

Original Research Article

Correlation between intake and feeding behavior of Holstein calves supplemented with pelleted and mash

ABSTRACT

The objective was to evaluate the correlation between behavioral and intake variables of Holstein calves fed pellets and meal. Twelve Holstein calves with initial average age of 10 days and weight of 27.5 kg have been used; the animals were randomly distributed into two treatments, with six repetitions. There was a moderate positive correlation between the variables 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 NDF and ADF intake variables. There was a negative moderate correlation between the behavior variable TPC and the NDF and ADF intake variables. Based on the study of behavioral variables, behavior variables are highly correlated with intake variables, thus fostering a better understanding of metabolic variables.

KEYWORDS: cattle, nutrition, production, ingestive

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 should
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.

48

49 MATERIAL AND METHODS

50 *Animal management and sampling*

The experiment was conducted at the Cattle Farming Unit of University State Bahia between November 2004 and February 2005 Twelve Black and White Holstein calves aged 10 days and weighting 27.5 kg were randomly divided into two treatment groups, six animals per treatment. Experimental design was used in units of repeated measures, in 2x2 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 seven 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 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.

70 The replacer was daily distributed at 7:00 a.m. in five liter plastic buckets,
71 while the concentrate was provided at the same time, in wood-clad plastic
72 buckets. Water was provided ad libitum and was available in full-time available in
73 automatic shell-shaped waterers. During the first 60 days of life, each animal daily
74 received four kilograms of milk replacer and concentrate was provided ad libitum.
75

Table 2 - Proportion of ingredients (%) and chemical composition of concentrate 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
Dry Matter	91.18
Crude Protein	23.38
Ethereal Extract	3.1
NDF	15.02
ADF	8.09
Calcium	1.0
Phosphorus	0.50
	Chemical composition of hay
Dry Matter	92.77
Crude Protein	6.30
Ethereal Extract	0.35
NDF	81.50
ADF	51.82

76 ¹ 91.8% DM of natural matter.

77 ² Ca (233g/kg), P (80g/kg), Mg (5g/kg), Na (48g/kg), Co (25mg/kg), Cu (380mg/kg), I
78 (25mg/kg), Mn (1080mg/kg), Se 3.75 mg/kg, Zn 1722 mg/kg, 300.000 U.I of vitamin
79 A/kg, 55.000 U.I of vitamin D/kg, 200 mg of vitamin E/kg.

80

81 The amount of concentrate provided was adjusted according to the
82 previous day's intake, thus allowing an availability rate of 5-10% as leftovers (for

safety). The amount of concentrate provided was daily recorded and the amount of leftovers was weekly assessed and weighed for every single animal. The animals were weaned at 60 days of age and then started to be fed two pounds of concentrate/day and hay made from chopped and pre-dried elephant grass (L. d. libitum). Hay supply was monitored in order that 5-10% leftovers were produced. According to Silva & Queiroz (2002), the concentrate samples were stored in plastic bags and shortly thereafter ground in 1 mm mesh sieve for later laboratory analysis of DM, CP, EE, NDF and AD.

Ingestive behavior

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

108

109 *Statistical analysis*

110 Data analysis consisted of the Pearson's linear correlation coefficient
 111 between behavior variables and DM, NDF and ADF intakes. The coefficients
 112 found had their significance obtained through the Student's t-test at 5%
 113 probability, using the software package Statistical Analysis for Genetic
 114 Epidemiology - SAEG (UFPA, 2000).

115

116 RESULTS AND DISCUSSION

117 The variables power, rumination and resting are not correlated with DMI
 118 ($P>0.05$). Regarding the intake of NDF and ADF, these variables ($P<0.05$)
 119 showed moderate positive correlation with feeding and strong positive correlation
 120 with rumination and resting (Table 3). According to Albright (1993), fiber intake is
 121 highly correlated with the time allocated for rumination, thus confirming the
 122 results observed in this study.

123

124

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

126

127 In line with the results observed in this study, Missio et al. (2010) have
 128 evaluated the ingestive behavior of confined cattle fed different levels of

129 concentrate and have found that the levels of neutral detergent fibre had a
130 correlation of 0.72 with the total resting time.

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

134 It is therefore possible to associate such occurrence with the CM that can
135 determine a higher concentration of necessary nutrients to meet growth needs.
136 DMI can be related to several factors. According to Forbes (1995), animals living
137 in healthy and comfortable environments tend to consume a greater amount of dry
138 matter

139

Table 4. Correlation between number and time of feeding, rumination and resting
and DM, NDF and ADF 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

140

141 The times per feeding (TFP) and rumination period (TRuP) were highly
142 correlated with NDF and ADF intakes (Table 5). Correlations between the TFP
143 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

tends to have a greater number of meals and consequently there is direct interference in TFP and TRuP expenses for acquiring and breaking food into smaller particles.

