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Sources of carbohydrates in the ingestive behavior of feedlot steers

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ABSTRACT - In this article we research the influence of different sources of carbohydrates (corn, soybean hulls or wheat bran) upon the digestive behavior of 24 confined castrated steers with an initial average age and weight of 20 months and 330 kg born from the cross between Charolais and Nellore. The diet was composed of 40% sorghum silage and 60% concentrate. The time spent on total ruminating (an average of 454.6 min/day) was not influenced by the source of carbohydrate. The animals from the wheat bran treatment spent less time idle (718 min) in relation to those on the corn and soybean hulls treatments, which did not differ between themselves (an average of 792 min/day). The steers from the wheat bran treatment remained less time feeding (184 min/day) compared with those fed the other treatments, whose average time of permanence in this activity was 214 minutes per day. The other studied variables did not present a significant difference between the treatments. Inclusion of wheat bran in the diet of the confined steers results in less spent time idle, while steers feeding on soybean hulls spend less time feeding. The use of corn, soybean hulls, or wheat bran in the diet of the confined steers does not affect the total cudding time.

Key Words: confinement, feeding, idleness, soybean hull, wheat bran

Introduction

The quality of food and the manner in which it is offered to animals are some of the most impacting factors on an animal reproduction system, as they can lead to the success or failure of their productive response. Through observations of the digestive behavior, it is possible to obtain information that helps understand the biological and physiological mechanisms that occur with variation in the feed intake and feed efficiency of animals, thereby indicating breeding systems less aggressive to the ecosystem and that contribute to the health and wellness of calves (Epps, 2002; Nkrumah et al., 2007; Durunna et al., 2011).

The main source of carbohydrates in the diet of finishing cattle is composed of cereal grains (especially corn). However, because of its wide use in human and monogastric animals feeding, corn is economically impractical (Zambon et al., 2001). In these situations the use of by-products that are highly available and have a low commercial cost is an alternative that can cover the cost of finishing cattle. Wheat bran is the preferred by-product because of its good palatability and nutritional composition, having approximately 16% CP, 44% NDF, and 72% TDN (Valadares Filho et al., 2010).

Based on the forgoing, it is possible to understand the relevance of research that investigates the relationship between the type of feed and the physiological activities and welfare of cattle. Therefore, the objective of this study was to evaluate the influence of different sources of dietary carbohydrates on the feeding behavior of feedlot steers.

Material and Methods

Twenty-four Charolais × Nellore crossbred steers were distributed into three treatments in which the carbohydrate source in the concentrate diet was milled corn grain, soybean hulls, or wheat bran (Table 1), totaling eight animals per treatment.

The animals were fed daily and the diet was divided into two meals, supplied at 08.00 h and 14.00 h, in which the concentrate portion was mixed with the sorghum silage at the time of feeding. The steers remained confined in covered and paved individual stalls of 12 m^2, having an adaptation period of 16 days and a total experimental period of 57 days. Diets were composed of 40.2% forage (sorghum) and 59.8% concentrate, calculated according to NRC (2000). Samples of all the ingredients of the diet as well as orts were collected to be analyzed in laboratory.

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Table 1 - Participation of the ingredients and nutritional composition of the experimental diets (g/kg of dry matter)

Ingredient	Carbohydrate source		
	Corn grain	Soybean hulls	Wheat bran
Sorghum silage	390.00	390.00	390.00
Soybean meal	117.7	82.3	17.3
Milled corn	449.6	-	-
Soybean hulls	-	494.7	-
Wheat bran	-	-	531.6
Soybean soapstock	29.9	29.9	29.9
Calcitic limestone	9.0	0.6	28.1
Sodium chloride	3.0	3.0	3.0
Nutritional composition			
Dry matter	636.18	639.16	637.31
Crude protein	126.60	128.66	131.04
Neutral detergent fiber	358.58	607.45	510.27
Total digestible carbohydrates	768.56	765.02	723.76
Non-fibrous carbohydrates	444.75	211.36	266.99
Total digestible nutrients	744.14	670.77	646.85

Further information related to the methodology of chemical composition (utilized in this research) is shown by Freitas et al. (2013).

