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Feeding behavior of dairy cows in feedlot and fed on crude glycerin levels in the diet

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ABSTRACT. Current experiment evaluated the inclusion effect of crude glycerin levels in the diet on the feeding behavior of confined dairy cows. Fifteen crossbred Holstein x Zebu cows were used, divided into three 5 x 5 Latin squares, with treatments: control (no addition of glycerin) and inclusion of 50, 100, 150 and 200 g crude glycerin per kg of dry matter (DM) in the diet. The animals were subjected to five visual assessments of feeding behavior for 24 hours in each period. Linear increase on feeding time and rumination and on decrease of idle time with the inclusion of crude glycerin levels ($p < 0.05$) was reported. There was a linear effect on consumption of dry matter and neutral detergent fiber (NDF) corrected for ash and protein (NDF); a similar effect was registered for intake and ruminating efficiencies of dry matter and NDF with the inclusion of crude glycerin in the diet ($p < 0.05$). The number of periods and duration of behavioral activities was not affected by the inclusion of crude glycerin ($p > 0.05$). Crude glycerin did not drastically affect the feeding behavior of dairy cows.

Keywords: feeding, visual assessment, feed efficiency, leisure, rumination.

Comportamento ingestivo de vacas leiteiras confinadas com níveis de glicerina bruta na dieta

RESUMO. Objetivou-se avaliar o efeito da inclusão de níveis de glicerina bruta na dieta sobre o comportamento ingestivo de vacas leiteiras confinadas. Foram utilizadas 15 vacas mestiças Holandês x Zebu, distribuídas em três quadrados latinos 5 x 5, nos tratamentos: controle (sem inclusão de glicerina); inclusão de 50, 100, 150 e 200 g de glicerina bruta por kg de matéria seca (MS) da dieta. Os animais foram submetidos a cinco avaliações visuais do comportamento ingestivo, durante 24h, em cada avaliação. Foi observado aumento linear sobre os tempos de alimentação e ruminação e decréscimo do tempo de ócio com a inclusão dos níveis de glicerina bruta ($p < 0,05$). Houve efeito linear decrescente sobre o consumo de matéria seca e fibra em detergente neutro corrigida para cinzas e proteína (FDNcp), o mesmo efeito foi observado para as eficiências de alimentação e ruminação da matéria seca e da FDNcp com a inclusão da glicerina bruta na dieta ($p < 0,05$). O número de períodos e o tempo de duração das atividades comportamentais não foram afetados pela inclusão da glicerina bruta ($p > 0,05$). A glicerina bruta não afetou drasticamente o comportamento ingestivo das vacas leiteiras.

Palavras-chave: alimentação, avaliação visual, eficiência alimentar, ócio, ruminação

Introduction

Feeding behavior is a highly relevant tool to evaluate diets since it provides feed management of animals for a better production and reproduction performance (CAVALCANTI et al., 2008). Daily activities are characterized by three basic types of behavior: feeding, rumination and idleness, and their duration and distribution may be affected by diet, management, climatic conditions and activities of the animals in the herd (FISCHER et al., 1997). Intake of dairy cows is affected by the type of feed and diet with alterations on production levels, fertility rates and feed behavior.

According to Mertens (1994), animal performance is determined by nutrient intake, digestibility and metabolism. Intake may be affected by factors linked to feed, such as taste, texture, visual aspect and such factors as emotional state, interactions and learning. According to Costa et al. (2011), within conditions of non-competitive feed with regard to confined animals where no restriction exists with regard to feed quantity provided, the feeding and rumination time is affected by food characteristics, mainly its cell wall rates. Intake behavior may influence food digestion and rate through the gastro-intestine tract. On the other hand, the animals may change their feeding behavior and modify one or two of its components to overcome the consumption-limiting conditions and obtain the amount of required nutrients (ROCHA NETO et al., 2012).

