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Ingestive behavior of Nellore steers in feedlot fed with diets containing different corn hybrids[1]

Comportamento ingestivo de bovinos nelore em confinamento e alimentados com dietas contendo diferentes híbridos de milho

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Abstract

The objective of this work was to study the feeding behavior of Nellore beef cattle in feedlot fed with diets containing different corn hybrids. Twenty-seven animals averaging 350 ± 24 kg of body weight and 24 months of age, were used. The animals were distributed in a completely randomized design with three treatments (T), where, T1-TDFC: total diet containing flint corn, T2-TDSFC: total diet containing semi-flint corn and T3-TDSDC: total diet containing semi-dent corn, with 9 replicates per treatment. The animals were fed ad libitum twice a day (at 8:00am and 4:00pm) with a isocaloric and isonitrogenous diet, with 30% of sugar cane bagasse and 70% concentrate (88% maize, 8% soybean meal, 3% mineral and vitamin supplement and 1% urea) for 95 days (14 days of adaptation and 3 experimental periods of 27 days each). The animals were weighed at the beginning of the experiment and after each period of 27 days, always in a fasting period of 16 hours. The evaluation of animals feeding behavior occurred at the last day of each period by visual observation every five minutes for full periods of 24 hours. Observations were made in four shifts: morning (06:00 to 12:00), afternoon (12:00 to 18:00), evening (18:00 to 00:00) and early morning (00:00 06:00) to determine the number of ruminal bolus, chewing time, total feeding time, total ruminating standing time, total ruminating lying time, total standing idle time and total lying idle time. During the night's observations, the stalls received artificial illumination to facilitate the data collection and the animals were adapted with light at night for three days before observations. Animals fed with diets containing semi-dent corn had longer chew time and more ruminal bolus than those fed with flint corn, but did not differ from those that received semi-flint corn in the diet. The chewing time and number of ruminal bolus varied with the observation periods, being higher in the morning and decreasing in the afternoon, night and early morning. To the time spent feeding, ruminating and idle it was found that animals fed with diets containing flint corn had higher feeding time than those fed with diets containing semi-flint corn and semi-dent corn. Among the other variables there was no

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significant difference between treatments. It can be concluded that animals fed diets containing semi-dent corn spent more time chewing food had more ruminal bolus than those fed flint corn in the diet. Animals fed diets containing flint corn spent more time feeding than those fed diets with semi-flint or semi-dent corn. The chewing time and number of ruminal bolus is biggest in the morning and decrease in the afternoon, night and early morning.
Keywords: Concentrate, feeding, idle, rumination

Resumo

O objetivo deste trabalho foi estudar o comportamento ingestivo de bovinos da raça Nelore terminados em confinamento e alimentados com dietas contendo diferentes híbridos de milho. Foram utilizados 27 bovinos com peso vivo médio inicial de 350 ± 24 kg e idade média de 24 meses, distribuídos em delineamento inteiramente casualizado, em três tratamentos (T), sendo, T1-DTMDU: Dieta total contendo milho duro, T2- DTMSDU: Dieta total contendo milho semiduro e T3-DTMSDE: Dieta total contendo milho semidentado, com nove repetições por tratamento. As dietas foram isoenergéticas e isoprotéicas, com relação de volumoso: concentrado de 30:70, utilizando-se o bagaço de cana como volumoso e ração concentrada composta de farelo de soja (8%), milho grão moído (88%), suplemento mineral e vitamínico (3%) e uréia (1%). Essas dietas foram fornecidas aos bovinos duas vezes ao dia (8 h e 16 h). Os animais foram confinados por um período de 95 dias, compreendendo 14 dias de adaptação e três períodos experimentais de 27 dias. Os bovinos foram pesados em jejum de sólidos de 16 horas no início do experimento e ao final de cada período de 27 dias. A avaliação do comportamento ingestivo ocorreu no último dia de cada período experimental por meio de observação visual dos animais a cada cinco minutos, por períodos integrais de 24 horas. Foram realizadas observações em quatro turnos: manhã (06:00 às 12:00), tarde (12:00 às 18:00), noite (18:00 às 00:00) e madrugada (00:00 às 06:00) para determinar o número de bolos ruminais, tempo de mastigação, tempo de alimentação, tempo de ruminação em pé, tempo de ruminação deitado, tempo de ócio em pé e tempo de ócio deitado. No período noturno o ambiente recebeu iluminação artificial, sendo que três dias anteriores à coleta de dados, os animais foram adaptados a essa luminosidade noturna. Houve diferença entre os tratamentos para o tempo de mastigação e para o número de bolos ruminais. Animais alimentados com a dieta contendo milho semidentado apresentaram maior tempo de mastigação e maior número de bolos ruminais, do que aqueles alimentados com dieta contendo milho duro, entretanto não diferiram daqueles que receberam milho semiduro na ração. Os tempos de mastigação e os números de bolos ruminais variaram com os períodos de observação (manhã, tarde, noite e madrugada), sendo maior no período da manhã e decrescente no período da tarde, noite e madrugada. Quanto às médias de tempo despendido para alimentação, ruminação e ócio, verificou-se que animais alimentados com ração contendo milho duro apresentaram maior tempo de alimentação do que aqueles recebendo ração com milho semiduro ou semidentado. Entre as demais variáveis (ruminação em pé, ruminação deitado, ócio em pé e ócio deitado) não houve diferença significativa entre os animais recebendo diferentes dietas. Pode-se concluir que animais alimentados com dietas contendo milho semidentado apresentam maior tempo de mastigação e maior número de bolos ruminais do que aqueles alimentados com milho duro. Animais alimentados com dietas contendo milho duro na ração concentrada apresentam maior tempo de alimentação do que aqueles recebendo dietas com milho semiduro ou semidentado. O tempo de mastigação e o número de bolos ruminais são maiores no período da manhã e decrescem no período da tarde, noite e madrugada.
Palavras-chave: Alimentação, concentrado, ócio, ruminação

