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ADDING OF TIFTON-85 HAY TO WHOLE GRAIN CORN-BASED DIETS FOR GROWING CATTLE

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ABSTRACT - Advancements in ruminant nutrition have optimized productive efficiency in feedlot systems, reducing operational costs and enhancing animal performance. Understanding the impact of forage-free diets, such as whole corn grain usage, is essential to maximizing starch digestibility and minimizing nutritional losses. The objective of this study was to investigate the effects of adding Tifton-85 hay (*Cynodon* spp.) as a source of fiber on the consumption, digestibility and recovery of undegraded corn in feces in diets of growing cattle based on whole grain corn. The experiment was carried out in two simultaneous Latin squares, using 8 Holstein x Gir crossbred calves. The treatments consisted of four whole grain corn diets: the control treatment (F0) consisted of a diet without roughage, containing 85% whole grain corn and 15% pellets (pelletized supplement), in addition to the inclusion of three levels of hay. Tifton-85: 0.2% (F2); 0.4% (F4) and 0.8% (F8) of body weight. The inclusion of hay had no impact on dry matter intake, protein intake and mineral matter intake. No significant differences were observed in dry matter digestibility, protein digestibility and mineral matter digestibility. However, there was a significant increase in the consumption of neutral detergent fiber and its digestibility. The addition of hay resulted in a reduction in the amount of corn present in feces, indicating greater breakdown of the corn due to chewing. Furthermore, there was a lower percentage of corn retained in feces on the 4mm sieve. These results suggest that the inclusion of hay in whole corn-based diets may be a viable nutritional strategy to increase dietary energy efficiency.
Keywords: *Cynodon* spp., physically effective fiber, grain breakdown, corn recovery in feces.

ADIÇÃO DE FENO TIFTON-85 EM DIETAS A BASE DE MILHO INTEGRAL PARA BOVINOS EM CRESCIMENTO

RESUMO - Os avanços na nutrição de ruminantes têm otimizado a eficiência produtiva em confinamento, reduzindo custos operacionais e melhorando o desempenho animal. Compreender o impacto das dietas sem volumoso, como o uso de grão de milho inteiro, é essencial para maximizar a digestibilidade do amido e evitar perdas nutricionais. O objetivo deste estudo foi investigar os efeitos da adição de feno de Tifton-85 (*Cynodon* spp.) como fonte de fibra no consumo, digestibilidade e recuperação do milho não degradado nas fezes em dietas de bovinos em crescimento à base de milho grão inteiro. O experimento foi realizado em dois quadrados latinos simultâneos, utilizando 8 bezerros mestiços Holandês x Gir. Os tratamentos consistiram em quatro dietas de milho grão inteiro: o tratamento controle (F0) composto por uma dieta sem volumoso, contendo 85% de milho grão inteiro e 15% de pellet (suplemento peletizado), além da inclusão de três níveis de feno de Tifton-85: 0,2% (F2); 0,4% (F4) e 0,8% (F8) do peso corporal. A inclusão de feno não teve impacto no consumo de matéria seca, consumo de proteína e consumo de matéria mineral. Não foram observadas diferenças significativas na digestibilidade da matéria seca, digestibilidade da proteína e digestibilidade da matéria mineral. No entanto, houve um aumento significativo no consumo de fibra detergente neutro e na sua digestibilidade. A adição de feno resultou em uma redução na quantidade de milho presente nas fezes, indicando uma maior quebra do milho devido à mastigação. Além disso, houve uma menor porcentagem de milho retido nas fezes na peneira de 4mm. Esses resultados sugerem que a inclusão de feno nas dietas à base de milho inteiro pode ser uma estratégia nutricional viável para aumentar a eficiência energética da dieta.
Palavras-chave: *Cynodon* spp., fibra fisicamente efetiva, quebra do grão, recuperação de milho nas fezes.

