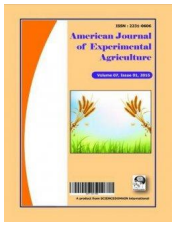

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Correlation between Intake and Feeding Behavior of Holstein Calves Fed Diets Supplemented with Pellets and Mash

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Authors' contributions

This work was carried out in collaboration between all authors. Author RRS Author of the project, collaborated with all stages. Authors ACO and FFDS contributed in the writing. Authors GGPC, FBLM, VVSDA, AAP and JWDS contributed in conducting the experiment and laboratory analysis. Author LBOR contributed in the statistical analysis and translation into English. Authors APGS and MML contributed in writing and correction article. All authors read and approved the final manuscript.

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ABSTRACT

The objective was to evaluate the correlation between behaviour al 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

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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.

Keywords: Cattle; nutrition; production; ingestion.

1. INTRODUCTION

The probability that food is ingested depends on a number of factors inherent to food, animal behaviour and environment [1].

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

Given the above, the intake of forage, milk and supplements by calves should be known through the study of ingestive behaviour in order that the nutritional management can be adjusted; thus, the formulation of more appropriate diets that meet the requirements of animals is needed, considering that it is directly connected with the performance and determines how long the animals will remain at this stage [2].

Over the last years, the need for further information on adequate nutritional management methods and understanding the feeding behaviour of ruminants has generated investments in researches. The generation of these data shall make it possible to develop correlational studies that, through detailed examination, will enable the selection of behaviour al variables to predict the consumption of these animals. By identifying these potential variables, it will be 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.

2. MATERIALS AND METHODS

2.1 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 m^2. 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.

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-shaped container. During the first 60 days of age, each

animal daily received four kilograms of milk replacer and concentrate *ad libitum*.

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.

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

Item	% of drymatter
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

Dry Matter (DM); Crude Protein (CP); Ether Extract (EE); Neutral Detergent Fibre (NDF); Acid Detergent Fibre (ADF), [1] 91.8% DM of natural matter.[2] Ca (233 g/kg), P (80 g/kg), Mg (5 g/kg), Na (48 g/kg), Co (25 mg/kg), Cu (380 mg/kg), I (25 mg/kg), Mn (1080 mg/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). 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 Kg concentrate/day and hay made from chopped and pre-dried elephant grass (*Pennisetum purpureum*) (*ad libitum*). Hay supply was monitored in order that 5-10% leftovers were produced. The concentrate feed samples were stored in plastic bags and shortly thereafter ground in a 1mm mesh sieve for subsequent laboratory analysis for Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) [3].

2.2 Ingestive Behaviour

The animals were subjected to four full-time observation periods (24 hours) by trained observers, for evaluation of their ingestive behaviour, totaling two days of observation per experimental period (lactation and post-lactation periods) [4]. 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, during the 24 hour period, totaling 288 daily observations [5] to identify the amount of time allocated to eating, rumination and resting. The collection and processing of data concerning the efficiency of feeding and rumination (g/h), total chewing time, number of ruminal boluses, rumination time/bolus and the number of chews per cud/bolus using digital timers handled by trained observers were carried out according to the procedures described by [6]. 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 [7]. The average duration of each discrete period was obtained by dividing the day-time of every activity by the number of discrete periods.

2.3 Statistical Analysis

Data analysis was carried out with the Pearson's linear correlation coefficient between the behaviour variables and the DM, NDF and ADF intakes. The coefficients found had their significance obtained through the Student's t-test at 5% probability, using the software package Statistical Analysis for Genetic Epidemiology – SAEG - Federal University of Viçosa [8].

3. RESULTS AND DISCUSSION

The variables, rumination and resting are not correlated with DMI (P>0.05). According to [9], the time spent by the animals to rest and rumination do not interfere in the consumption of dry matter and neutral detergent fiber, therefore, cannot be used as indicators of consumption actual, indicating that these variables do not correlate. Regarding the intake of NDF and ADF, these variables (P<0.05) showed positive correlation with feeding and strong positive correlation with rumination and resting (Table 3).

In line with the results observed in this study according to results found for [10], have evaluated the ingestive behaviour 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 behaviour al variables, number feeding periods (NFP) and number periods of resting (NRP), 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. [11], reporting that the level of concentrate used in the diet, may influence changes in consumption, nutrient digestibility and the performance parameters.

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 passage of forage, whose limitation is the physical effect caused by the high hay 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 lower the interest in animals concentrate diet, the greater the consumption of rumination and neutral detergent fiber per unit of time, since in general have a high forage NDF and ADF. The probable explanation for this is that, since the activities are mutually excluding when NDF is increased, the animals

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

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

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

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 was moderately positively correlated with DM (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 and efficiency.

The presence of concentrated supplement in animal diet contributes to an increase in efficiency of feeding and efficiency of rumination, [12], report that food concentrates require less time to ruminated forages when compared to the thus animals can ruminate larger amount of dry matter per unit time (kgMS.hora-1).

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 [13] 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.

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 do not show a high correlation with the variable under study. Understanding nutrient intake through the study of behaviour al variables would provide less invasive and

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

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	0.000
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

stressful solutions. Such information is extremely important for the traditional nutritional studies, considering that they interfere with the environment where the animals are raised, causing a series of inconveniences that can disturb their biological functioning. This study has identified a high positive correlation between the variables of behaviour al aspects such as total chewing time (TMT), neutral detergent fiber per ruminated bolus (NDF/BOLUS), acid detergent fiber per bolus (ADF/BOLUS), daily ruminated boluses, time per ruminated bolus, chews per ruminated bolus and NDF and ADF intakes.

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

4. CONCLUSION

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 and may cause positive results for animal performance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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