



Nutritive value of high and low tannin content of sorghum high moisture silage for horses

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ABSTRACT. There were used eight castrated male horses, crossbred. It was used randomized completely design. The objective was to evaluate the nutritive value of high-moisture grains silage of sorghum with low (SLT) and high (SHT) tannin in the feeding equine. The treatments consisted of two test-diets containing SLT or SHT, replacing 30% of dry matter (DM) of the reference-diet, constituted by only hay. The values of digestibility coefficients (DC) of nutrients SLT and SHT had differences for DCDM, DCOM, DCCE, DCCP and DCStarch, whose means values were 79.53, 84.54, 79.36, 76.11 and 100% to SLT e 60.29, 64.47, 59.38, 44.63 and 97.06% to SHT, respectively. It was concluded that high-moisture grains silage of sorghum with low tannin should be used in equine nutrition, this is an alternative feed.

Keywords: digestibility, digestible value, equine, nutrient.

Valor nutritivo das silagens de grãos úmidos de sorgo de alto e baixo teores de tanino para cavalos

RESUMO. Foram utilizados oito cavalos castrados sem raça definida em delineamento inteiramente casualizado. O objetivo foi determinar o valor nutritivo das silagens de grãos de sorgo de baixo (SBT) e alto (SAT) teores de tanino na alimentação de equinos. Os tratamentos consistiram de duas dietas-teste compostas pelos grãos de sorgo ensilados (SBT e SAT), substituindo em 30% a MS da dieta-referência, constituída exclusivamente por feno. Os valores de digestibilidade dos nutrientes dos SBT e SAT apresentaram diferenças nos CDMS, CDMO, CDEB, CDPB e CDAmido em que SAT foi inferior ($p < 0,05$) para todos os parâmetros, em que os valores médios foram de, respectivamente, 79,53, 84,54, 79,36, 76,11 e 100% para SBT e 60,29, 64,47, 59,38, 44,63 e 97,06% para SAT. Concluiu-se que a utilização do SBT é promissora na nutrição de equinos, tornando-se alimento alternativo nas formulações de rações.

Palavras-chave: digestibilidade, teor digestível, equino, nutriente.

Introduction

The supply of concentrates is important in maintaining health and to obtain the nutritional requirements for various categories of horses. Among the energy rich grains used for this species, corn and oats are the most fed, however the high prices of cereals limits inclusion in diet formulation. In spite of that, grain sorghum appears as a direct successor to corn, because besides its similar nutritional composition, is a cheaper alternative, having a lower cost / unit of supplemented energy. However, the supply of sorghum grain at high levels in the diet, is often associated with metabolic disorders. In this respect, Al Jassim (2006) stresses the need to determine a processing method to improve the nutritional value of sorghum grain

and thus preserving the status of animal health. This in fact has implications for the animal feed industry.

The use of high moisture grain silages in the production of horses corroborates with the demand to reduce feed costs, as well as for obtaining processed grains, resulting in increasing its nutritional value. The grain of sorghum, as well as other grains, presents a high degree of organization in their subcellular components. However, when the material is ensilage there is a dramatic change in this structure with the rupture of the endosperm, ie, the matrix protein, releasing free starch granules and protein bodies (LOPES et al., 2001; ROONEY; PFLUGFELDER, 1986; SULLINS; ROONEY, 1971). Additionally, high moisture sorghum grain silage has shown a beneficial effect on the

deactivation of tannins. Mitaru et al. (1983) reported that this process may decrease 95% of tannin levels present in sorghum.

According to Lewis (2000), sorghum grain is a low-tannin nutritious cereal for horses and can be offered as a single grain in the diet of this species, with no ill effects. There are few studies on the use of high moisture sorghum silage (HMSS) in the nutrition of horses. However, Oliveira et al. (2007) studied the feasibility of the use of high moisture sorghum grain silage with low and high tannin content for the feeding of mares in maintenance, as compared to dry grains. The diet consisted of 50% forage and 50% concentrate, containing sorghum grain as the main energy supplier. The authors found similarities among all diets consisting of HMSS (high or low in tannin) and dry sorghum low tannin, in which the mean values of digestible DM, starch, NDF and CP were 54.04, 98.91, 49.76 and 32.20%, respectively. Those results validated the use of HMSS, low or high tannin, as the main energetic grain in concentrates for horses. The authors also recommend that dry grain sorghum with high tannin content should not be included in concentrate feeds, since it decreases the protein and fiber digestibility.