Introduction

The production system for beef cattle is the set of technologies and management practices, exploiting the ability of the animal to achieve higher profitability of the sector. In this context, the study of animal behavior, especially in feedlot, is important because it allows the understanding of variations in food intake (DADO; ALLEN, 1994; DAMASCENO; BACCARI JÚNIOR; TARGA, 1999).

The feed behavior of ruminants can be characterized by uneven distribution of a succession

of periods defined and discrete activities, commonly classified as eating, ruminating and rest or idle (PENNING; ROOK.; ORR, 1991). Food intake is one of the most important functions of living beings, including the cattle that respond differently to various types of food and diet, changing production levels, fertility rate and feeding behavior (PIRES; VILELA; ALVIM, 2001). It is known that the foods characteristic has influence on feeding behavior and that these factors directly affect the production.

The study of ingestive behavior aims to understand the quantitative and qualitative effects of diet on the feeding behavior, relating it to the intake in order to maximize animal performance. The importance of feeding behavior in ruminants generates investments in researches to provide data that allow animals an adequate nutritional management.

In animal production, food represents about 60-70% of the total cost of production, both in animals confined or raised extensively (MARTINS et al., 2000). The grains are essential components in the diets of cattle, and corn is one of the most important cereal grains that make up the diet of ruminants, representing an energy source of high quality (CORREA et al., 2002). About 60% to 80% of the corn composition is represented by the starch.

Corn has four major anatomical structures in their formation, which are: endosperm, germ, pericarp (husk) and tip cap. The starch is found in the endosperm, and this structure can be classified as vitreous or floury endosperm, depending on the distribution of the starch granules and protein matrix. The floury endosperm does not have protein matrix surrounding the starch granules, while the vitreous endosperm has a dense protein matrix, structured surrounding these granules which gives the corn a glassy appearance (PAES, 2006). The protein matrix is a major factor affecting the utilization of starch by animals because they hinder the action of digestive enzymes and are present in larger quantities in the grains of corn and sorghum (KOTARSKI; WANISKA; THURN, 1992; SNIFFEN; ROBINSON, 1987). The increase in vitreousness grain is associated with a decrease in starch degradation, so it is necessary to evaluate the eating behavior of animals fed with three different corn hybrids, to investigate possible differences among hybrids for the number of food bolus, chewing time, eating, ruminating and idling. The use of a specific variety of corn that adequately meets the requirements of cattle is an alternative that can reduce production costs and serve as an alternative for cattle.

The objective of this work was to study the feeding behavior of animals fed with different corn hybrids (flint, semi-flint and semi-dent), evaluating number of ruminal bolus (RB), rumination time (RT), total feeding time, rumination and idleness.

Materials and Methods

The experiment was carried out at the Farm School of Universidade Estadual de Londrina (UEL), located in Londrina – Paraná - Brasil. Laboratory tests were performed at the Laboratory of Animal Nutrition at the Animal Science Department of UEL.