The data of the digestive behavior was collected in four full periods of 24 hours (on the 10th, 18th, 29th, and 42nd days of the experimental period), in which the time spent feeding, ruminating (standing and lying) and idle (standing and lying) were recorded every five minutes. The number of rumination chews per cud and the time of rumination chews per cud were obtained using a digital stopwatch, presenting an average of 15 observations per animal in each evaluation period.

The variables feeding, rumination, and idle times and other activities were obtained by filling the individual feeders, with the observers recording the activity corresponding to the animal every five minutes, in accordance with the methodology described by Burguer et al. (2000) and Polli et al. (1995). The time spent at the drinking trough and interactions with the infrastructure or other animals is considered as other activities. A minimum time of ten consecutive minutes of permanence in each activity was used to calculate the number of meals, rumination periods and idle periods. During the experimental period of these activities, the infrastructure was maintained with artificial light at night to avoid different behavior from the steers on evaluation days.

The experiment set in a completely randomized design. The data were subjected to variance analysis through the PROC MIXED procedure (using the covariance structures) from the respective variable, which presented a lower AIC value. When significant differences were detected, means were compared using the DMS test and the result was $\alpha = 0.05$. The mathematical method used was: $Y_{ij(k)} = \mu + \alpha_i + \varepsilon_{ij(k)}$, in which $Y_{ij(k)}$ = dependent variable; μ = average of all the observations; α_i = diet (*i*-th treatment with milled corn grain; soybean hulls, or wheat bran); and $\varepsilon_{ij(k)}$ = random residual error, NID (0, σ^2). The normality of the data was tested using the Kolmogorov-Smirnov test and the SAS (Statistical Analysis System, version 9.2) software was used for the statistical procedures.

Results

The times spent feeding, idling, idling standing or lying, ruminating, ruminating standing or lying, and on other activities were influenced ($P<0.05$) by the sources of carbohydrates (Table 2). The steers fed wheat bran remained less time in total idleness (718 min/day) compared with those treated with soybean hulls and corn grains, the two of which did not differ (792 min/day).

The results obtained for total idleness (corn grain and soybean hulls, 792 min/day; wheat bran, 441 min/day), idle standing (191 min/day), idle lying (corn grain, 557; soybean hulls, 431 min/day; wheat bran, 468 min/day), total rumination (454 min/day), rumination standing (49 min/day) and rumination lying (corn grain and soybean, 404 min/day; wheat bran, 441 min/day) corroborate the studies that adopted a similar roughage:concentrate ratio to that used herein (Souza et al., 2007; Missio et al., 2010). The steers spent, on average, 67% of the idle and on 90% of the rumination times lying, and the animals fed wheat bran spent less time lying idle (468 min/day) compared with those on the corn treatment (557 min/day), both of which did not differ from those receiving soybean hulls (531 min/day). The steers fed wheat bran also remained longer ruminating while lying (441 min/day) compared with those fed corn and soybean hulls (404 min/day).

The variables number of daily chews, number of chews per cud and rumination time per cud (Table 3) did not present least significant differences amongst the treatments, averaging 27,479; 57; and 0.94, respectively.

The number of daily meals observed in the present study, 8.2 periods per day (Table 4), may be related to the roughage:concentrate ratio used in all studied diets.

Two well-defined peaks of feeding could be observed during the day (Figure 1); such peaks coincide with the time in which feed was supplied (08.00 and 14.00 h). The presence of animals at the feeder during the night was lower than 25% decreasing from 19.00 h, and this behavior was observed in the animals of all treatments.