National and international literature does not contain information about the digestible nutrients of HMSS for feeding horses. Because of that, it is highly relevant the development of research that, in addition to give importance for the use of low-cost technologies, may also increase ingredients data available for the formulation programs libraries. In this sense, this study aims to determine the nutritional value of HMSS of low and high tannin content in feed for horses, through a digestibility trial.

Material and methods

The assays were undertaken in the Equine Metabolism Section of the Department of Animal Sciences of the Federal University of Lavras, Brazil. Eight crossbreed castrated horses, mean age and body weight (BW) of 6 years and 330 kg, respectively, were used. In a preliminary phase of this trial, the apparent digestibility coefficients (DC) of the nutrients of coast-cross hay were determined. This preliminary phase was conducted to allow the calculation, by difference, of the nutrients coefficients of digestibility for the two sorghum genotypes (low and high tannin content). For this purpose, eight horses, with daily dry matter (DM) intake of 2.0% of BW of 100% coast-cross hay, thus characterizing the reference diet, were used. This phase lasted 20 days, consisting of 15 days for adaptation and five days of total feces collection.

During the experimental period, eight horses (the same used for the preliminary phase) were used in a completely randomized design with repeated samples in the same animals. Treatments consisted of two test diets composed of the two genotypes of high moisture sorghum grain silage with high (SSHT) or low (SSLT) tannin, replacing 30% of the MS reference diet (100% hay).

The varieties of sorghum (*Sorghum bicolor* L. Moench) used for the production of the HMSS were Sara and BRS-701 for low and high tannin content, respectively. Harvest was done in the same physiological maturity, when grains had 29.32 and 30.73% of humidity for the genotypes of low and high tannin content, respectively. An equipment was used for the filling the “bag” silo type “bag” (Boelter model B 20) and to perform grinding of the grains. Because of the impossibility of using sieves, due to the low dry matter of the grain at the ensilage, particle size was monitored by the determination of the geometric diameter mean (GDM) (ZANOTTO; BELLAVER, 1996), yielding a GDM of 8 mm. Once milled, the material was placed in 200 L experimental plastic buckets and sealed by a period of 45 days. At the time of the silo opening, samples were collected for chemical composition analysis.

Feeding amount was established according to the recommendations of the National Research Council (NRC, 1989), to meet the nutritional requirements for the category. The daily DM intake was 2.0% of the BW, and the test diets were composed by 30% grain sorghum silage and 70% coast-cross hay, with the supply of mineral salt “ad libitum” for all treatments. Diets were fed three times daily (8, 12 and 17h), 15 minutes after the orts removal and weight. The chemical compositions of hay, SSH and SSL and the experimental diets are shown in Tables 1 and 2, respectively.

Table 1. Feed chemical composition¹.

Feed	DM (%)	Nutrient (% MS)					GE (Mcal kg ⁻¹)
		OM	Starch	CP	NDF	ADF	
Coast-cross hay	91.20	95.21	2.59	7.47	80.70	42.79	4.35
SSLT ²	70.68	98.57	62.94	12.91	16.64	3.97	4.51
SSHT	69.27	98.22	61.82	11.44	19.85	9.47	4.43

¹Results from Animal Nutrition laboratories of FMVZ/Unesp and Feed Analysis of Esalq/USP; ²SSLT = sorghum silage low tannin; ³SSHT = sorghum silage high tannin.

Table 2. Experimental diets chemical composition¹.

Dieta	DM (%)	Nutrient (% MS)					GE (Mcal kg ⁻¹)
		OM	Starch	CP	NDF	ADF	
Hay + SSLT ²	85.04	96.22	20.70	9.10	61.48	31.14	4.40
Hay + SSHT ³	84.62	96.33	20.36	8.66	62.45	32.79	4.37

¹Data calculated from chemical composition (Table 1); ²Diet containing 30% hay and 70% sorghum silage low tannin (SSLT); ³Diet containing 30% hay and 70% sorghum silage high tannin (SSHT).

The experiment lasted 20 days, with the first 15 days corresponding to adaptation of animal to the facilities, diet and management conditions. Animals were housed in individual non-bedded concreted floor pens (2 x 3 m), provided with troughs for feed, minerals and water. After the adaptation period, horses were allocated in metabolism cages, fitted with plastic buckets for water and minerals, frontal trough and feces collector. Total feces collection was done during 5 days, four times a day (6, 12, 18 and 24h). Feces were weighed, homogenized and sampled at 10% total rate, placed in labeled plastic bags and stored at -15°C for subsequent analysis. Prior to the start of the experiment, wide spectrum anthelmintics were given to the horses.