As other species, ruminants adjust feed intake to their nutritional needs, especially in the case of energy (VAN SOEST, 1994). Confined animals spend approximately one hour to intake energy-rich feed or more than six hours on low-energy feed. Similarly, rumination time is affected by the type of feed and is probably proportional to the roughage cell wall rate (MENDONÇA et al., 2004).

Supplementation has been based on the use of drought-adapted forage resources, co-products and wastes of the local agro-industry and concentrated feed. Among the alternative feeds for the animal, crude glycerin is becoming a highly promising alternative. Due to its energy similarity with corn, several studies on the subject have been undertaken (DONKIN, 2008). The effects of the inclusion of crude glycerin levels in the diet on the feeding behavior of confined dairy cows have been evaluated.

Material and methods

Current experiment was performed on the Paulistinha Farm, Macarani BA Brazil, with 15 half-breed Dutch x Zebu dairy cows (degree varying between ½ and ¾ D x Z), third or fourth lactation order, with a mean milk production adjusted to 300 lactation days, previously between 3,000 and 4,000 kg. Dairy cows were also selected for lactation days between 80 and 120 days, at the start of the experimental period. Five of the cows were equipped with ruminal fistulas. The fifteen milk cows were distributed into three 5 x 5 squares, with the following treatments: 0 = control (without inclusion of crude glycerin in the diet); 50 = inclusion of 50 g of crude glycerin kg^{-1} of DM of the diet; 100 = inclusion of 100 g of crude glycerin kg^{-1} of DM of the diet; 150 = inclusion de 150 g of crude glycerin kg^{-1} of DM of the diet; 200 = inclusion de 200 g of crude glycerin kg^{-1} of DM of the diet.

Roughage used was derived from sugar cane (*Saccharum officinarum*), RB 72454, treated with 10 g kg^{-1} of DM of a mixture of urea and ammonium sulfate (9:1 pp) during the experimental phase. In a 7-day period before the start of the experiment, cows were fed on roughage with only 5 g of urea mixture so that they could adapt themselves to the roughage and avoid possible intoxication.

The volume:concentrate ratio (Table 1) was defined by the equilibrium of diets to contain sufficient nutrients to maintain body weight gain at 0.15 kg day^{-1} and production at 15 kg de milk day^{-1}, following NRC (2001), based on data from the chemical composition of sugarcane, maize, soy meal and crude glycerin, performed a week before the experimental period.

Table 1. Proportions of ingredients in the diets (g kg^{-1}).

Feed	Glycerin levels (g kg^{-1} DM)				
	0	50	100	150	200
Sugarcane	606.1	615.8	620.8	628.2	635.1
Ground corn grains	263.9	197.1	134.2	71.8	10.9
Crude glycerin	0.0	47.6	94.8	140.2	184.7
Soybean meal	111.5	121.0	131.6	141.3	150.7
Mineral salt	8.7	8.5	8.3	8.2	8.4
Bicalcium phosphate	5.9	6.5	6.8	7.4	7.7
Clacitric limestone	3.9	3.5	3.4	3.0	2.6

[1]Composition: Calcium 200 g; Cobalt 200 mg; Copper 1.650 mg; Sulfur 12 g; Iron 560 mg; Fluor (max.) 1.000 g; Phosphorus 100 g; Iodine 195 mg; Magnesium 15 g; Manganese 1.960 mg; Nickel 40 mg; Selenium 32 mg; Sodium 68 g; Zinc 6,285 mg.

The animals were placed in covered individual 16 m^2 pens, with concrete feed trough and a 200 L water trough for the two pens. Feed was provided *ad libitum* in a complete mixture, twice a day, at 7:00 am and 3:00 pm, so that a 5% excess could be obtained.

The experiment started on the 19th July 2011 and consisted of five experimental periods with 15 days each. The adaptation period comprised the first 10 days. Collection of roughage and supplements was done at each experimental period to evaluate its chemical composition (Table 2).

