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Glycerin levels for crossbred heifers supplemented in pasture: intake behavior

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ABSTRACT. The effect of glycerin inclusion on the intake behavior of heifers was analyzed. During the 102-day experimental period, thirty-six 13-month old heifers, average initial weight 226±12 kg, were distributed in a completely randomized design with four treatments and nine replications: G0.0 = control, G2.8 = 2.8%, G6.1 = 6.1%, and G9.1 = 9.1% glycerin in DM intake. Intake behavior was undertaken by monitoring animal activities for 24 hours every five minutes. The inclusion of glycerin in the diet resulted in a linear decrease in grazing time, linear increase in idle time and quadratic effect on trough time. Moreover, glycerin inclusion did not affect the number of grazing and rumination periods. The number of idle periods showed a quadratic effect, whereas trough period decreased linearly with increasing glycerin. Glycerin did not affect grazing time and rumination period. Idle time increased linearly with increasing glycerin in the diets. Time had a quadratic effect and feeding and total chewing time showed a linear decrease with glycerin inclusion in the diets.

Keywords: additives, alternative foods, animal behavior, ruminants.

Níveis de glicerina para novilhas mestiças suplementadas a pasto: comportamento ingestivo

RESUMO. O experimento foi realizado para estudar a inclusão de glicerina sobre o comportamento ingestivo de novilhas. O período foi de 102 dias. Foram utilizadas 36 novilhas com peso inicial médio de 226 + 12 kg e 13 meses de idade, distribuídas em delineamento inteiramente casualizado com quatro tratamentos e nove repetições: G0,0 = controle; G2,8 = 2,80%; G6,1 = 6,10% e G9,1 = 9,10% de glicerina na MS ingerida. O comportamento ingestivo foi acompanhado pelas atividades dos animais durante 24h a cada 5 min. A inclusão de glicerina na dieta das novilhas determinou a redução linear no tempo de pastejo, aumento linear no tempo de ócio e efeito quadrático no tempo de cocho. Ainda, não alterou o número de período em pastejo e ruminação. O número de período em ócio mostrou efeito quadrático. O período de cocho mostrou redução linear com o aumento de glicerina. A glicerina não alterou o tempo por período de pastejo e ruminação. O tempo de período de ócio aumentou de forma linear com aumento da glicerina. O tempo de alimentação e de mastigação total mostrou redução linear com inclusão de glicerina.

Palavras-chave: aditivos, alimentos alternativos, comportamento animal, ruminantes.

Introduction

Intake of animal forage in pasture is affected by three groups of factors, or rather, those that influence the digestion process, those that influence the intake process and those that influence nutritional requirements and nutrient supply (PRADO; MOREIRA, 2002; BERCHIELLI et al., 2006). Moreira et al. (2003) report that one of the issues in heifer breeding in pasture consists of variations in the quantity and in the quality of dry matter, with negative results in animal productivity.

Supplementation in pasture is one of the main economical viable alternatives in the production of beef cattle in natural or cultivated pasturelands (PRADO; MOREIRA, 2002). During the months in which forage is scarce, supplementation in pasture provides higher weight gain per animal and area (MOREIRA et al., 2004).

Consequently, one of the principal aims of the entire cattle production system in pasture is the supplementation of the animals' nutritional requirements throughout the year, coupled to a permanent and sufficient supply in quantity and quality to obtain a satisfactory production response (PARDO et al., 2003). According to Chacon and Stobbs (1976), a decrease in forage availability and changes in plant structure may occur in rotation pasture affected by middle and high pasturing. This fact may modify intake behavior and, therefore, animal production. According to Forbes (1988), ruminants may modify one or more intake behavior components to minimize the effects of unfavorable feed conditions and thus supply their nutrition requirements for production maintenance. Supplementation effects on feed intake may be additive when supplement intake is aggregated to the animals' current intake, or substitutive when supplementation intake decreases forage consumption without any improvement in animal performance (BARBOSA et al., 2001).

Supplementation intake changes ruminants' intake behavior in the pasture (MARQUES et al., 2005). Better efficiency in the use of energy from forage may occur when some parts of the required nutrients are supplied by supplementation intake, due to better conditions in rumen microbiota activities (SILVA et al., 2005). Consequently, a decrease in pasture time, an increase in idle and rumination time and an improvement in feed intake by animals may occur. On the other hand, supplement quality may change the intake behavior and determine more or less pasture, idle and rumination time. As a rule, protein supplementation is supplied during the winter and energy supplementation increases production costs due to the energy sources' economic value.

The use of glycerin as a corn substitute, an energy source, determines fast rumen fermentation (TRABUE et al., 2007) which modifies intake behavior to the point that animals require more time to consume feed when compared to glycerin-less diets.

