Lamb feeding preference for maize, bean, and broad bean stubble treated with silage effluent, urea-molasses, or phosphoric acid

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ABSTRACT

Objective: To determine the acceptability of several stubbles: maize stubble treated with urea-molasses (MaUM), silage effluent with phosphoric acid (MaEflAcP), and control (MaTes); bean stubble treated with silage effluent (FrEfl), effluent silage with urea-molasses (FrEflUM), and control (FrTes); and broad bean stubble treated with silage effluent and urea-molasses (HaEflUM), urea-molasses and phosphoric acid (HaUMAcP), and control (HaTes).

Design/Methodology/Approach: Six Dorper/Katahdin lambs of 21 kg (LW) were used to carry out the feeding preference test. In the morning, lambs were fed with a mixture of the three treatments of each stubble (70% of the dry matter (DM) requirement/40 min); meanwhile, in the evenings, they were offered each treatment in independent feeders (10% of the DM requirement/20 min). This process lasted 7 days. Intake was measured in grams (offer minus rejection). Once the ordinal qualitative variables of consumption frequency (1=low, 2=medium, and 3=high) were classified, the data were analyzed using the ordinal logistic regression model. The results were expressed as the estimated proportion of incidence of the frequencies (1, 2, or 3).

Results: The proportion estimated for the high consumption frequency recorded higher results for MaUM, HaUMAcP, and FrEflUM, reaching 95.24, 73.44, and 43.49%, respectively. The proportion estimated for the low consumption frequency for HaTes, MaTes, and FrTes was 95.12, 88.11, and 48.77%, respectively.

Study Limitations/Implications: The diets with different quality and flavors did not meet the assumptions of normality and homoscedasticity; however, the results provide valuable information for the improvement of dry matter intake and animal production.

Finding/Conclusions: Urea-molasses (UM) promoted consumption preference both alone or in combination with other ingredients, in all the stubbles tested.

Keywords: Food preference test, lambs, treated stubbles.

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INTRODUCTION

The scarcity of high-quality forages limits the physical development of ruminants and meat and dairy production. Consequently, improving the nutritional quality of crop residues used in production systems of the Mexican plateau or dry tropic (Montossi *et al.*, 2013) is fundamental to reduce the competition among species for access to grains grown for human consumption (Giraudo *et al.*, 2014; Crosby *et al.*, 2018).

Maize (RMa), bean (RFr), and broad bean (RHa) stubbles provide few nutrients to ruminants (Chegeni *et al.*, 2013); however, nutrition and animal productivity can be enhanced, if these stubbles are treated to improve their digestibility. Therefore, considering the demand *vs.* nutrient concentration interaction, the feeding preference of ruminants and the potential benefits should be evaluated (Favreau-Peigné *et al.*, 2012). Authors Ginane *et al.* (2011) researched the sweet, salty, and bitter flavors of feeds and classified the level of flavor acceptance among ruminants as low, medium, and high. Their conclusion was that sweet flavors were highly accepted by cows and goats, but not by sheep. Salty flavors were positively or negatively accepted (depending on the mineral needs of the body), while bitter flavors recorded very negative values. Villalba *et al.* (2019) evaluated the feeding preferences of lambs and concluded that palatability increased the consumption of medusahead (*Taeniatherum caput-medusae* (L.) Nevski), common wheat (*Triticum aestivum* L.), and *quebracho* (*Schinopsis quebracho-red*) dry matter (DM) with 17, 2.4, and 9.9 g DM/kg LW condensed tannins, respectively. Taking for granted the sensorial characteristics of the animals, as well as the palatability and acceptance of feed leads to tedious diets that reduce livestock production, alters animal welfare, and damages the economy of farmers (Catanese *et al.*, 2012; Ginane *et al.*, 2011). Therefore, the objective of this study was to evaluate the feeding preferences of lambs, using RMa, RFr, and RHa treated with UM, Efl, and AcP combinations, in order to determine which combination is the favorite of lambs. This information will lay the foundations for the improvement of supply management.

MATERIALS AND METHODS

The stubbles were produced during the 2021 agricultural cycle in Tlachichuca, Puebla, Mexico (19° 01' 36" and 19° 19' 54" N and 97° 10' 24" and 97° 30' 18" W, at 2,603 m.a.s.l). According to the Köppen-Geiger climate classification, the area has a BSk (cold and semi-arid) climate, with a 16.7 °C mean annual temperature and a 513 mm mean precipitation (Climate-data.org., 2022; Municipios.mx., 2023). The feeding preference of lambs was evaluated in this locality.