Table 2. Chemical composition of sugarcane and experimental diets.

Components (g kg^{-1} DM)	Sugarcane + Urea	Glycerin levels				
		0	50	100	150	200
Dry matter	300.5	527.4	509.5	501.1	488.8	477.9
Organic matter	965.8	948.3	937.3	938.2	937.1	934.7
Crude protein	132.6	152.1	152.2	153.9	155.0	159.5
Ether extract	12.0	20.9	30.8	43.8	59.2	70.1
Neutral detergent fiber[cp]	506.2	388.7	384.4	376.0	380.8	374.4
Acid detergent fiber	298.2	209.7	210.9	213.2	213.8	215.6
Non-fibrous carbohydrates	409.1	451.7	427.9	424.4	401.1	390.4
Total digestible nutrients[1]	555.0	735.1	742.1	749.2	756.2	763.3
Mineral matter	34.2	51.7	62.7	61.8	62.9	65.3

[1]Sugarcane was estimated following Cappelle et al. (2001).

Crude glycerin was provided by the firm Comanche Biocombustíveis da Bahia Ltda (Simões Filho, Bahia State, Brazil), at each experimental period, to evaluate rates of methanol and glycerol, their chemical composition, and fatty acids (Table 3).

Table 3. Chemical composition of crude glycerin.

Components	Glycerin
Methanol (% DM)	5.73
Glycerol (% DM)	51.84
DM (%)	90.00
OM (% DM)	93.00
CP (% DM)	0.0001
Lipids (% DM)	36.70
Fatty acids	
Saturated (% lipids)	27.07
Polyunsaturated (% lipids)	47.93
Monounsaturated (% lipids)	25.00

Environmental variables of temperature and rainfall (Table 4) were registered during the experimental period by the meteorological station on the experimental area.

Table 4. Mean temperature, mean maximum (TMAX) and minimum (TMIN) temperatures and total rainfall for each month, during the experimental phase.

Variables	Month		
	July	August	September
TMAX (°C)	28.38	31.42	33.60
TMIN (°C)	18.05	17.51	16.38
Mean (°C)	23.65	26.01	25.88
Rainfall (mm)	19.7	3.0	3.9

Feed provided and surplus were weighed from the 11^{th} to the 15^{th} day of the experimental period to calculate intake and obtain samples for the chemical analyses. At the end of the experimental period, samples were pre-dried and ground in 1 mm sieve mills, conditioned in previously labeled plastic pots with lids, and stored for later analyses of dry matter and neutral detergent fiber corrected to ashes and protein, following method by Silva and Queiroz (2002).

The animals were periodically evaluated with regard to their feeding behavior during a 24 hours period, on the 15^{th} day of each period. Activities were reported at intervals of 5 min., following Gary et al. (1970). On the following day, the number of cud-chewing and the time spent in the rumination of each ruminal cake were undertaken by digital chronometer. Three ruminal cakes in all the experimental animals were evaluated at three different periods of the day (10-12; 14-16 and 19-21 hours), following methodology by Bürger et al. (2000). Artificial illumination was maintained during the evening observation of the animals.

Food efficiency (FE), rumination efficiency (RE), number of ruminal cakes per day (NRC), total chewing time per day (TCT) and the number of cud-chewing per day (NCC) were obtained following method by Bürger et al. (2000).

Voluntary intake of DM and NDF_{cp} were used to evaluate feed and rumination efficiencies with regard to the quantity of DM and NDF grams per unit of time and feed period. The number of ruminated meal cakes per day was obtained by dividing total rumination time (in min.) by the mean time spent in the rumination of each meal cake.

Feed and rumination efficiency was obtained as follows:

FE = DIDM/FT
FENDFcp = INDFcp/FT
RT = DIDM/RT
RENDFcp = INDFcp/RT

where:
FE = feeding efficiency;
DIDM = daily intake of dry matter (grams of DM);
FT = feed time (hours);
FENDFcp = feeding efficiency of NDFcp;
INDFcp = daily intake of NDFcp (grams of NDFcp);
RT = rumination time (hours);
RENDFcp = rumination efficiency (grams of NDFcp).