Table 2 - Behavioral activities of steers fed different sources of carbohydrates

Activity (min/day)	Carbohydrate source			SEM	P-value
	Corn grain	Soybean hulls	Wheat bran		
Feeding	208A	184B	217A	10.11	0.010
Idle	783A	802A	718B	25.99	0.010
Idle (standing)	181	223	171	26.30	0.140
Idle (lying)	557A	531AB	468B	33.16	0.038
Rumination	444	435	485	20.40	0.054
Rumination (standing)	33	56	59	14.85	0.190
Rumination (lying)	403B	405B	441A	16.19	0.040
Others	18B	29A	27A	3.45	0.011

SEM - standard error of the mean.

Table 3 - Activities spent on rumination time of steers fed different sources of carbohydrates

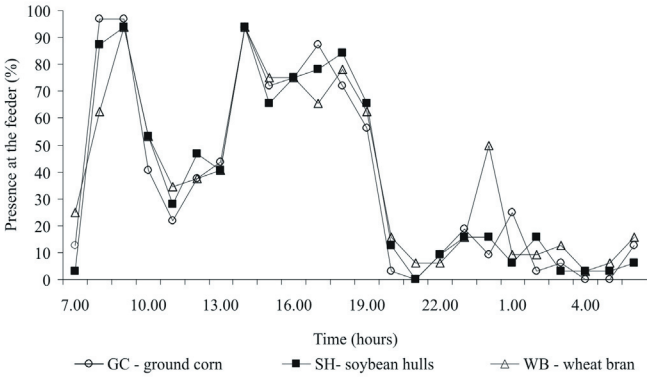
Variables	Carbohydrate source			SEM	P-value
	Corn grain	Soybean hulls	Wheat bran		
NCC	56	56	60	2.78	0.32
RTC, min	0.96	0.90	0.98	0.03	0.08
NDC	24865	27949	29623	2006	0.07

SEM - standard error of the mean.
NCC - number of chews per cud; RTC - rumination time per cud; NDC - number of daily chews.

Table 4 - Number and time spent per period of meal, period of rumination and idleness of steers fed different sources of carbohydrates

Variable	Carbohydrate source			SEM	P-value
	Corn grain	Soybean hulls	Wheat bran		
Period of meal/day	7.90	8.12	8.59	0.77	0.66
Rumination/day	14.56	13.95	14.02	0.78	0.69
Idleness/day	18.84	19.18	19.28	0.96	0.89
Time (minutes)					
Meal	27.62	25.65	27.92	2.21	0.54
Rumination	31.41	31.02	36.33	2.36	0.06
Idleness	42.42	44.28	41.20	2.49	0.47

SEM - standard error of the mean.



GC - ground corn; SH - soybean hulls; WB - wheat bran.

Figure 1 - Presence of the animals at the feeder (%), during the 24 hours of evaluation, according to treatment.

Discussion

Feeding is an activity that is strictly related to the physical characteristics of the diet, the feeling of fulfillment, physiological factors that include hunger control and satiety through the hypothalamic region of the brain, and psychogenic factors such as the palatability of the food and environmental factors such as temperature and stress (Dougherty and Collins, 2003). Based on the nutritional composition of the diet (Table 1), it can be inferred that the shortest feeding time being with the soybean hull diet (184 min/day) can be related to the cell-wall composition of this ingredient, which is rich in pectin. This structural carbohydrate is highly rumen-degradable, so it is classified as a fiber, which rapidly ferments without diminishing the concentration of acetate from the rumination, responsible for the size and number of meals (Ipharraguerre and Clark, 2003).

According to the studies of Albright (1993), Deswysen et al. (1993) and Fischer et al. (1997), idle time and rumination time in animals are inversely proportional, which can be observed in the present data (Table 2). Some authors suggest that an animal remaining in a standing position or lying down can be an indicator of welfare, thermal comfort, and adaptability to the environment and management. The presented data also supports Brscic et al. (2007), who worked

with confined steers and reported an average idling time of 798 min/day.