INTRODUCTION

Continuous advances in ruminant nutrition have made it possible to increase the productive efficiency of animals raised in confinement systems, seeking greater performance in a shorter period of time. In the last two decades, the use of grain-based diets, with little or no source of roughage, has seen greater growth in Brazilian feedlots (SILVESTRE and MILLEN, 2021). An important factor for the adoption of forage-free diets is the reduction of operational costs with daily use of roughage and the

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promotion of greater animal performance which, consequently, promotes greater profitability in confinement (ARCANJO et al., 2022).

This type of diet has advantages such as promoting greater energy density, feed efficiency and better carcass finishing (DIAS et al., 2016). One of the techniques for using a forage-free diet is the use of whole corn grain, which aims to promote greater stimulation of chewing, rumination and salivation, contributing to the balance of rumen pH, reducing metabolic disorders. It is notable that each 1 kg increase in dry matter intake results in a 0.08 to 0.09 kg/day increase in average daily gain in finishing cattle on silage-based diets, and from 0.14 to 0.16 kg/day in grain-based diets. These results highlight the importance of CMS in animal performance (MIN et al., 2022). Although there is an increase in feed efficiency with the use of whole corn without forage (MARQUES et al., 2016), these diets can promote a large loss of corn in feces and consequently starch (CUNHA et al., 2021).

Particle size, together with the presence of the protein matrix, emerges as the main factor limiting starch digestion. This results in a slower rate of ruminal digestion and reduced extent. Starch, one of the most prevalent polysaccharides in grain-rich diets, is often used to improve animal performance and tends to be more favorable to saccharolytic bacteria (RAMOS et al., 2021).

Starch degradability can also be influenced by roughage consumption, which plays an important role in maintaining the rumen environment (MELO et al., 2019). Since the source, the physical nature, together with its fiber content, are the factors that most influence chewing and rumination time (GOULART et al., 2020a; ARCANJO et al., 2023). Thus, the inclusion of a physically effective fiber source in whole grain corn diets can influence the degradability of the corn grain.

In view of the above, the objective of this study was to determine the effects of supplementing levels of tifton-85 hay (*Cynodon* spp.) on the consumption of dry matter and nutrients; in apparent total digestibility and recovery of undegraded corn in feces, in diets of growing cattle based on whole grain corn.

MATERIAL AND METHODS

This study was carried out in the Ruminant Nutrition Sector of the Institute of Agricultural Sciences (ICA) of the Federal University of Vales do Jequitinhonha and Mucuri (UFVJM), in Unaí County, MG, Brazil. The research project was approved by the Ethics Committee on Animal Use (CEUA) at UFVJM, protocol 10/2016.

Two simultaneous 4x4 latin squares were balanced, using eight Holstein x Gir crossbred calves (*Bos taurus taurus* L. x *Bos taurus inducus* L.) with an initial average body weight of 100±10 kg and an average age of 4 months. The work lasted 56 days, divided into 4 periods of 14 days, comprising 11 days of adaptation and 3 days of data collection.

The treatments consisted of including levels of Bermuda grass hay cultivar Tifton-85 (*Cynodon* spp.) in the diet with a high percentage of whole corn kernels. The control treatment was a diet of 85% whole grain corn and 15% pellet (pelletized supplement) (F0), and the inclusion of three levels of 0.2% hay (F2); 0.4% (F4) and 0.8% (F8) of body weight.

The chemical composition of the dietary components is presented in Table 1. The samples of diet offered, leftovers and feces from each period were homogenized, removing a composite sample. They were subsequently pre-dried in a forced ventilation oven at 55°C for 72 h and ground in a Willey mill, on 1mm sieves. Analyzes of dry matter, mineral matter, crude protein and neutral detergent insoluble fiber were carried out using the method proposed by Detmann et al. (2021).

TABLE 1 - Chemical composition of corn, pellets and hay used in diets.