Experimental variables were evaluated by analysis of variance and analysis of regression with SAEG 9.1. Statistical models were chosen according to the significance of regression coefficients with test f at 5%, and determination coefficient (R^2), with the biological phenomenon under analysis.

Results and discussion

The inclusion of crude glycerin in the diets (Table 5) affected time spent on feed, rumination and idleness ($p < 0.05$). Feed and rumination time had an increasing linear effect ($p < 0.05$), 0.018 and 0.045 hour, respectively, for each glycerin unit added to the diet. Expected effect was similar to DIDM with linear decrease. The less the intake, the less feed and rumination time spent. However, the animals which received higher rates of crude glycerin showed satisfaction due to the great amount of volatile fatty acids immediately available in the rumen, promoted by glycerol metabolism and, consequently, increase in feed and rumination time. According to Trabue et al. (2007), glycerin as a replacement of maize as energy source may change feed behavior since the animals require more time to consume feed when compared to time spend on diets without glycerin. High glycerin levels decrease the population of ruminal microorganisms and, consequently, fiber digestibility. The above may explain increase in feed and rumination time. Polli et al. (1996) reported that the distribution of rumination activity is greatly affected by feed since rumination occurs immediately after the feed period when the animal is calm.

Table 5. Behavioral activities of dairy cows fed on different glycerin levels in the diet.

Activity	Glycerin level (g kg^{-1} MS)					Eq.[1]	CV[2]	P[3]
	0	50	100	150	200			
Feed (hours)	5.84	5.73	5.59	6.11	6.12	4	9.52	0.0497
Rumination (hours)	7.98	8.31	8.45	8.08	9.22	5	12.14	0.0145
Idleness (hours)	10.25	10.04	10.03	9.88	8.74	6	11.30	0.0038

[1]Equations of regression. [2]Coefficient of variation (%). [3]Probability of error; [4]Y = 5.682+0.018x. R^2 = 0.41; [5]Y = 7.958+0.045x. R^2 = 0.52; [6]Y = 10.42-0.063x. R^2 = 0.70.

Time spent in idleness had a decreasing linear effect, with a decrease of 0.063 hour for each glycerin unit added ($p < 0.05$). The above effect may be due to the increase reported in feed and rumination times which, as a consequence, provided a decrease in the time spent in idleness in proportion to the amount of glycerin included in the diet.

There was a linear decrease ($p < 0.05$) in DIDM and INDFcp as glycerin was included in the diet (Table 6). DIDM may have caused such an effect due to the great glycemic volume provided by a great amount of propionate available for ruminal fermentation in treatments with high glycerin levels. The above factor is directly related to ruminants´ intake regulation processes.

According to Trabue et al. (2007), when glycerin intake is high, it may inhibit food intake by animals at a certain instance due to the amount of energy provided to the animal by fast fermentation of glycerol in volatile fatty acids. The lack of fiber in crude glycerin composition may explain the decrease of 0.044 kg for the intake of NDFcp as glycerin is introduced in the diet.

Effects reported for the feeding efficiency of dry matter (FE), the feeding efficiency of corrected neutral detergent fiber (FENDFcp), the rumination efficiency of dry matter (RE) and the rumination efficiency of corrected neutral detergent fiber (RENDFc) decreased linearly ($p < 0.05$), following the same trend as DIDM and INDFp, respectively with a decrease of 26.4; 11.0; 20.8 and 8.2 g $hours^{-1}$.

