods

This study was conducted at the Brazilian Agricultural Research Corporation (Embrapa-Brazil) of the Semi-Arid in the city of Petrolina, Permabuco State at 09°09′ south latitude and 40°22′ west longitude in strict compliance with the recommendations in the Guide of the National Council for the Control of Animal Experimentation of the Federal University of Recôncavo of Bahia, Bahia State, Brazil (Permit Number: 0002/140814).

2.1. Silage production and treatments

The cassava used in the silage consisted of the above-ground biomass (manioc + leaf) of the *Recife* variety harvested after approximately six months of cultivation. Cassava silage was produced in an irrigated system and grown with a spacing of 1.0 m between plants and 1.2 m between rows. After harvest and transport, the above-ground biomass was crushed into 3- to 4-cm pieces with the aid of sieves in a fodder machine (Royal ®EC4000, São Paulo, Brazil). The *G. sepium* used for planting was cut from four-year-old trees, and planting occurred at a spacing of 1.5 m × 1.0 m. The branches were cut into 20-cm lengths with a mean diameter of 3 to 5 cm for each seedling. The variation in the mean particle size of the harvested forage and the silages was evaluated by particle stratification following the Penn State Particle Separator methodology proposed by Lammers et al. (1996), which determines the percentages of the material with a diameter greater than 38 mm (sieve 1), from 38 to 19 mm (sieve 2), from 19 to 7.9 mm (sieve 3) and less than 7.9 mm. Additionally, the difference in amplitude was determined between the mean particle size of the largest (4 cm) cassava and the smallest (2 cm) gliricidia.

After obtaining the above material and before the silage process, the gliricidia was mixed with the above-ground cassava biomass at proportions 0, 200, 400, and 600 g/kg in the mixture, which constituted the experimental treatments. Mini-silos (five replicates per treatment) were constructed using polyvinyl chloride (PVC) tubes that were 100 mm in diameter and 50 cm in length (5-L capacity). In the same proportions as in the mini-silos, above-ground cassava biomass was also added to gliricidia silage in barrels (Polyembalagens®, São Paulo, Brazil) with a 200-L capacity (20 replicates per treatment). The material was compacted by trampling, and the barrels were closed with a metal seal. The barrels were then stored in the shade at a temperature between 20 °C and 25 °C and opened after 75 days.

2.2. Fermentative profile

After the fermentation period (75 days), the dry matter losses (DML) were obtained from the weights before and after the silo-