Twenty-seven Nellore beef cattle, castrated males, averaging 350 ± 24 kg of body weight and 24 months of age were used. The animals were distributed in a completely randomized design with three treatments (T), where, T1-TDFC: total diet containing flint corn, T2-TDSFC: total diet containing semi-flint corn and T3-TDSDC: total diet containing semi – dent corn. The animals were confined for 95 days, including 14 days for adaptation and three experimental periods of 27 days and were distributed in a way to stay three animals per pen and three pens per treatment (total of 9 pens). The pens were partly covered, provided with a concrete floor, with feeder and drinker.

Diets were formulated to be isocaloric and

isonitrogenous the way that each treatment contained a different corn hybrid, obeying the relation of forage and concentrate of the 30:70 (Table 1 and 2). The forage used was sugar cane bagasse and concentrate composed of soybean meal (8%), corn grain (88%), vitamin and mineral supplement (3%) and urea (1%). These diets were offered twice daily (at 8:00am and 4:00pm).

Table 1. Percentage composition of experimental diets.

Proportion	Food	Diets		
		TDFC[1] (%)	TDSFC[2] (%)	TDSDC[3] (%)
Forage (30%)	Sugar cane bagasse	30	30	30
Concentrate (70%)	Flint corn	61.6	----	----
	Semi-flint corn	----	61.6	----
	Semi-dent corn	----	----	616
	soybean meal	5.6	5.6	5.6
	Supplement[4]	2.1	2.1	2.1
	Urea	0.7	0.7	0.7

[1]TDFC: total diet with 30% of sugar cane bagasse and 70% of concentrate containing flint corn.
[2]TDSFC: total diet with 30% of sugar cane bagasse and 70% of concentrate containing semi-flint corn.
[3]TDSDC: total diet with 30% of sugar cane bagasse and 70% of concentrate containing semi-dent corn.
[4]Mineral and vitamin supplement, which level of assurance contains at least: Calcium, 120g; Cobalt, 60mg; Copper, 650mg; Sulfur, 20g; Iron, 1.120mg; Phosphorus, 40g; Iodine, 40mg; Magnesium, 94g; Manganese, 520 mg; Selenium, 9mg; Sodium, 92g; Zinc 1.960mg; Lasalocid, 1000mg; TDN, 95g; Crude Protein, 50g; Vitamin A, 100,000 IU/kg; Vitamin E, 1000 IU/kg; and a maximum of: Fluorine, 400; NPN - Equivalent protein, 45g.
Source: Elaboration of the authors.

The amount of forage and concentrate fed was initially calculated based on 2.5% of body weight in DM and adjusted daily to achieve 7% of remains, enabling the animal to the food selection without suffer restriction or forced consumption. The remains were weighed daily at the next day and weekly samples were stored for further analysis.

At the samples collected were analyzed dry matter, crude protein, ether extract, ash, NDF and ADF according to the methods described by Mizubuti et al. (2009). The TDN were calculated by the formula described by Patterson et al. (2000): TDN = [88.9 - (0.779 *ADF%)].

During the experiment, feeding behavior was evaluated at the last day of each period totalizing three observations. To evaluate feeding time, rumination and idle time was used the visual observation every five minutes for full periods of 24 hours. Observations were made in four shifts: morning (06:00 to 12:00), afternoon (12:00 to 18:00), evening (18:00 to 00:00) and early morning (00:00 06:00), as described by Bürguer et al. (2000), to determine the number of ruminal bolus (RB), chewing time (CT), total feeding time (FT), total ruminating standing time (RST), total ruminating lying time (RLT), total standing idle time (SI) and total lying idle time (LI).

Table 2. Chemical composition of sugar cane bagasse, concentrates and total diets containing flint corn, semi-flint corn or semi-dent corn (dry basis).

	Chemical Composition *						
	DM (%)	MM (%)	CP (%)	NDF (%)	ADF (%)	EE (%)	TDN (%)
FC[1]	88.3	5.1	17.0	17.4	3.8	1.7	85.9
SFC[2]	88.1	5.3	17.0	18.7	4.8	1.3	85.2
SDC[3]	86.7	5.7	17.0	14.2	4.7	1.7	85.2
Sugar cane bagasse	56.1	8.4	1.9	90.5	63.7	0.5	39.3
TDFC[4]	58.8	6.6	16.2	59.3	32.7	1.5	63.4
TDSFC[5]	61.9	6.2	17.2	57.4	29.2	1.8	66.2
TDSDC[6]	59.7	6.5	17.1	61.1	31.7	1,.3	64.2

***** DM- Dry matter; MM-Mineral matter; CP-Crude protein, NDF- Neutral detergent fiber, ADF-Acid detergent fiber, EE- Ether extract, TDN - Total digestible nutrients.
[1] FC: Concentrate containing flint corn.
[2] SFC: Concentrate containing semi-flint corn.
[3] SDC: Concentrate containing semi-dent corn.
[4] TDFC: Total diet containing 30% of sugar cane bagasse and 70% of FC.
[5] TDSFC: Total diet containing 30% of sugar cane bagasse and 70% of SFC.
[6] TDSDC: Total diet containing 30% of sugar cane bagasse and 70% of SDC.
Source: Elaboration of the authors.