The above shows a deep relationship between the evaluated variables and the influence of the inclusion of crude protein on the variables which decreased as glycerin was added. Efficiency probably decreased due to the reduction of fiber rate in the diets. In fact, glycerin does not have any fiber. According to Van Soest (1994), feed efficiency with which the animal takes food is related to the time spent in feed intake and to the specific weight of the feed consumed. Silva et al. (2005) stated that feed efficiency depended on the variation size of the diet´s fiber components and the efficiency of feed rumination is affected positively by increasing dry matter in the diet. Costa et al. (2011) reported a linear increase ($p < 0.05$) for feed and rumination efficiency and justified results because of increase in DM and NDF.

In their research on different NDF rates in the diet, Pereira et al. (2007) reported that FE was low when NDF rates were high in the diet, whereas Carvalho et al. (2012) in their research on total replacement of corm by 10.8% glycerin in the diet for cows during the post-partum period registered an increase in feed efficiency during certain periods of the day without affecting the intake of dry matter. Above data disagree with those of current study in which the effect of the co-product under analysis on the variables was registered, with less efficiency for diets with less fiber rates in their composition.

Glycerin inclusion effect on the number of ruminated cakes per day (NRC) with mean rate 524.19; number of chewing per ruminated cake (NCc), with mean rate 59.25 and time spent per ruminated cake (TRC), with mean rate 59.79, for glycerin levels under analysis ($p > 0.05$) was not reported. Glycerin levels in the diet did not affect these parameters even though rumination time (Table 5) had an increasing linear effect. The above was probably due to the difference in the coefficients of variation.

Table 6. Intake, parameters of feed and cud-chewing efficiency of dairy cows fed on different glycerin levels in the diet.

Intake	Glycerin levels (g kg^{-1} DM)					Eq.[1]	CV[2]	P[3]
	0	50	100	150	200			
DIDM (kg dia^{-1})[15]	14.62	13.79	14.54	13.36	12.21	4	10.90	0.0002
INDFcp (kg dia^{-1})[16]	5.39	5.01	5.22	4.81	4.38	5	12.44	0.0005
Food efficiency								
FE (g MS h^{-1})[17]	2550.00	2450.00	2630.00	2210.00	2010.00	6	14.91	0.0001
FENDFcp (g NDF_C h^{-1})[18]	940.00	890.00	940.00	800.00	710.00	7	16.02	0.0001
RE (g DM h^{-1})[19]	1850.0	1730.0	1760.0	1710.0	1340.0	8	16.40	0.0001
RENDFc (g FDN_C h^{-1})[20]	680.00	620.00	630.00	610.00	480.00	9	17.21	0.0001
Chewing and Rumination								
TCT (h day^{-1})[21]	13.82	14.03	14.05	14.18	15.33	10	7.76	0.0038
NCR (nº day^{-1})[22]	479.42	526.23	547.45	509.26	558.60	11	18.19	0.0808
NCd (nº day^{-1})[23]	2855.71	29925.92	30426.19	29426.32	33210.26	12	14.06	0.0347
NCc (nº $cake^{-1}$)[24]	59.58	58.03	57.26	58.12	63.28	13	17.06	0.5024
TRC (s $cake^{-1}$)[25]	60.99	58.71	57.62	57.94	63.71	14	16.40	0.4067

[1]Equations of regression; [2]Coefficient of variation (%); [3]Probability of error; [4]Y = 14.75 - 0.104x; R^2 = 0.71; [5]Y = 5.414 - 0.044x; R^2 = 0.81; [6]Y = 2634.0-264x; R^2 = 0.66; [7]Y = 966.0-11x; R^2 = 0.75; [8]Y = 1886.0-20.8x; R^2 = 0.71; [9]Y = 686.0-8.2x; R^2 = 0.76; [10]Y = 13.65 + 0.063x; R^2 = 0.70; [11]Y =524.19; [12]Y = 28367+188.1x; R^2 = 0.65; [13]Y =59.25; [14]Y =59.79; [15]DIDM – intake of dry matter; [16]INDFcp – intake of fiber in neutral detergent fiber corrected for ashes and protein; [17]FE – feed efficiency of dry matter; [18]FENDFcp – feed efficiency of corrected neutral detergent fiber; [19]RE – rumination efficiency of dry matter; [20]RENDFcp – rumination efficiency of corrected neutral detergent fiber; [21]TCT – total chewing time; [22]NCR – number of cakes ruminated per day; [23]NCd – number of chewings per day; [24]NCc – number of chewings per cake; [25]TRC – time spent per ruminated cake.