Variables	Corn	Pellet*	Hay
DM (g kg^{-1})	865.0	878.3	844.6
Ash (g kg^{-1} DM)	12.8	144.5	75.8
CP (g kg^{-1} DM)	78.3	390.0	123.4
NDF (g kg^{-1} DM)	91.6	110.3	668.0
ADF (g kg^{-1} DM)	25.4	38.5	301.7

DM = dry matter, Ash = Ash content in dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber. *Pellet warranty levels: 3.0% Ca, 8.5% P, 6% Na, 7.7% Mg, 7.7% S, 0.30% Mn, 0.43% Zn, 0.2% Fe, 0.109% Cu, 0.003% Co, 0.007% I, 0.003% Se, 0.17% de virginiamycin, 0.12% de monensin, 36000 IU kg^{-1} of vitamin A, 4488 IU kg^{-1} of vitamin D and 226,9 IU kg^{-1} of vitamin E.

To analyze the apparent digestibility (ADp) of nutrients, *in vivo* digestibility method was adopted with total feces collection, using the recommendations proposed by Van Soest (1994) using the following Equation 1:

$$\text{ADp}~(\%) = ((\text{IDM} \times \%\text{Nutrient}) - (\text{EDM} \times \%\text{Nutrient}) \times 100) / (\text{IDM} \times \%\text{Nutrient}) \quad \text{(Equation 1)}$$

Where:

IDM = ingested dry matter and
EDM = excreted dry matter.

To recover the corn fractions in the fecal cake, a sample consisting of 500 grams of feces was used, which was placed in a container with ten liters of water, and constantly mixed manually to separate the liquid and solid fractions of the fecal cake. After complete decantation of the solid compounds, the material was separated using sieves with different screens (1.5, 3.0 and 4.0 mm). The material in the different sieves was constantly washed with running water, under agitation, until the complete recovery of the undegraded corn fractions present in the sample.

Subsequently, the corn fractions recovered in the feces were dried in an oven at 55ºC for 72 h. Finally, the granulometric separation of the corn recovered in the feces was carried out and the proportion of corn in the feces and in each sieve separately was quantified. Data on consumption, digestibility and recovery of corn in feces were subjected to analysis of variance using the R software. The variables were evaluated according to Equation 2.

$$Yikl = \mu + \alpha i + ak\,n + pl + eikl \quad \text{(Equation 2)}$$

Where:
Y_{ikl} = the observation measured in the ith supply of hay according to the kth animal in the lth period.

The fixed effects are the mean (μ) and the hay supply (α_i).

RESULTS AND DISCUSSION

Hay consumption was small when compared to corn + pellet consumption, which did not influence dry matter intake, crude protein intake and mineral matter intake (Table 2). This fact shows that there was no substitutive effect between the supplemental hay and the whole grain + pellet corn diet. The highest hay consumption provided by the F8 treatment corresponded to 6.86% of the consumption observed for the corn + pellet mixture, highlighting the low participation of hay in the total dry matter consumption. No differences were also found for the variables of apparent digestibility, dry matter digestibility (DMS), protein digestibility and mineral matter digestibility.

TABLE 2 - Intake of total dry matter (kg day^{-1}), of the diet ingredients (corn + pellet e hay) and the nutrients (crude protein, neutral detergent fiber) and digestibility (g kg^{-1} of dry matter) of nutrients (dry matter, crude protein, neutral detergent fiber e acid detergent fiber.

Treatments	H0			H2			H4			H8				*P*
	Average	Ll	Ul	Average	Ll	Ul	Average	Ll	Ul	Average	Ll	Ul	SEM	value
DMI	4.16	2.98	5.33	4.76	3.58	5.94	4.53	3.35	5.71	4.63	3.45	5.81	0.37	0.5735
DMICP	4.16	3.06	5.25	4.62	3.53	5.72	4.25	3.15	5.34	4.32	3.22	5.42	0.34	0.7176
DMIH	0	-0.24	0.24	0.14	-0.10	0.38	0.28	0.04	0.521	0.31	0.07	0.55	0.08	0.0185
CPI	0.53	0.38	0.68	0.61	0.45	0.76	0.58	0.43	0.729	0.59	0.44	0.74	0.48	0.5893
NDFI	0.37	0.19	0.57	0.51	0.32	0.70	0.58	0.39	0.769	0.61	0.42	0.798	0.06	0.0600
ADFI	0.12	0.03	0.20	0.17	0.08	0.25	0.20	0.11	0.287	0.21	0.13	0.300	0.03	0.0400
DMd	734	670	797	720	657	783	727	664	791	715	652	779	1.99	0.9170
CPd	755	697	812	731	673	788	712	655	770	728	671	786	1.81	0.4605
NDFd	427	234	620	479	286	772	530	337	723	450	257	643	6.07	0.6679

