

Original Research Article

Correlation between intake and feeding behavior of Holstein calves fed diets supplemented with pellets and mash

ABSTRACT

The objective was to evaluate the correlation between behavioral and intake variables of Holstein calves fed pellets and meal. Twelve PO Holstein calves with initial average age of 10 days and weight of 27.5 kg were used; the animals were randomly distributed into two treatments, with six repetitions. There was a moderate positive correlation between the variable behavior: dry matter per bolus, number of discrete eating and resting periods and the variable of dry matter intake (DMI). There was a strong positive correlation between the variables of behavior: total chewing time, NDF/BOLUS, ADF/ BOLUS and neutral detergent fiber (NDF) and acid detergent fiber (ADF) intake variables. There was a negative moderate correlation between the behavior variable TPO and the NDF and ADF intake variables. Based on the study of behavioral variables, are highly correlated with intake variables, thus fostering a better understanding of metabolic variables.

KEYWORDS: cattle, nutrition, production, ingestion

INTRODUCTION

The probability that food is ingested depends on a number of factors inherent to food, animal behavior and environment (Pereira et al., 2009).

26 Several factors can interfere with the daily activities of the animals: forage
27 characteristics, time of food supply, temperature, space available to animals raised
28 in confinement and others. These factors can bring about changes in the time of
29 ingestion or consumption of food, affect the animal performance and hence the
30 efficiency of the productive system.

31 Given the above, the intake of forage, milk and supplements by calves
32 should be known through the study of ingestive behavior in order that the
33 nutritional management can be adjusted; thus, the formulation of more appropriate
34 diets that meet the requirements of animals is needed, considering that it is
35 directly connected with the performance and determines how long the animals
36 will remain at this stage (Silva et al. 2011).

37 Over the last years, the need for further information on adequate
38 nutritional management methods and understanding the feeding behavior of
39 ruminants has generated investments in researches. The generation of these data
40 shall make it possible to develop correlational studies that, through detailed
41 examination, will enable the selection of behavioral variables to predict the
42 consumption of these animals. By identifying these potential variables, it with will
43 be possible to develop predictive models that could accurately estimate the
44 variable of dry matter intake, which in turn is considered essential in nutrition and
45 performance trials. Thus, the aim of this work was to evaluate the correlation
46 between the variables of behavior and food consumption by Holstein calves fed
47 pellets and meal.

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49 MATERIAL AND METHODS

50 *Animal management and sampling*

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The experiment was conducted at the Cattle Farming Unit of University State Bahia, between November 2004 and February 2005. Twelve (12) Black and White Holstein calves aged 10 days and weighing 27.5 kg, were randomly divided into two treatment groups six (6) animals per treatment. The experimental design used in this study was a 2 x 2 factorial design (two types of feed and two feeding stages). The animals were confined in individual concrete-floored stalls of 2.5 m². The length of the trial period was 91 days, whereof 7 days were for the adaptation of animals to a new environment, diet and experimental methods.

A diet consisting of a Sprayfo® milk replacer at 1:8 dilution and concentrate were provided *ad libitum* during suckling.

The concentrates had the same bromatological composition, but one of them was supplied as meal and the other as pellets. The composition of the replacer is shown in Table 1 and that of hay and concentrate is shown in Table 2.

Table 1- Chemical composition of the milk replacer used for feeding calves

Item	Replacer (%)
Dry Matter (maximum)	97.0
Crude protein ¹ (minimum)	20.0
Lactose ¹ (minimum)	45.0
Fat content ¹ (minimum)	15.0
Fiber ¹ (maximum)	0.4
Ashes ¹ (maximum)	8.5
Calcium ¹ (minimum)	0.7
Phosphorus ¹ (minimum)	0.7

¹ % in dry matter.

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The replacer was daily distributed at 7:00 a.m. in five liter plastic buckets, while the concentrate was provided at the same time, in wood-clad plastic buckets. Water was provided *ad libitum* in full-time available in automatic shell-

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shaped waters. During the first 60 days of age, each animal daily received four kilograms of milk replacer and concentrate was provided *ad libitum*.

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Table 2 - Proportion of ingredients (%) and chemical composition of concentrate and hay in the diet of calves

and hay in the diet of calves	
Item	% of dry Matter
Concentrate ¹	
Milled grains of maize	44.8
Soybean meal	39.23
Wheat meal	9.45
Mineral salt ²	4.0
Palm oil	2.0
Sodium bicarbonate	1.0
Calcitic limestone	0.24
Chemical composition of feed	
DM	91.18
CP	23.38
EE	3.1
NDF	15.02
ADF	8.09
Calcium	1.0
Phosphorus	0.50
Chemical composition of hay	
DM	92.77
CP	6.30
EE	0.35
NDF	81.50
ADF	51.82

(DM) Dry Matter; (CP) Crude Protein; (EE) Ether Extract; (NDF) neutral detergent fiber; (ADF) acid detergent fiber.

¹ 91.8% DM of natural matter.