Supplies

The stubbles were obtained from the local native varieties and their production was carried out according to the local traditions and customs. Maize was fertilized using the 138-00-00 formula using urea as a source of nitrogen; meanwhile, the leaves of bean and broad bean were sprayed with a 1 kg/ha Micromin® 20-30-10 (Mezclas y fertilizantes S.A. de C.V.) fertilizer during flowering.

The effluent (Efl) was obtained from maize silage in its milky-doughy phenological stage. It had 23% DM, with 42, 37, and 21% leaf, stem, and grain, respectively. A commercial urea (Agrogen S. A. de C. V. México) was used with 46% nitrogen. Liquid molasses (without brand) was used. The phosphoric acid (Greenhow S. A. de C. V. México) had a 79% purity and 57% phosphorous oxide. The DM percentage of Rma, RFr, and Rha was 90.4%. The feeding preference test was carried out with six male Dorper/Kattadin sheep, with 21.0±1.7 kg live weight and 100 days of age. They had a homogeneous physiological state and were used for zootechnical purposes. They

were handled according to the *Reglamento para uso y cuidado de animales destinados a la investigación* (Guidelines for the use and welfare of animals used in research works) of the Colegio de Postgraduados (COLPOS, 2019).

Stubble treatments

The doses used consisted of 2% urea, 6% molasses, and 0.57 mL/kg phosphoric acid (AcP), mixed with 30% water. The percentages and figures were based on the amount of DM and the doses were homogeneously sprayed on the stubbles. Efl was obtained from the maize silage process: ~25% of stubble (RMa, RFr, or RHa) was added to the bottom of a silo bag and ~75% of the silage fodder was placed in the upper part of the bag (volume:volume). The silage bags were completely sealed in order to achieve fermentation and they were opened at 160 days.

Feeding preference consumption test

This evaluation was based on the procedures reported by Oliviera *et al.* (2015), Costes-Thire *et al.* (2018), and Pedernera *et al.* (2020). The diet of the lambs was balanced to meet their development nutritional requirements (NRC, 2007) and it was supplemented with 16% of crude protein (CP). The lambs were fed twice a day, at 8:00 am and 6:00 pm; they also had free access to water and to a mineral salt block.

During the mornings, lambs were fed with a mix of the three different stubble treatments for 40 minutes (70% of the ration). Afterwards, three feeders (each filled with 10% of the rest of the stubble treatments) were placed in an individual metabolism crate. The containers were randomly placed in each session to eliminate biases in the resulting data. Using this configuration, each lamb selected and consumed *ad libitum* the stubble treatment of their preference for 20 minutes. Afterwards, consumption was measured as the difference between the weight of the offer and the rejection. Finally, all the rejected feeding was mixed with the concentrate and fed again to the sheep for their total consumption at the communal stable. During the evenings, a mixture of the concentrate and the stubble treatments was offered at the communal stable. This process was carried out for seven days in a row, for each of the stubble treatments. The adaptation period lasted five days.

Experimental design

The experiment was carried out using a completely random block design. Each lamb was considered as a block in which all the treatments were evaluated. Given that the assumption of normality and homoscedasticity were not satisfactorily met, the data were analyzed using the ordinal logistic regression model. This model establishes and estimates the statistical significance of the factors (stubbles) in face of the success probability response (feeding preference) for each combination of the factor levels (treatments). This significance is established through the inverse logarithm of the probability ratio, according to the lineal prediction (Heredia *et al.*, 2012), using the expression (logit function):

$$\ln\left(0_i\right) = \alpha_i + t_i$$

Where: α_i is the intercept associated with the equation that models the probability ratio of the i category; t_i is the effect of the i treatment; 0_i is the odds ratio associated with the i category of the dependent variable, that used the ratio expression

$$0_i = \frac{P(\text{if the value } \leq i \text{ category /value of } x)}{P(\text{if the value } > i \text{ category /values of } x)}$$

Data were classified as the ordinal qualitative variables observed in each evaluation session. Consumption frequency was classified as 1 (low), 2 (medium), and 3 (high). The results were analyzed according to the different stubble treatments, because the feeding preference was tested using the three different treatments of the same stubble, during the same period. The analysis was carried out using the R 4.1.1 statistical package (R Core Team, 2020). The response variable (feeding preference) was adjusted to the ordinal regression model using the R 4.1.1 statistical package. The compliance of the data with the assumption of proportionality was verified.

The relationship between the parts (ratio) was taken into account. The analysis of variance used the incidence (the times when a feeding frequency was recorded) of the feeding preference (1, 2, or 3) as a measure unit. The percentage observed between the ratios was used to develop the graphs.