At the end of the collection period, samples were thawed at room temperature and homogenized by treatment, to obtain a composed sample for each animal. Further, 10% aliquots were then retrieved, weighed and pre-dried at 60°C for 72h. After drying, the samples were once more weighed and ground in a 1 mm mesh sieve. Chemical composition analysis of feed and fecal samples was performed according to Silva (1989) for DM, OM and CP; and cell wall components (FDN and FDA), according to Van Soest et al. (1991), at the Animal Nutrition Laboratory of the Faculty of Veterinary Medicine and Animal Sciences, Unesp, Campus of Botucatu, São Paulo State, Brazil. Starch content was determined following Macrae and Armstrong (1968) at the Feed Analysis Laboratory of the Department of Animal Sciences of Esalq-USP, Brazil. Gross energy content of grains, hay and feces were determined by adiabatic calorimeter (Parr Instruments Co).

The levels of digestible dry matter (DDM), digestible protein (DP), digestible neutral detergent fiber (DNDF), digestible starch (AD) and digestible energy (DE) of the sorghum silages were obtained using the equations of Matterson et al. (1965). However, the apparent digestibility of DM and nutrients of tested diets were calculated by the equations proposed by Church (1993).

Levels and coefficient of digestibility of nutrients were processed by variance analysis by the *Statistical Analysis System* (SAS, 2000), using the following model: $Y_{ij} = \mu + D_i + E_{ij}$; where Y_{ij} = DM, OM, CP, GE, NDF, ADF and starch apparent digestibility coefficient of horse j fed diet i ; μ = general constant; D_i = diet effect i ; $i = 1, 2$; E_{ij} = randomized error associated with each observation Y_{ij} .

Comparison of means was undertaken by Tukey's test at 5% significance.

Results e discussion

Digestibility coefficients (DC) of diets for horses feeding consisting coast-cross hay and HMSS with low and high tannin content were not different ($p > 0.05$) for DM, OM, GE, starch or NDF. There are few studies in the literature on the use of high moisture grain silage to feed horses. However, Oliveira et al. (2007) found similarity between the values of diets with SSLT and SSHT DC of DM (54.40%), NDF (43.50%) and starch (98.91%), consistent with the average results obtained of 54.34, 42.48 and 97.40% respectively (Table 3). By replacing 25% of the concentrate DM by high moisture corn silage (HMCS) for foals, in a diet consisted of 40% forage and 60% concentrate, Santos et al. (2002) observed a GE DC of 71.10%, which exceeded the average of 53.49% observed in the present study with HSS. This observation should be viewed with caution since were obtained with different grains and animal category, besides different ratios of concentrate: forage consumed. The combination of such factors as in the Santos et al. (2002) study, using corn, growing horse and lower intake of hay may have contributed to the discrepancy in results of GE DC between experiments.

Table 3. Dry matter and nutrients apparent digestibility of test-diets containing high moisture sorghum silage for horse feeding (% DM).

Apparent digestibility (%)	Test-diets		Mean	CV (%)
	Hay + SSLT ¹	H + SSHT ²		
Dry matter	56.69	51.98	54.34	6.53
Organic matter	59.28	54.70	56.99	5.41
Gross energy	55.88	51.10	53.49	6.21
Crude protein	55.86 ^a	40.29 ^b	-	12.79
Starch	98.20	96.60	97.40	1.24
Neutral detergent fiber	45.31	39.64	42.48	9.14

¹Diet containing 30% hay and 70% sorghum silage low tannin (SSLT); ²Diet containing 30% hay and 70% sorghum silage high tannin (SSHT). Means followed by different letters in the same row differ by Tukey test at $p < 0.05$.

The negative effect of the inclusion of SSHT in the diet of horses was observed only for the crude protein digestibility, with a reduction ($p < 0.05$) of about 15 percent points (55.86 vs. 40.29%). This result was unexpected, since there are reports in the literature on the deactivation of tannins in high moisture sorghum grain silage in the order of 98% in grains with 30% U (MITARU et al., 1984). Additionally, Oliveira et al. (2007) observed similarities between CP DC (65.63%) in diets consisting of cross-coast and concentrated (50:50) containing 32.5% DM of SSHT or SSLT, fed to mares in maintenance. In the current study, the participation of the SSHT was 30% DM in the diet of castrated horses, which does not justify the lower protein digestion by the level of inclusion.