DMI = dry matter intake, DMICP = dry matter intake of corn plus pellets, DMIH = dry matter intake of hay, CPI = crude protein intake, NDFI = neutral detergent fiber intake, ADFI = acid detergent fiber intake, DMd= dry matter digestibility, CPd = crude protein digestibility, NDFd = neutral detergent fiber digestibility, LI = lower limit, Ul = upper limit, SEM = standard error of the mean.

However, for the consumption of total neutral detergent fiber (CTFDNT) and total acid detergent fiber (CFDAT) there was a significant effect, increasing as hay was added to the diet, providing an increase in CFDNT in the order of 22.06; 48.58 and 52.89%, for F2 treatments; F4 and F8, respectively (Figure 1).

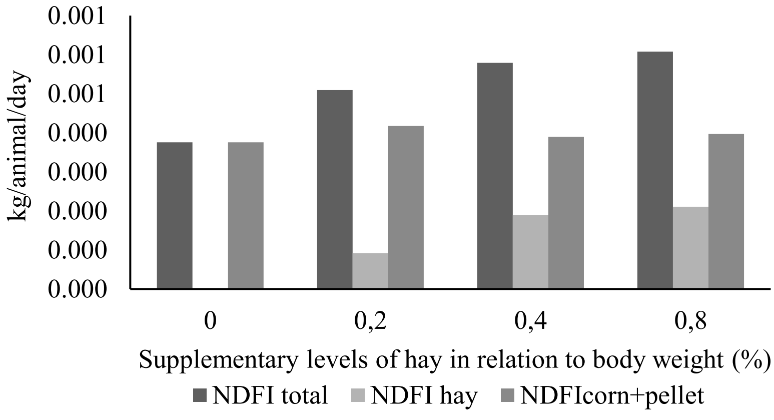

FIGURE 1 - Total NDF intake ($NDFI_{total}$), hay NDF intake ($NDFI_{hay}$) and NDF intake of corn + pellet ($NDFI_{corn+pellet}$), according to different levels of hay supply.

The increase in hay in the diet reduced the amount of corn in feces (Figure 2), where the highest level of hay supplementation (F8) provided a 5.49% reduction in corn in feces. The highest percentage of corn in the feces was retained on sieve 1 (4mm) considered as whole corn (Figure 3). However, there was an increasing reduction in corn retained in this sieve as hay consumption increased, where the reduction compared to the control treatment was 2.95%, 6.33% and 9.49% for the F2 treatments, F4 and F8, respectively.

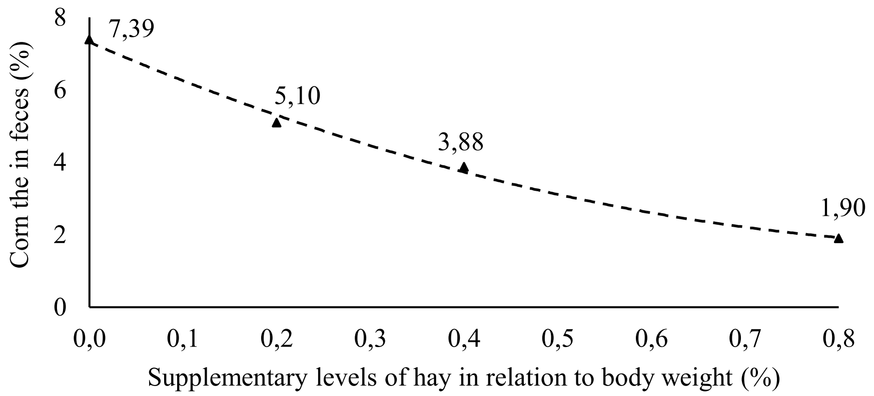

FIGURE 2 - Percentage of corn recovered in feces according to the inclusion of hay in the diet.