RESULTS AND DISCUSSION

Preference per treatment depending on the type of stubble

There were differences in the estimated feeding preference of RMa (p=0.001, Figure 1). The most popular feeding option was MaUM, which reached a high (3) consumption frequency ratio (95%). The second option was MaEfAcP, which recorded a medium (2)

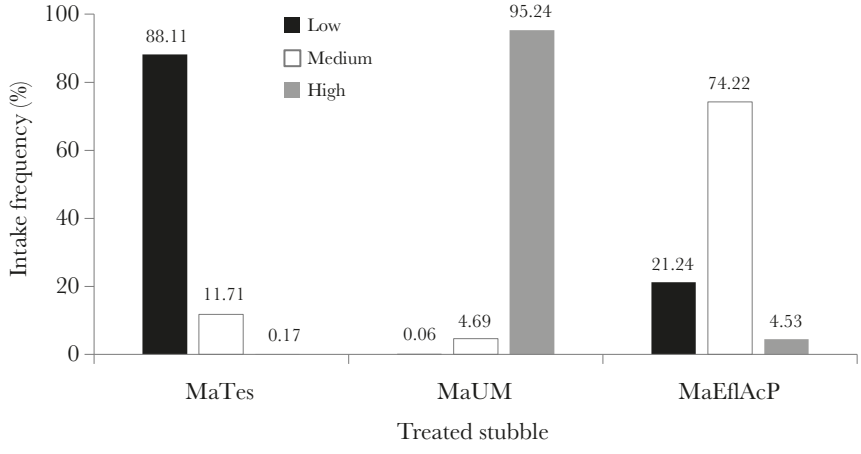

Figure 1. Estimated feeding preference of maize stubble among lambs. Low: low consumption frequency; Medium: medium consumption frequency; High: high consumption frequency; MaTes: maize stubble control; MaUM: maize stubble mixed with urea-molasses; MaEflAcP: maize stubble mixed with silage effluent and phosphoric acid.

frequency ratio (74%), while Tes obtained a low (1) frequency ratio (88%) and, consequently, was the less attractive option in the feeding preference test.

Figure 2 shows differences (p=0.001) regarding the estimated RFr consumption; however, the differences were narrower than the results obtained by RMa and RHa. The high (3) consumption frequency of FrEflUM was higher (43.49%), which proves the influence of this treatment in the feeding preference of lambs. The results of the medium (2) consumption frequency were closer between the FrTes (33%), FrEfl (36%), and Fr EflUM (35%) treatments. However, the low (1) consumption frequency recorded differences (p=0.001): FrTes had the highest values (48.77%), while FrEfl and FrEflUM obtained medium and low values, respectively.

There were differences (P=0.001) regarding the estimated consumption frequency of the RHa treatments. The UMAcP treatment recorded a high (3) frequency ratio (73%), while the EflUM treatment reached a medium (2) frequency consumption (70%) (Figure 3). Meanwhile, HaTes recorded a low (1) frequency consumption (95%) and, consequently, was the least popular options among lambs.

Van-Den-Berg *et al.* (2016) concluded that the feeding preference of ruminants is influenced by nutritional quality and palatability: pleasant flavors and aromas encourage a higher DM consumption. In this study, the UM and EflAcP mixed with RMa recorded a higher incidence in the high consumption frequency than Tes.

This preference is a consequence of flavor and nutritional quality improvement. In this regard, Abera *et al.* (2018) pointed out that the RMa mixed with urea (4%) and molasses (10%) treatment had 4.1% more CP content than the control, while it recorded a 5.5, 4.6, and 1.2% reduction of the NDF, ADF, and ADL concentration, respectively. In addition, they recorded a 538 g and a 771 g DM/d consumption of RMa Tes and RMa mixed with urea and molasses, respectively.

Catanese *et al.* (2015) mentioned a feeding preference test with sheep, using alfalfa and oat hay. These treatments recorded an 820 and 205 g DM/d consumption of alfalfa and oat, respectively. They concluded that the feeding preferences of animals are determined

