

Original Research Article

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

ABSTRACT

The objective was to evaluate the correlation between behavioural and intake variables of Holstein calves fed pellets and meal. Twelve pure Holstein calves with initial average age of 10 days and weight of 27.5 kg were used; The experimental design used in this study was a 2 x 2 factorial design (two types of feed and two feeding stages lactation and post-lactation periods), with six repetitions. Was found significant effects the time allocated to eating, rumination and resting. The data concerning the efficiency of feeding and rumination, total chewing time, number of ruminal boluses, rumination time/bolus and the number of chews per cud/bolus and discretization of the time series. There was a moderate positive correlation between the variable behaviour: 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 behaviour: 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 behaviour variable TRP (time resting period) and the NDF and ADF intake variables. According to the correlations found in this study, between the behaviour aspects and intake of NDF and ADF can support studies aimed to the formulation of diets supplemented based the understanding on behaviour of food intake by animals.

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28 KEYWORDS: cattle, nutrition, production, ingestion

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30 INTRODUCTION

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

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

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

45 Over the last years, the need for further information on adequate
46 nutritional management methods and understanding the feeding behaviour of
47 ruminants has generated investments in researches. The generation of these data
48 shall make it possible to develop correlational studies that, through detailed
49 examination, will enable the selection of behavioural variables to predict the
50 consumption of these animals. By identifying these potential variables, it will be
51 possible to develop predictive models that could accurately estimate the variable

of dry matter intake, which in turn is considered essential in nutrition and performance trials. Thus, the aim of this work was to evaluate the correlation between the variables of behaviour and food consumption by Holstein calves fed pellets and meal.

MATERIAL AND METHODS

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 weighing 27.5 kg, were randomly divided into two treatment groups six 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 lactation and post-lactation). 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.

74

75 The replacer was daily distributed at 7:00 a.m. in five liter plastic buckets,
76 while the concentrate was provided at the same time, in wood-clad plastic
77 buckets. Water was provided ad libitum in full-time available in automatic shell-
78 shaped container. During the first 60 days of age, each animal daily received four
79 kilograms of milk replacer and concentrate ad libitum.

80

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	
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

81 Dry Matter (DM); Crude Protein (CP); Ether Extract (EE); Neutral Detergent Fibre (NDF); Acid

82 Detergent Fibre (ADF)

83 ¹ 91.8% DM of natural matter.

84 ² Ca (233g/kg), P (80g/kg), Mg (5g/kg), Na (48g/kg), Co (25mg/kg), Cu (380mg/kg), I (25mg/kg),
 85 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
 86 vitamin D/kg, 200 mg of vitamin E/kg.

87

88 The amount of concentrate provided was adjusted according to the
 89 previous day's intake, thus allowing an availability rate of 5-10% as leftovers (for
 90 safety). The amount of concentrate provided was daily recorded and the amount of
 91 leftovers was weekly assessed and weighed for every single animal. The animals
 92 were weaned at 60 days of age and then started to be fed two Kg concentrate/day
 93 and hay made from chopped and pre-dried elephant grass (*Pennisetum*
 94 *purpureum*) (*ad libitum*). Hay supply was monitored in order that 5-10% leftovers
 95 were produced. The concentrate feed samples were stored in plastic bags and
 96 shortly thereafter ground in a 1mm mesh sieve for subsequent laboratory analysis
 97 for Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Neutral Detergent
 98 Fibre (NDF) and Acid Detergent Fibre (ADF) (Silva e Queiroz, 2002).

99

100 *Ingestive Behaviour*

101 The animals were subjected to four full-time observation periods (24
 102 hours) by trained observers, for evaluation of their ingestive behaviour , totaling
 103 two days of observation per experimental period (lactation and post-lactation
 104 periods) (Fischer, 1996). In order to determine the time spent on each activity,
 105 data collection was performed using appropriate spreadsheet. At night time,
 106 artificial lighting was used. The animals were simultaneously observed at
 107 intervals of five minutes, during the 24 hour period, totaling 288 daily
 108 observations (Gary et al., 1970) to identify the amount of time allocated to eating,

109 rumination and resting. The collection and processing of data concerning the
 110 efficiency of feeding and rumination (g/h), total chewing time, number of ruminal
 111 boluses, rumination time/bolus and the number of chews per cud/bolus using
 112 digital timers handled by trained observers were carried out according to the
 113 procedures described by (Bürger et al., 2000). Discretization of the time series
 114 was directly made in data collection spreadsheets, including the count of discrete
 115 feeding, rumination and resting periods, as described by (Silva et al., 2003). The
 116 average duration of each discrete period was obtained by dividing the day-time of
 117 every activity by the number of discrete periods.

118

119 *Statistical analysis*

120 Data analysis was carried out with the Pearson's linear correlation
 121 coefficient between the behaviour variables and the DM, NDF and ADF intakes.
 122 The coefficients found had their significance obtained through the Student's t-test
 123 at 5% probability, using the software package Statistical Analysis for Genetic
 124 Epidemiology – SAEG - Federal University of Viçosa (SAEG, 2000).