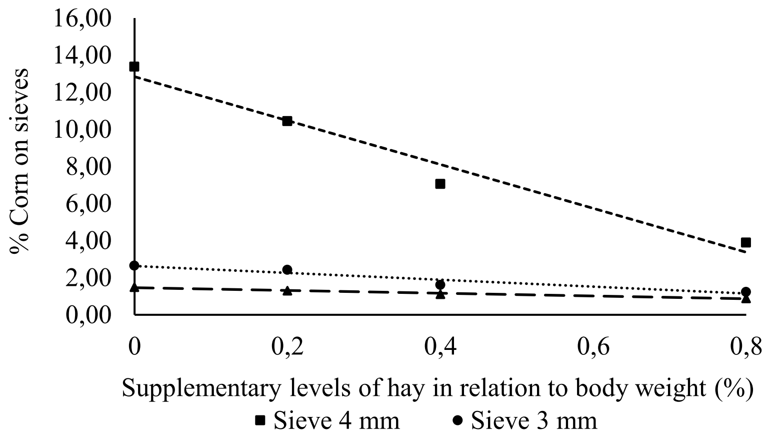

FIGURE 3 - Percentage of corn recovered in feces, in the three sieves (4, 3 and 1.7 mm) according to the inclusion of hay in the diet.

The lack of effect of hay supplementation on DMI, CPB and MMC indicates that the maximum CFDN in this study, 6.08 g kg day^{-1}, was not sufficient to restrict the animals' consumption, with no substitutive effect being evident. However, the results of this work disagree with the review by Galyean and Hubbert (2014), who reported that when fiber does not limit DMI and a fibrous ingredient is added to a diet rich in grains, it tends to increase DMI, because the "the animal" can compensate for the energy dilution effect of the diet by increasing the consumption of concentrate, thus maintaining energy consumption. The same was found in several other studies (MARQUES et al., 2016; CAETANO et al., 2015).

What may have occurred in the present study is that hay consumption was low, being lower than the studies mentioned above, not being sufficient to implement the effect of diluting dietary energy, where the amount of energy supplied in all diets was sufficient to meet the demands of the animals. Furthermore, young animals with low energy requirements were used (VALADARES FILHO et al., 2016), which also contributed to the absence of this dilution effect on consumption in the CMS.

Marques et al. (2016) observed that DMI was lower (8.4 kg day^{-1}) in cattle fed diets without the inclusion of sugarcane bagasse with 85% whole Flint corn and the diet with 6% inclusion bagasse in the diet with 78.8% flaked Flint corn, compared to diets with 3% and 6% inclusion of bagasse with 81.9% and 78.8% whole Flint corn (10.5 and 10.1 kg day^{-1}). The same authors also observed approximately 20% better feed efficiency in the diet with flaked corn and 6% inclusion of bagasse, compared to the diet with whole Flint corn and 6% inclusion of bagasse.

Melo et al. (2019) also observed that Flint corn flocculation promoted lower consumption and better feed efficiency regardless of the level of inclusion of sugarcane bagasse in the diets evaluated in relation to the diet with coarsely ground Flint corn with the same inclusion levels of bagasse.

The lack of significant effect of hay addition on DMS, DPB and DMM values can be explained by some factors: reduced hay consumption in diets, not being enough to influence the passage rate (Kp) and degradation rate (Kd), lower concentration of these nutritional components in hay compared to their levels in the whole corn + pellet mixture, efficient buffering action of the commercial pellet, contributing to the maintenance of the ruminal environment.