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

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

Table 5 - Correlation between the efficiency of feeding (Effe) and rumination (Efru) and DM, NDF and ADF 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	-	-	-	-

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,

164 regarding ADF consumption, there was only moderate and positive correlation
165 with the feed efficiency of DM (Table 5).

166 According to Van Soest (1994), the feed efficiency used by animals to acquire
167 food is related to the time allocated for consumption of food and to the specific
168 weight of the food consumed.

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

171

172

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 dry matter/bolo, ³neutral detergent fiber/bolus, ⁴acid detergent fiber/bolus.

173

174 Considering that the dry matter intake does not fully reflect the amount of
175 fractions with lower digestibility potential and that it may vary depending on the
176 levels of non-structural carbohydrates of NDF and ADF levels, dry matter intake
177 truly tends to not show a high correlation with the variable under study.
178 Understanding nutrient intake through the study of behavioral variables would
179 provide less invasive and stressful solutions. Such information is extremely
180 important for the traditional nutritional studies considering that they interfere

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

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

195

196 CONCLUSIONS

197 In a near future, the high correlations between behavioral aspects and NDF
198 and ADF intakes might be able to support studies aimed at the formulation of
199 intake estimates based on information regarding the ingestive behavior of the
200 animals.

201

202 REFERENCES CITED

203

204 Bürger, P.J., Pereira, J.C., Queiroz, A.C., Coelho da Silva, J.F., Valadares Filho,
205 S.C., Cecon, P.R., Casali. A.D.P., 2000. Ingestive behavior in Holstein calves

- 206 fed diets containing different levels of concentrate. R. Bras. Zootec, 29, 1,
207 236-242
208
- 209 Fischer, V. Effects of photoperiod, the grazing pressure and diet on the feeding
210 behavior of ruminants. 1996. 243p. Thesis (Ph.D. in Animal Science) - Federal
211 University of Rio Grande do Sul, Porto Alegre
212
- 213 Forbes, J.M., 1995. Voluntary Food Intake and Diet Selection in Farm Animals.
214 CAB International, Wallingford, UK
215
- 216 Gary, L.A., SHERRITT, G.W., HALE, E.B. 1970. Behavior of Charolais cattle on
217 pasture. J Anim Sci, 30, 303-306
218
- 219 Missio R.L., BRONDANI I.L., FILHO D.C.A. SILVEIRA M.F., FREITAS L. S.,
220 RESTLE J. 2010. Ingestive behavior of feedlot finished bulls fed different
221 concentrate levels in the diet. R. Bras. Zootec, 39, p.1571-1578
222
- 223 Pereira E.S., MIZUBUT I.Y., RIBEIRO E. L.A.A., VILLARROELI A.B.S.,
224 Pimentel P.G., 2009. Intake, apparent digestibility of nutrients and feeding
225 behavior of Holstein cattle fed hay diets containing Tifton 85 with various
226 particle sizes. R. Bras. Zootec., 38, 190-195
227
- 228 Silva D.J., Queiroz A.C., 2002. Food analysis (chemical and biological). Viçosa:
229 Federal University of Viçosa, p.235
230

- 231 Silva R.R., Silva, F.F., Veloso C.M., Aguiar M.S.M., Carvalho G.G.P., Almeida
232 V.S., Santos C.B., Dutra G.S., Matos R.S. Assessment of ingestive behavior of
233 $\frac{3}{4}$ Holstein x Zebu heifers fed elephant grass silage plus 10% cassava meal.
234 Methodological Aspects. In: 40th ANNUAL MEETING OF THE BRAZILIAN
235 SOCIETY OF ZOOTECNIA, 40, 2003, Santa Maria. Proceedings ... Santa
236 Maria: SBZ, 2003
237
- 238 Silva R.R., Silva F.F., Mendes F.B.L., Almeida V.V.S., Carvalho G.G. P.,
239 Lisboa M.M., 2011. Study of correlations between discrete periods of
240 behavior with the variables of food intake by Holstein calves supplemented
241 with pelleted and mash. Proceedings ... 48th Annual Meeting of the Brazilian
242 Society of Animal Science: The Development of Animal Production and
243 Responsibility Challenges Facing New Belém – PA
244
- 245 Federal University of Viçosa. SAEG - System statistics and genetic analysis.
246 Version 8.0. Viçosa, 2000. 142 p. User manual
247
- 248 Van Soest P.J., 1994. Nutritional ecology of the ruminant. 2.ed. Ithaca: Cornell
249 University Press, 476p
250
251