125

126 RESULTS AND DISCUSSION

127 The variables, rumination and resting are not correlated with DMI
 128 ($P>0.05$). According to (Pinto et al., 2010), the time spent by the animals to rest
 129 and rumination do not interfere in the consumption of dry matter and neutral
 130 detergent fiber, therefore, can not be used as indicators of consumption actual,
 131 indicating that these variables do not correlate. Regarding the intake of NDF and
 132 ADF, these variables ($P<0.05$) showed positive correlation with feeding and
 133 strong positive correlation with rumination and resting (Table 3).

134

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

Behaviour 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

135 Dry Matter (DM); Neutral Detergent Fibre (NDF); Acid Detergent Fibre (ADF)

136

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

141 Regarding the behavioural variables, number feeding periods (NFP) and
 142 number periods of resting (NRP), there was positive correlation with the dry
 143 matter intake variable (DMI) (Table 4).

144 It is therefore possible to associate such occurrence with the dry matter
 145 intake (DMI) that can determine a higher concentration of necessary nutrients to
 146 meet growth needs and this consumption can be related to several factors.
 147 (Mateus et al., 2010), reporting that the level of concentrate used in the diet, may
 148 influence changes in consumption, nutrient digestibility and the performance
 149 parameters.

150

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

Behaviour 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

151

152 The times per feeding (TFP) and rumination period (TRuP) were highly
153 correlated with NDF and ADF intakes (Table 4). Correlations between the TFP
154 and TRuP with the NDF and ADF intake are probably due to the massive rate of
155 passage of forage, whose limitation is the physical effect caused by the high hay
156 NDF content. When high NDF concentrations are present in the diet, the animal
157 tends to have a greater number of meals and consequently there is direct
158 interference in TFP and TRuP expenses for acquiring and breaking food into
159 smaller particles.

160 Moderate and negative correlations were observed between TRP ($r = -$
161 0.58 , $P = 0.00229$) and NDF and ADF intakes. The lower the interest in animals
162 concentrate diet, the greater the consumption of rumination and neutral detergent
163 fiber per unit of time, since in general have a high forage NDF and ADF. The
164 probable explanation for this is that, since the activities are mutually excluding
165 when NDF is increased, the animals have to feed and ruminate for longer periods,
166 which results in a reduction in time per resting period.

167 The efficiency of feeding and rumination of DM was moderately
168 positively correlated with DM (Table 5). As the food was provided in the form of
169 pellets or meal, the observed time of ingestion of the pellets was observed to be
170 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 and efficiency.

The presence of concentrated supplement in animal diet contributes to an increase in efficiency of feeding and efficiency of rumination, (Mendes Neto et al., 2007), report that food concentrates require less time to ruminate forages when compared to the thus animals can ruminate larger amount of dry matter per unit time (kgMS.hora⁻¹).

178

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

Behaviour 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	-	-	-	-

EffeDM = efficiency feeding Dry Matter; EffeNDF = efficiency feeding neutral detergent fiber; EffeADF = efficiency feeding acid detergent fiber; EfruDM = efficiency rumination Dry Matter; EfruNDF = efficiency rumination neutral detergent fiber; EfruADF = efficiency rumination acid detergent fiber.

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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.

190 There was a moderate and positive correlation between dry matter per
 191 ruminated bolus (DM/BOLUS) and dry matter intake (DMI) as shown in Table 6.
 192

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

Behaviour 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 (DM) /bolus, ³ neutral detergent fiber (NDF) /bolus, ⁴ acid

detergent fiber (ADF) /bolus.

193
 194 Considering that the dry matter intake does not fully reflect the amount of
 195 fractions with lower digestibility potential and that it may vary depending on the
 196 levels of non-structural carbohydrates of NDF and ADF levels, dry matter intake
 197 truly do not show a high correlation with the variable under study. Understanding
 198 nutrient intake through the study of behavioural variables would provide less
 199 invasive and stressful solutions. Such information is extremely important for the
 200 traditional nutritional studies, considering that they interfere with the environment
 201 where the animals are raised, causing a series of inconveniences that can disturb
 202 their biological functioning. This study has identified a high positive correlation
 203 between the variables of behavioural aspects such as total chewing time (TMT),
 204 neutral detergent fiber per ruminated bolus (NDF/BOLUS), acid detergent fiber
 205 per bolus (ADF/BOLUS), daily ruminated boluses, time per ruminated bolus,
 206 chews per ruminated bolus and NDF and ADF intakes.

207 The high correlation between these variables shows the strong association
 208 between the behavioural aspects related to food intake. For a long time, many
 209 researchers have put into question the actual usefulness of behavioural studies
 210 related to food intake. The information contained in this publication can
 211 potentially guide innovative researches aimed at the use of behavioural variables
 212 as a tool for guiding the development of new predictive food intake methods for
 213 both confined and in field cattle.

214

215 CONCLUSION

216 According to the correlations found in this study, between the behavioural
 217 aspects and intake of NDF and ADF can support studies aimed to the formulation
 218 of diets supplemented based the understanding on behaviour of food intake and
 219 may cause positive results for animal performance.

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