Results agree with those by Mendonça et al. (2004); Pereira et al. (2007) and Costa et al. (2011) who failed to report any significant effect in treatments on NRC and TRC. These studies do not differentiate treatments by similarity in the time spent in rumination or rumination per cake. Santana Júnior et al. (2013) reported that there was no glycerin inclusion influence in the diet (0, 45, 90, 135 and 180 g kg^{-1}) on the time spent with ruminated cake (TRC), the number of cud-chewing/ruminated cake (NCc) and the amount of cakes ruminated per day (NRC) by dairy cows.

Total chewing time (TCT) and the number of chewing per day (NCD) were affected by treatments, with a linear increase for each unit of crude glycerin added to the diet ($p < 0.05$). The above effect may be due to increase in rumination and feeding time (Table 5) and to the low quality of roughage fiber (sugarcane). In their research with glycerin inclusion levels 0, 45, 90, 135 and 180 g kg^{-1}, Santana Júnior et al. (2013) did not report any difference in TCT with the insertion of glycerin in the diet, perhaps due to the absence of the effect in rumination and feeding time.

The inclusion of crude glycerin in the diet (Table 7) did not affect ($p > 0.05$) the number of feeding (NFP), rumination (NRP) and idleness (NIP) periods, respectively with mean 14.78, 18.35 and 25.25; and the time spent feeding (TF), ruminating (TR) and in idleness (TI), respectively with mean 0.42, 0.47 and 0.40.

According to Rook (2000) and Mezzalira et al. (2011), the number of feeds and their duration are directly related, probably due to the animals´ feeding habits. In other words, depending on the diet, the difference in time spent on feed or rumination, the number of periods and time spent per period in these activities may be similar when diets are provided homogenously and at the same time of the day. Mendes Neto et al. (2007) reported that changes in timetable or in the frequency of providing feed to the animal may change the percentage distribution of feeding times in confined animals. In fact, current study did not register any difference in the number of feed, rumination and idleness periods since diets were strictly provided daily at 7 and 15 hours.

Table 7. Number of periods and duration time of behavior activities of dairy cows fed on diets with different glycerin levels.

Behavioral activities	Glycerin levels (g kg^{-1} MS) 0	50	100	150	200	Eq.[1]	CV[2]	P[3]
NFP (no.)[4]	14.66	14.06	14.20	16.46	14.53	Y=14.78	16.30	0.5901
NRP (no.)[5]	18.00	17.66	18.00	18.20	19.93	Y=18.35	13.70	0.1204
NIP (no.)[6]	25.06	25.13	24.40	26.13	25.53	Y=25.25	12.40	0.6473
TFP (hour)[7]	0.40	0.41	0.39	0.37	0.42	Y=0.42	19.20	0.1396
TRP (hour)[8]	0.44	0.47	0.47	0.44	0.46	Y=0.47	13.60	0.7035
TIP (hour)[9]	0.41	0.40	0.41	0.38	0.34	Y=0.40	22.44	0.0627

[1]Equation of regression; [2]Coefficient of variation (%); [3]Probability of error; [4]NFP – number of feeding periods; [5]NRP – number of rumination period; [6]NIP – number of idleness periods; [7]TFP – time per feeding period; [8]TRP – time per rumination period; [9]TIP – time per idleness period.

Conclusion

Crude glycerin did not affect drastically the feed behavior of dairy cows. The recommendation of the use or not of crude glycerin depends on its effects on milk production.

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