It is thought that the tannin deactivation mechanism by the water content of the ensiled grain is similar to the reaction occurring in the grains close to its stage of physiological maturity (REICHERT et al., 1980). However, Hibberd, (1985) found no reduction in the tannin content of high moisture sorghum silage with 30% U, suggesting that this level of water content of grain, may not have been sufficient for optimum fermentation, which could lead to tannin deactivation by its polymerization. In the present study and in the research of Oliveira et al. (2007), sorghum grain was ensiled with 30.73% and 33% U, respectively, suggesting a possible interference of the moisture content of silage on the deactivation of tannin, besides the dependence of the variety of sorghum used.

Considering the values of apparent digestibility for SSLT and SSHT, there were differences ($p < 0.05$) for coefficients of digestibility for DM, OM, GE, CP and starch among sources in the diet of horses, with lower values for the SSHT (Table 4). This result is consistent with the fact that tannin has a negative influence on animal nutrition, since it inhibits microbial and enzymatic activity along the digestive tract of non-ruminant species (SALGADO, 1991). However, Santos et al. (2002) found similar coefficients of digestibility of DM, GE, CP and starch when fed high moisture grain silage for horses, as compared to the SSLT (86.66, 81.96, 64.18 and 100.00%, respectively). These results corroborates that not only the sorghum grain has similar nutritional quality to corn grain, but also that the same occurs between high moisture corn silage (HMCS) and SSLT. While HMCS has the best coefficient of digestibility for energy, the SSLT has the best coefficient of digestibility for crude protein, similar to that reported by Rostagno (1986), comparing dry corn and sorghum grain.

Table 4. Dry matter and nutrients apparent digestibility of high moisture sorghum silage with low (SSLT) or high (SSHT) tannin content for horse feeding (%DM).

Apparent digestibility (%)	High moisture silage		CV (%)
	SSLT	SSHT	
Dry matter	79.53 ^a	60.29 ^b	11.58
Organic matter	84.54 ^a	64.47 ^b	9.24
Gross energy	79.36 ^a	59.38 ^b	10.83
Crude protein	76.11 ^a	44.63 ^b	15.87
Starch	100.00 ^a	97.06 ^b	3.17
Neutral detergent fiber	39.04	27.11	23.01

Means followed by different letters in the same row differ by Tukey test at $p < 0.05$.

Campos et al. (2003) found that the presence of tannins in sorghum silage did not influence the degradation of NDF in ruminant animals ($p > 0.05$). Likewise, in the current study feeding

SSHT for horses did not decreased the CD of NDF of the diet or the or even of the silage, with the mean values of 39.64 (Table 3) and 27.11% (Table 4), respectively. In contrast, Oliveira et al. (2007) found that a diet containing a higher content of active tannin, had a negative effect ($p < 0.05$) in NDF digestibility in horses.

The digestible nutrients observed for SSLT and SSHT (Table 5) indicates that SSLT has nutritional value most suitable for horses, especially as regards the ED 3.58 Mcal kg⁻¹, which resembles the tabulated value for dried sorghum grain in National Research Council (NRC 1989) of 3.56 Mcal kg⁻¹. Santos et al. (2002), evaluating the feeding of HMCS for foals, reported digestible contents of DM, CP, starch and NDF of 86.66, 4.94, 70.54, 3.56%, respectively. In general, it can be stated that the nutritional value of high moisture sorghum silage with low and high tannin content is around 90-92 and 70-87% respectively of the HMCS value for horses feeding.

Table 5. Dry matter and nutrients digestible contents of high moisture sorghum silage with low (SSLT) or high (SSHT) tannin.

Digestible content	High moisture silage		CV (%)
	SSLT	SSHT	
DM (%)	79.53 ^a	60.29 ^b	12.45
OM (%)	83.33 ^a	63.32 ^b	9.80
E (Mcal kg ⁻¹)	3.58 ^a	2.63 ^b	11.48
CP (%)	9.83 ^a	4.87 ^b	18.60
Starch (%)	62.94	61.28	3.52
NDF (%)	6.50	5.38	34.35

Means followed by different letters in the same row differ by Tukey test at $p < 0.05$.

Regarding the feeding of SSHT for horses, despite having the same digestible contents of starch and NDF, their inferiority on other nutrients, in addition to its negative effect on protein utilization, limit its inclusion to rates lower than 30%. However, more research should be conducted to elucidate the effects of SSHT for horses feeding, as well as the as the variety of sorghum and the humidity at the time of ensiling, because literature results of among are not conclusive.

Conclusion

The use of the high moisture sorghum silage with low tannin content is promising in horse nutrition, being a good alternative for diet formulation without compromising digestible nutrients supply.

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