The average time spent with the total rumination (454 min/day) is similar to the 472 and 467 min/day stated by Silva et al. (2005) and Salla et al. (2003), respectively. These authors attributed the variation in the duration and distribution of the intake and rumination activities to the supply of the energy requirements met, rumen filling and the type of feed that composes the diet (Abijaoudé et al., 2000), especially an increase in dietary fiber, stimulating the rumination activity (Mertens, 1997). However, this behavior was not seen in the present study. Missio et al. (2010), studying the behavior of bulls fed diets containing growing levels of concentrated feed (22, 40, 59, and 79%), verified a reduction in lying down and total rumination time, and attributed this result to the decrease in neutral detergent fiber (NDF) intake. Some research results have suggested that the rumen pH and the volatile fatty acids acetate/propionate ratio in the rumen can increase the time of permanence of the animals in rumination, as it is a physiological reflex of the animals in an attempt to produce more saliva, stabilizing the rumen pH (Mialom et al., 2008). The fact that there was no difference in the rumination time can also be related to the stability of the rumen pH because of the offered diets.

Some arguments presented by Saenz (2006) refer to facts that could alter these activities, among which the chemical composition of the food and its particle size are remarkable for having a great effect on the chewing activities, as 80% of the total breaking of food take place in this activity. The diets offered to the animals in the present study were very similar regarding their particle size, as the corn grain was ground to compose the concentrate fraction.

Animals that consume larger quantities of food may ruminate fewer cuds and spend less time chewing per cud (Fischer et al., 1997). According to the data presented by Freitas et al. (2013), no difference in the dry matter intake was observed in their experiment, which could have contributed to the similarity of these variables.

Mialom et al. (2008) evaluated three roughage: concentrate ratios in the diets (8:92; 44:56 and 57:43) and verified that the animals had an average of 12, 11 and 14 daily meals, respectively. The same authors suggest that the animals have a tendency to fractionate their meals when the diet interferes with the stability of the rumen pH. The times spent per meal in the present study were 27, 25 and 27 min/meal for the corn-grain, soybean-hulls and wheat-bran diets, respectively.

Luginbuhl et al. (2000) observed 6.6 and 7.9 meals/day with an average duration of 53.2 and 42.1 min/meal, while the rumination periods were 1.8 and 13.5 per day, lasting 42.9 and 41.7 min/period for steers fed hay and silage, respectively. Salla et al. (2003) fed different sources of fat to Jersey cows in lactation and obtained an average of 14.7 feeding periods, 15.6 rumination periods and 22.5 idle periods per day. The results of time per feeding, rumination and idle periods of the current study are close to the 31.9, 31.8, and 37.3 min/period found by Silva et al. (2005), who worked with an inclusion of 10% cassava bagasse in the diet of ¾ Dutch × Zebu steers.

As can be observed in Figure 1, animals reared in intensive systems tend to condition their feeding time to the times the feed is supplied (Cozzi et al., 2005; Abijaoudé et al., 2000). According to Epps (2002), cattle are animals of twilight habit; that is, they are more active at nightfall and at dawn, which are the times when they present their peaks of feeding. Like sheep and goat, cattle can also adequate their feeding behavior according to type, availability, and chemical characteristics of the feed in order to meet their needs (Goetsch et al., 2009).

In view of the nutritional composition of the diet (Table 1), it can be concluded that the NDF content could have temporarily limited the intake, causing the animals to fractionate their meals. The diet with wheat bran presented 607.4 g/kg of NDF dry matter, while the diet with soybean hulls presented 510.2 g/kg of dry matter; however, the energy density of the former was lower (670.7 versus 646.8 g/kg of TDN dry matter, respectively). This can be attributed to the inherent differences of the chemical composition and digestibility between these ingredients. In diets with high NDF and low energy content, animals have the tendency to raise their dry matter intake until the energy requirement is met. However, a physical limit of 12 g/kg of body weight to the rumen fill can be observed (Mertens, 1994).

Conclusions

The inclusion of wheat bran as main source of carbohydrate in the concentrate fraction results in a lower idling time, whereas soybean hulls promote a lower feeding time. However, the use of corn, soybean hulls, or wheat bran in diets for confined steers does not affect their total rumination time.

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