Although hay consumption did not influence DMI, as expected, its high concentration of NDF was decisive in increasing NDF, demonstrating the animal's voluntary search for a source of fiber. It should be noted that, when the animal consumes a diet rich in grain, the fermentation of starch causes the rumen pH to drop drastically (VAN SOEST, 1994), and the consumption of ENDF plays a fundamental role, stimulating rumination, causing a balance between production and absorption of fermentation acids, and secretion of salivary buffers (MARQUES et al., 2016; GOULART et al. 2020b).

Control of the ruminal environment due to increased fiber consumption also contributed to NDDF. Since it favors fermentative activity in the rumen as a whole, reducing the negative effects of starch fermentation on fiber degradation (MARQUES et al., 2016; CUNHA et al., 2021).

Bacteria that degrade fibrous carbohydrates (cellulose and hemicellulose) are sensitive to reducing pH, and require rumen pH close to neutrality to optimize their action. The fiber effectiveness factor refers to the fiber's ability to maintain rumen health. On the other hand, effective neutral detergent fiber is directly related to the physical characteristics of the fiber, such as particle size. This is associated with the ability to stimulate chewing and rumination, which, in turn, stimulate the secretion of saliva containing bicarbonates and phosphates, helping to neutralize the acids produced by the fermentation of organic matter. Although several studies have highlighted the potential of supplementation to improve ruminant performance, its effects, its potential to reduce methane production and its changes in microbial populations remain unclear, especially after different forage ratios and supplementation regimes (AZMI et al., 2023).

Grass hay, as it has a large number of long particles, is considered an important source of ENDF in high-concentrate diets, contributing positively to increased chewing and rumination. This was demonstrated by Mertens (1997), who conducted a data analysis and correlated the chewing time with the physical processing of forage, demonstrating that whole grass hay promoted a chewing activity of 134 min kg^{-1} of NDF, even when the hay was chopped into 38 mm particles and chewing capacity was reduced to 109 min kg^{-1} of NDF, attributing this difference to reduced fiber effectiveness.

In work that was carried out simultaneously with this study, Ortêncio et al. (2020) evaluated the influence of hay consumption on the ingestive behavior of animals, and found that the increase in hay consumption provided greater rumination time, increasing from 248 min day^{-1} for the control treatment to 435 min day^{-1} when 0. 8% of body weight hay in the diet.

The results found by Goulart et al. (2020a), show that rumination times are longer in diets with forage fiber sources (corn silage and sugar cane) and diets with sugarcane bagasse, when compared to diets with fibrous co-products (soybean hulls and cake cotton). Silva et al. (2022) and Arcanjo et al. (2023) also observed longer rumination times in diets with forage compared to diets with co-products as a source of ENDF.

It is observed in these works that the greater retention of particles, with a higher concentration of NDF, from forage fiber sources on the 19 mm sieve. In the Pen State Particle Separator evaluation, the 19 mm sieve was designed to capture long forage, which would be floating in the rumen (forming the forage mat) and which would require greater rumination. PSPS is a practical tool to obtain fast and accurate particle size estimates. In the original proposed configuration, the PSPS was composed of plastic sieves of 19 and 8 mm in diameter and a lower plate, but more recent versions include an additional sieve with holes of 1.18 or 4 mm, and this seems to be quite relevant in the more accurate acquisition of particle size (SPINA et al., 2024).

Goulart et al. (2020a) reported that the sugarcane bagasse diet promoted greater rumen filling. This demonstrates that in addition to the physical nature of the fiber, compounds with low degradability present in NDF, such as cellulose and lignin, can promote greater rumen retention and reduce the rate of passage of intake. On the other hand, particles $\leq$ 1.18 mm may have lower digestibility due to a higher ruminal passage rate, mainly affecting fiber digestibility due to low microbial action (ZHOU et al., 2022). In whole corn diets, grain degradation can be influenced by several factors, such as animal age, forage source and level, ruminal pH, dietary protein and grain characteristics (OLIVEIRA et al., 2015).