Digital timers were used, handled by trained observers, who observed the animals during the pre-determined periods to obtain the time spent on each activity. During the night's observations, the pens received artificial illumination to facilitate the data collection and the animals were adapted with light at night for three days prior to observations.

Data were analyzed by restricted maximum likelihood for repeated measures on time (periods 1, 2 and 3) using the mixed procedure of SAS (2003). The model used was:

$$Y_{ijk} = \mu + t_i + p_j + e_{ijk}$$

Where:

Yijk = observation of the animal k subjected to the diet i at time j;

μ = general constant;

t_i = diets effect i; i = 1; ...3;

p_k = effect of period; k = 1;...3;

e_{ijk} = random error associated with each observation Y_{ijk} with mean 0 (zero) and variance $\sigma 2$.

For the chewing time and number of ruminal bolus variables, was included in this model, the effect of shift (morning, afternoon, night and early morning). When necessary, means were compared by Tukey-Kramer adjusted. The significance level was 5%.

Results and Discussion

The experiment showed difference between treatments ($P < 0.05$), both for chewing time and for the number of ruminal bolus (Table 3).

Animals fed with diets containing semi-dent corn had more chewing time and number of ruminal bolus than those fed with flint corn, but did not differ from those that received semi-flint corn in the diet.

Table 3. Means of chewing time (minutes) and number of ruminal bolus, depending on the treatment of Nellore cattle in feedlot.

Variable	Observation period	Diets			Means	CV (%)	Test fixed effects (P>F)		
		TDFC[1]	TDSFC[2]	TDSDC[3]			Corn	Shift	Interaction
CT	Early morning	52.8	55.8	60.2	56.3b	-	-	-	-
	Morning	58.6	59.7	66.2	61.5 a	-	-	-	-
	Afternoon	51.2	52.2	62.1	55.1b	-	-	-	-
	Evening	42.7	47.8	50.1	46.9c	-	-	-	-
	Means	51.3 b	53.9 ab	59.6 a	-	24.3	0.0122	<0.001	0.5250
NRB	Early morning	51.3	54.5	58.7	54.84 b	-	-	-	-
	Morning	58.2	59.8	65.8	61.3 a	-	-	-	-
	Afternoon	47.6	50.8	56.1	51.50 b	-	-	-	-
	Evening	41.8	48.4	49.1	46.41 c	-	-	-	-
	Means	49.71 b	53.38 ab	57.42 a	-	25.1	0.0267	<0.0001	0.7338

CT-chewing time (minutes), NRB-number of ruminal bolus, CV-coefficient of variation.
[1] TDFC: Total diet containing 30% of sugar cane bagasse and 70% of FC (Concentrate containing flint corn).
[2] TDSFC: Total diet containing 30% of sugar cane bagasse and 70% of SFC (Concentrate containing semi-flint corn).
[3] TDSDC: Total diet containing 30% of sugar cane bagasse and 70% of SDC (Concentrate containing semi-dent corn).
Means followed by different letters in the same row between treatments differ (P <0.05).
Means followed by different letters in the same column between observation period differ (P <0.05).
Source: Elaboration of the authors.

According to Marques et al. (2008), the need for a higher rate of chewing is related to the amount of indigestible material consumed, material strength and reduction of particle size. Therefore, foods with high content of NDF require more chewing and rumination, requiring the animal more time to complete the feeding process. Likewise, Pereira et al. (2007), found an increase in chewing per ruminal bolus, number of bolus, number of chews per day and total chewing time, when it increased the level of NDF in the diet from 30 to 60%. In this experiment, were found compatible results with the researchers cited, because animals fed diets with semi-dent corn (TDSDC) and 61.08% of NDF had more chewing time and number of ruminal bolus.

According to Mertens (1992), the fiber is a very important component in the diet of ruminants, it is linked to stimulation of chewing, rumen motility, maintenance of stable rumen environment, animal health, dry matter intake and energy supply. Moreover, Dulphy, Remond and Theriez (1980) reported that when decreasing the proportion of cell wall constituents of the diet by increasing the starch content, there is a decrease of the total chewing time.