² Ca (233g/kg), P (80g/kg), Mg (5g/kg), Na (48g/kg), Co (25mg/kg), Cu (380mg/kg), I (25mg/kg), Mn (1080mg/kg), Se 3.75 mg/kg, Zn 1722 mg/kg, 300.000 U.I of vitamin A/kg, 55.000 U.I of vitamin D/kg, 200 mg of vitamin E/kg.

The amount of concentrate provided was adjusted according to the previous day's intake, thus allowing an availability rate of 5-10% as leftovers (for safety), where the amount of concentrate provided was daily recorded and the

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82 amount of leftovers was weekly assessed and weighed for every single animal.
 83 The animals were weaned at 60 days of age and then started to be fed two pounds
 84 of kg concentrate/day and hay made from chopped and pre-dried elephant grass
 85 (*Pennisetum purpureum*) (*ad libitum*). Hay supply was monitored in order that 5-
 86 10% leftovers were produced. The concentrate feed samples were stored in plastic
 87 bags and shortly thereafter ground in a 1mm mesh sieve for subsequent laboratory
 88 analysis for (DM) Dry Matter; (CP) Crude Protein; (EE) Ether Extract; (NDF)
 89 neutral detergent fiber and (ADF) acid detergent fiber (Silva and Queiroz, 2002).

Comment [DGK8]: Use its equivalent in Kg as the SI unit

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Comment [DGK10]: Present like this: Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF)

91 *Ingestive behavior*

92 The animals were subjected to four full-time observation periods (24
 93 hours) by trained observers, for evaluation of their ingestive behavior, totaling
 94 two days of observation per experimental period (lactation and post-lactation
 95 periods) (Fischer, 1996). In order to determine the time spent on each activity,
 96 data collection was performed using appropriate spreadsheet. At night time,
 97 artificial lighting was used. The animals were simultaneously observed at
 98 intervals of five minutes, during the 24 hour period, totaling 288 daily
 99 observations (Gary et al., 1970) to identify the amount of time allocated to eating,
 100 rumination and resting. The collection and processing of data concerning the
 101 efficiency of feeding and rumination, total chewing time, number of ruminal
 102 boluses, rumination time/bolus and the number of chews per cud/bolus using
 103 digital timers handled by trained observers were carried out according to the
 104 procedures described by Burger et al. (2000). Discretization of the time series
 105 was directly made in data collection spreadsheets, including the count of discrete
 106 feeding, rumination and resting periods, as described by Silva *et al.* (2003). The

average duration of each discrete period was obtained by dividing the day-time of every activity by the number of discrete periods.

109

110 *Statistical analysis*

111 Data analysis was carried out with the Pearson's linear correlation
112 coefficient between the behavior variables and the DM, NDF and ADF intakes.

113 The coefficients found had their significance obtained through the Student's t-test
114 at 5% probability, using the software package Statistical Analysis for Genetic
115 Epidemiology – SAEG - Federal University of Viçosa (UFV, 2000).

116

117 RESULTS AND DISCUSSION

118 The variables, rumination and resting are not correlated with DMI
119 ($P>0.05$). According to Pinto et al (2010), the time spent eating and ruminating
120 indicate that these variables have no correlation with the intake of dry matter and
121 neutral detergent fiber and can not therefore be used as indicators of consumption
122 real animals. Regarding the intake of NDF and ADF, these variables ($P<0.05$)
123 showed positive correlation with feeding and strong positive correlation with
124 rumination and resting (Table 3).

125

Table 3 - Correlation between the sum of variables related to behavior and food intake by Holstein calves.

Behavior Variables	Intake Variables					
	DM Intake		NDF Intake		ADF Intake	
	R	P	R	P	R	P
Feeding	-	-	0.76	0.0022	0.69	0.0062
Rumination	-	-	0.87	0.0001	0.89	0.0001
Resting	-	-	0.85	0.0002	0.84	0.0003

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Please rephrase it for a better understanding.

In line with the results observed in this study, Missio et al. (2010) have evaluated the ingestive behavior of confined cattle fed different levels of concentrate and have found that the levels of neutral detergent fiber (NDF) had a correlation of 0.72 with the total resting time.

Regarding the behavioral variables, number feeding periods (NPA) and number periods of resting (NPO), there was positive correlation with the dry matter intake variable (DMI) (Table 4).

It is therefore possible to associate such occurrence with the dry matter intake (DMI) that can determine a higher concentration of necessary nutrients to meet growth needs and this consumption can be related to several factors. Mateus et al. (2011), reporting that the level of concentrate used in the diet, may influence changes in consumption, nutrient digestibility and the performance parameters.

Table 4 - Correlation between number and time of feeding, rumination and resting and (DM) Dry Matter, (NDF) neutral detergent fiber and, (ADF) acid detergent fiber intake by Holstein calves.