Grain structure plays a crucial role in the degradation process. The pericarp, as the outer layer of the grain, has the function of protecting the germ and endosperm. It acts as a physical barrier that hinders microbial attack and the action of the animal's digestive enzymes. As a result, ruminal fermentation does not begin until the pericarp is ruptured. This aspect was considered when evaluating the removal of long fiber from the diet of cattle fed in confinement, based on daily ad libitum provision of fully mixed feed (GIUERTI et al., 2014).

Therefore, the act of chewing and ruminating becomes extremely important in grain-based diets, where the grain breaks down and consequently the pericarp ruptures, allowing bacterial access to the starch granules in the grain endosperm. And when this physical action is reduced in diets with little or no roughage consumption, starch digestibility decreases (CUNHA et al., 2021).

In the present study, the level of hay supply influenced the damage caused to the corn grain, where in addition to reducing the amount of corn in the feces, it also reduced the proportion of corn retained in the 4 mm sieve as hay was included in the diet, demonstrating that there was greater breakdown of corn grains with CFDN. Possibly, CFDN in hay led to increased rumination and chewing, providing greater grain breakdown, reducing the passage of whole grains through the gastrointestinal tract, improving their degradation and consequently reducing fecal losses of corn, since the passage of particles large sizes for the small intestine negatively influences the digestion of corn and consequently starch (RAMOS et al., 2021).

Furthermore, increased grain breakdown will break down the physical barriers of the corn grain, increasing the access of ruminal microorganisms and enzymes to starch granules, thus reducing corn in feces is highly correlated with utilization. of starch by the animal, showing when there is a reduction in the amount of corn in feces, consequently there will be a reduction in fecal starch.

In this way, the addition of forage to high-concentrate diets can maximize energy consumption by confined cattle, potentially improving the feed efficiency of the diet. Therefore, we can assume that in a grain-based diet, the use of a source of ENDF can interfere with energy availability and consequently with the animal's productive efficiency.

Similar to the present study Marques et al. (2016), carried out their work in Brazil using Flint corn, where starch granules are less exposed to microbial attack in the rumen, and demonstrated that the inclusion of 3 and 6% of sugarcane bagasse as a source of ENDF in Whole corn diets increased starch degradation, reducing fecal starch from 32.2% to 26.6% when 6% sugarcane bagasse was included, increasing net energy consumption, resulting in greater weight gain in the animals. The authors highlighted that Flint corn can benefit from a greater degree of chewing and rumination when compared to corn hybrids with mealy endosperm.

In another study carried out using Flint corn, Caetano et al. (2015), who found in their work with the inclusion of NDF from sugarcane silage in whole corn diets a linear reduction in fecal starch according to the addition of NDF in the diet, improving energy efficiency and gain of weight. The authors estimated that the inclusion of 14.5% NDF should optimize the performance of animals on whole corn diets.

Arroquy et al. (2018) reported that replacing alfalfa hay with cotton husk promoted higher DMI and higher grain passage rate. Forage NDF controls grain retention and digestion at the ruminal level, which translates into the production and profile of ruminal volatile fatty acids.

The results of this study demonstrate that the inclusion of Tifton-85 hay in whole grain corn-based diets positively influences fiber intake and digestibility while reducing fecal corn losses. Although the addition of hay did not significantly impact dry matter intake or nutrient digestibility, it played a crucial role in increasing rumination and chewing activity, thereby improving the breakdown of corn grains. This effect contributed to better starch utilization and overall energy efficiency of the diet. Given the importance of optimizing feed efficiency in confinement systems, incorporating a source of physically effective fiber such as Tifton-85 hay can be a viable strategy to enhance the productive performance of growing cattle. Future research should explore the long-term impacts of forage inclusion on ruminal fermentation dynamics and its potential to improve overall animal health and performance.

CONCLUSIONS

The addition of hay to whole corn diets provided an increase in consumption of neutral detergent fiber without affecting the intake of dry matter and nutrients.

The treatment 0.8% of body weight stands out, which did not reduce dry matter intake and reduced the proportion of corn in feces with greater intensity, thus being able to be used as a nutritional tool aiming to increase the use of energy from the diet and/or reduce costs. of production.

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