In this study, the diets of all treatments contained equal amounts of sugar cane bagasse (effective fiber of diet), and the only difference between them were the corn genotypes of the concentrate. It is known that the main difference between the genotypes is the amount of protein matrix surrounding the starch granule, and the semi-dent type contains less protein matrix in comparison with two other genotypes. It is assumed that the animals fed with the diet containing semi-dent corn, has occurred quicker release of the starch, leading to a metabolic response of the animal, where increased the number of ruminal bolus and the ruminating time to produce higher amount of saliva in order to buffer the rumen.

In evaluating the chewing time and the number of bolus with the observation times (morning, afternoon, evening and early morning) it can be verified that the chewing time and the number of bolus were reduced throughout the day and that there was a higher chewing time in the morning decreasing in the afternoon, evening and early morning.

As Dulphy and Faverdin (1987), cited by Freitas et al. (2010), the ruminants have a daytime habits and the pattern of foraging by the animals in confinement is very characteristic and features in two main stages: early in the morning and evening. These times coincided with the food was provided to the animals (8:00 and 17:00 hours). Moreover, animals are conditioned to ingest food immediately after the offering in the feeder, when the food is fresh (FARIA, 1982; DADO; ALLEN, 1995) and the distribution of rumination is greatly influenced by the diet, since the ruminating takes place after the feeding periods, when the animal is relaxed (POLLI et al., 1996). In this experiment it was observed that the number of ruminal bolus was greater in the periods immediately after feeding.

As for the average time spent feeding, ruminating and idle (Table 4), in minutes per day, it was found that animals fed with diets containing flint corn (TDFC) had higher feeding time ($P<0.05$) those fed diets with semi-flint corn (TDSFC) or semi-dent corn (TDSDC) (Table 4). Among the other variables (standing ruminating, lying ruminating, standing idle and lying idle) no significant difference between animals of different treatments were observed.

The flint corn has dense protein matrix that makes it to the glassy appearance. Probably the animals had more difficulty in chewing it and because this spent more time feeding (Table 4). However, as has glassy character, his break with chewing may have been more efficient, which could explain the fact that the animals that consumed this corn genotype had lower chewing time and fewer number of ruminal bolus (Table 3).

Table 4. Mean time spent feeding, ruminating and idle (in minutes per day), depending on the treatment of Nellore cattle in feedlot.

Variable	Diets			CV(%)*	P>F
	TDFC[1]	TDSFC[2]	TDSDC[3]		
Feeding time	230.7a	197.4b	185.7b	20.09	0.0001
Standing ruminating	98.2	100.2	125.7	40.27	0.1268
Lying ruminating	238.9	243.5	235.0	30.11	0.9238
Standing idle	335.9	385.0	374.3	22.95	0.0629
Lying idle	536.3	513.7	518.8	17.08	0.5546

[1] TDFC: Total diet containing 30% of sugar cane bagasse and 70% of FC (Concentrate containing flint corn).
[2] TDSFC: Total diet containing 30% of sugar cane bagasse and 70% of SFC (Concentrate containing semi-flint corn).
[3] TDSDC: Total diet containing 30% of sugar cane bagasse and 70% of SDC (Concentrate containing semi-dent corn).
*CV- coefficient of variation.
Means followed by different letters in the same row between treatments differ (P <0.05).
Source: Elaboration of the authors.

Regarding the time spent on each activity throughout the day, in this experiment it was observed that the animals spent an average of 204 minutes a day feeding, 347 minutes a day ruminating and 888 minutes a day in idleness. The results obtained in this study were similar to those observed by others researchers (DAMASCENO; BACCARI JÚNIOR; TARGA, 1999; GOULARTE, 2009). Similarly, Silva et al. (2005), working with crossbred heifers Holstein x Zebu, found average times of 239, 472 and 728 minutes a day spent in the activities of feeding, ruminating and idling.

Even though the animals interleaving the activities of feeding, rumination and rest several times during the day, it was observed in this study that none of these variables were influenced by diets.

Animals fed with diets containing flint corn in the concentrate ration spend more time feeding than those fed with diets containing semi-flint or semi-dent corn.

The different corn hybrids in the diet did not influence the variables of standing rumination, lying rumination, standing idle and lying idle in Nellore cattle in feedlot.

Conclusions

Animals fed with diets containing semi-dent corn in the concentrate ration spend more time chewing food and have more ruminal bolus than those fed with flint corn in the ration.

The chewing time and number of ruminal bolus is greater in the morning and decrease in the afternoon, evening and early morning.

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