Behavior Variables	Intake Variables					
	DM Intake		NDF Intake		ADF Intake	
	R	P	R	P	r	P
NFP ¹	0.76	0.0022	-	-	-	-
NRuP ²	-	-	-	-	-	-
NRP ³	0.53	0.0376	-	-	-	-
TFP ⁴	-	-	0.82	0.0005	0.79	0.0010
TRuP ⁵	-	-	0.85	0.0003	0.89	0.0001
TRP ⁶	-	-	-0.63	0.0135	-0.58	0.0229

¹ number feeding period, ² number rumination period, ³ number resting period, ⁴ time feeding period, ⁵ time rumination period, ⁶ time resting period

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The times per feeding (TFP) and rumination period (TRuP) were highly correlated with NDF and ADF intakes (Table 4). Correlations between the TFP and TRuP with the NDF and ADF intake are probably due to the massive rate of

144 passage of forage, whose limitation is the physical effect caused by the high hay
 145 NDF content. When high NDF concentrations are present in the diet, the animal
 146 tends to have a greater number of meals and consequently there is direct
 147 interference in TFP and TRuP expenses for acquiring and breaking food into
 148 smaller particles.

149 Moderate and negative correlations were observed between TRP ($r = -$
 150 0.58 , $P = 0.00229$) and NDF and ADF intakes. The probable explanation for this
 151 is that, since the activities are mutually excluding when NDF is increased, the
 152 animals have to feed and ruminate for longer periods, which results in a reduction
 153 in time per resting period.

154 The efficiency of feeding and rumination of DM **was** moderately and
 155 positively correlated with DMI (Table 5). As the food was provided in the form of
 156 pellets or meal, the observed time of ingestion of the pellets was observed to be
 157 shorter than that regarding the meal. That has occurred in both feeding phases and
 158 may be explained by the fact that the more concentrated the diet, the higher its
 159 intake efficiency.

160

Table 5 - Correlation between the efficiency of feeding (Effe) and rumination (Efru) (g/h) and (DM) Dry Matter, (NDF) neutral detergent fiber and (ADF) acid detergent fiber intake by Holstein calves.

Behavior Variables	Intake Variables					
	DM Intake		NDF Intake		ADF Intake	
	R	P	R	P	r	P
EffeDM	0.65	0.0106	-	-	-	-
EffeNDF	0.85	0.0003	-	-	-	-
EffeADF	0.82	0.0005	-	-	0.52	0.0411
EfruDM	0.58	0.0233	-	-	-	-
EfruNDF	0.97	0.0000	-	-	-	-
EfruADF	0.95	0.0000	-	-	-	-

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Unlike the results for DM intake, NDF intake was not correlated ($P > 0.005$) with the efficiency of feeding and rumination regarding DM, NDF and ADF. Yet, regarding ADF consumption, there was only moderate and positive correlation with the feed efficiency of DM (Table 5). According to Van Soest (1994), the feed efficiency used by animals to acquire food is related to the time allocated for consumption of food and to the specific weight of the food consumed.

There was a moderate and positive correlation between dry matter per ruminated bolus (DM/BOLUS) and dry matter intake (DMI) as shown in Table 6.

Table 6- Correlation between the sum of variables related to behavior and food intake by Holstein calves.

Behavior Variables	Intake Variables					
	DM Intake		NDF Intake		ADF Intake	
	r	P	R	P	r	P
TMT ¹	-	-	0.80	0.0009	0.80	0.0010
DM/BOLUS ²	0.67	0.0085	-	-	-	-
NDF/BOLUS ³	-	-	0.99	0.0000	0.98	0.0000
ADF/BOLUS ⁴	-	-	0.98	0.0000	0.97	0.0000
BOLUSES/DAY	-	-	0.98	0.0000	0.94	0.0000
TIME/BOLUS	-	-	0.63	0.0137	0.61	0.0184
CHEWING/BOLUS	-	-	0.62	0.0150	0.60	0.0192

¹ total chewing time, ² (DM) dry matter/bolus, ³ (NDF) neutral detergent fiber/bolus, ⁴ (ADF) acid detergent fiber/bolus.

Considering that the dry matter intake does not fully reflect the amount of fractions with lower digestibility potential and that it may vary depending on the levels of non-structural carbohydrates of NDF and ADF levels, dry matter intake truly with do not show a high correlation with the variable under study. Understanding nutrient intake through the study of behavioral variables would provide less invasive and stressful solutions. Such information is extremely

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179 important for the traditional nutritional studies, considering that they interfere
180 with the environment where the animals are raised, causing a series of
181 inconveniences that can disturb their biological functioning. This study has
182 identified a high positive correlation between the variables of behavioral aspects
183 such as total chewing time (TMT), neutral detergent fiber per ruminated bolus
184 (NDF/BOLUS), acid detergent fiber per bolus (ADF/BOLUS), daily ruminated
185 boluses, time per ruminated bolus, chews per ruminated bolus and NDF and ADF
186 intakes.

187 The high correlation between these variables shows the strong association
188 between the behavioral aspects related to food intake. For a long time, many
189 researchers have put into question the actual usefulness of behavioral studies
190 related to food intake. The information contained in this publication can
191 potentially guide innovative researches aimed at the use of behavioral variables as
192 a tool for guiding the development of new predictive food intake methods for both
193 confined and in field cattle.

194

195 CONCLUSION

196 In the near future, according to the correlations found in this study
197 between the behavioral aspects and intake of NDF and ADF, will support studies
198 aimed to the formulation of diets based on behavioral understanding of food
199 intake by animals.

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