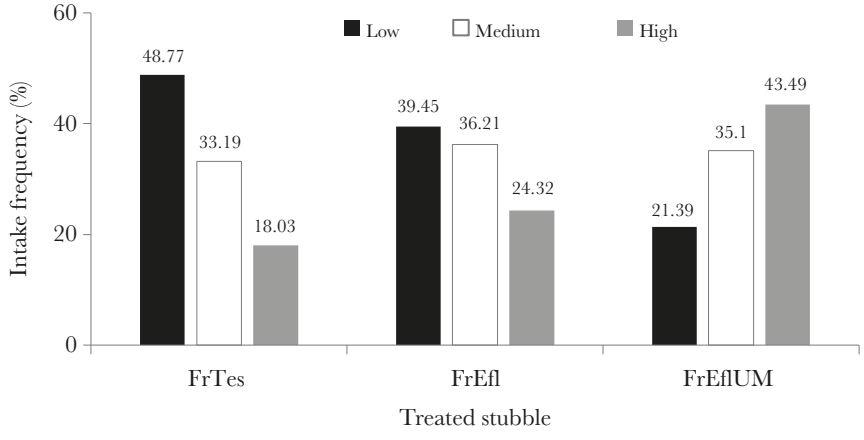

Figure 2. Estimated feeding preference of bean stubble among lambs. Low: low frequency consumption; Medium: medium frequency consumption; High: high frequency consumption. FrTes: bean stubble control; FrEfl: bean stubble mixed with silage effluent; FrEflUM: bean stubble mixed with urea-molasses.

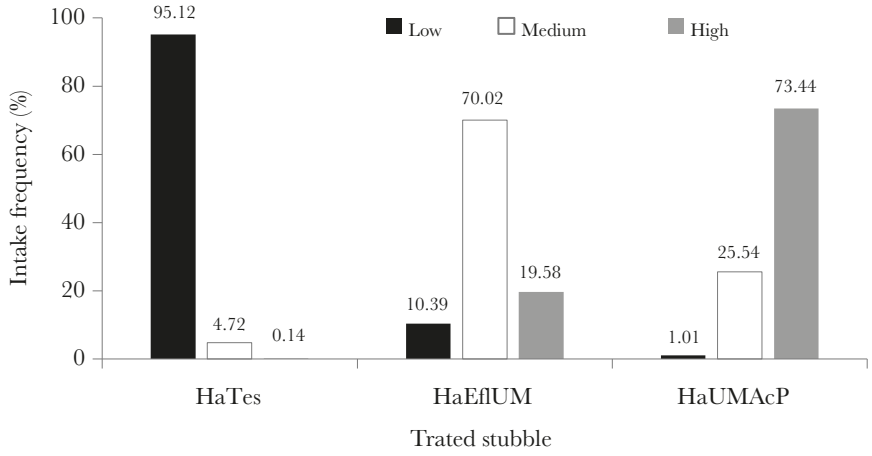

Figure 3. Feeding preferences of broad bean stubble among lambs. Low: low frequency consumption; Medium: medium frequency consumption; High: high frequency consumption. HaTes: broad bean control; HaEflUM: broad bean stubble mixed with silage effluent and urea-molasses; HaUMAcP: broad bean stubble mixed with urea-molasses and phosphoric acid.

mainly based on nutrition. Likewise, Meagher *et al.* (2017) studied the feeding preferences of Holstein calves, using the following combinations: 1) Timothy grass and alfalfa hay; 2) tall fescue and orchard-grass hay; 3) chopped rye straw; and 4) a mixture of all these ingredients. They concluded that No. 4 was the most palatable treatment for the animals, due to its high nutrient concentration. Consequently, the calves ate an average of 554 out of 600 seconds.

Therefore, the feeding behavior of ruminants indicates the nutritional quality of the forages, which decreases as the fiber components increases (Neave *et al.*, 2018). In their report about treatments with RFr and 4% urea, Rodríguez *et al.* (1985) pointed out that, compared with control, NDF decreased by 1.65%, ADF increased 3.18%, and ADL remained the same (11.07%). In addition, they concluded that RFr had a high ADL content.

The results of this study match the findings of Cardoza and López (2016), who emphasized the ADL concentration, pointing out that lignin content influenced the feeding preference of goats. Their study shows that *Acacia pennatula* mixed with 7.78% ADL recorded a higher consumption than *Gliricidia sepium* mixed with 18.44% ADL. These results also match the findings of Monllor *et al.* (2020), who studied the feeding preference of Murcia-Granada goats, using a silage made up of bracts of artichoke (*Cynara scolymus*) with 48% NDF, 33% ADF, and 5% ADL. These treatments were compared with broccoli (*Brassica oleracea*, var. Italica) silage byproducts with 49% NDF, 36% ADF, and 7% ADL. The Murcia-Granada goats consumed 113 g DM/d of bracts of artichoke and 13 g DM/d of broccoli byproducts.

CONCLUSIONS

Sheep differentiated between the MaTes, FrTes, and HaTes treatments, without rejecting them. The stubble treatments influence the feeding preferences of sheep, as a result of their attractive flavors and improved nutritional quality. The most prefered treatment was the addition of urea-molasses.

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