Current experiment evaluates the effects of glycerin inclusion levels in the supplementation of crossbreed heifers in *Brachiaria brizantha* cv. Marandu pastures with regard to their intake behavior.

Material and methods

The experiment was undertaken on the farm Princesa do Mateiro in the municipality of Ribeirão do Largo, Bahia State, Brazil between September and December 2009. The first 14 days of the 102-day experimental period was an adaptation period to the experimental diets and management. The experimental area was divided into ten enclosures with approximately 1.8 ha each, with a total of 18 ha of *Brachiaria brizantha* cultivar Marandu pasture.

Thirty-six crossbreed 13-month old heifers, mean initial weight 226 ± 12 kg were distributed in a totally randomized design, with four treatments and nine repetitions: G0.0 = control, G2.8 = 2.8%, G6.1 = 6.1% and G9.1 = 9.1% of glycerin in total dry matter of the diet. Supplement was placed once a day (10h) in a lidless plastic trough.

Daily supplement quantity given to heifers for each treatment was the sum of quantities that should be given to each animal, since they were fed in groups. Table 1 shows the dry-matter based percentage composition of the supplements. Glycerin had 16% methanol and the latter's elimination occurred when it was heated at 75ºC, previous to its mixture to diets.

Table 1. Percentage composition of concentrates.

Ingredients (%)	Glycerin levels (% of DM)			
	G0.0	G2.8	G6.1	G9.1
Ground maize	80.50	74.84	68.38	61.52
Soybean meal	16.00	17.67	20.09	22.78
Urea	2.00	2.09	2.17	2.29
Mineral salt[1]	1.50	1.55	1.62	1.71
Bicalcium phosphate	0.00	0.52	1.08	1.13
Lime	0.00	0.00	0.00	0.58
Glycerin	0.00	3.33	6.66	9.99

[1]Guarantee levels (per kg): calcium - 175 g; phosphorus – 100 g; sodium – 114 g; selenium – 15 g; magnesium – 15 g; zinc – 6.004 mg; manganese – 1.250 mg; copper – 1.875; iodine – 180 mg; cobalt – 125 mg; selenium – 30 mg; fluorine (maximum) – 1.000 mg.

Table 2 provides the chemical composition of *Brachiaria brizantha* and diets.

Table 2. Chemical composition of *Brachiaria brizanta* cv. Marandu and concentrates (% DM), total availability of dry matter, residual biomass, allotment rate, accumulation rate and forage supply.

Ingredients	*Brachiaria brizantha*	Glycerin levels, % DM			
		G0.0	G2.8	G6.1	G9.1
Dry matter (%)	90.16	91.66	92.37	91.83	92.23
Crude protein (%)	5.62	21.07	22.13	23.27	24.65
Ethereal extract (%)	1.20	2.47	2.72	2.79	2.82
Total carbohydrates (%)	84.30	72.80	71.00	68.92	66.70
Non-fiber carbohydrates (%)	19.13	58.90	57.33	55.50	53.42
Crude energy (kcal kg^{-1})	4224.56	4305.15	4242.60	4234.65	4197.13
Neutral detergent fiber (%)	66.52	13.90	13.67	13.42	13.28
Acid detergent fiber (%)	40.51	3.59	3.79	3.92	4.17
Total digestible nutrients (%)	51.02	63.68	60.58	61.38	61.38
Ashes (%)	8.87	3.66	4.15	4.99	5.82
Total availability of DM (kg ha^{-1})	3103.54	-	-	-	-
Residual biomass (kg DM ha^{-1} day^{-1})	110.84	-	-	-	-
Allotation rate (AU ha^{-1})	1.33	-	-	-	-
Accumulation rate (kg DM ha^{-1} day^{-1})	27.71	-	-	-	-
Forage supply (kg DM 100 kg LW^{-1} day^{-1})	23.19	-	-	-	-

Heifers were weighed at the start and finish of the experiment. Every 28 days intermediate weighing was undertaken for mean daily gain of live weight so that diet could be adjusted accordingly.

Pasture was evaluated every 28 days and space allotment (SA) was calculated according to animal unit (AU) calculated at 450 kg LW. The following formula was used: SA = (AUt)/area = space allotment in AU/ha, where AUt = total animal unit; Area = total experimental area in ha. Twelve enclosure samples were delimited, cut close to the ground, in a 0.25 m^2 square, according to methodology by Wilm et al. (1944), so that DM availability could be estimated. The viable allotment method with the same animal load was adopted. Ten 1.8 ha enclosures were used. Heifers remained in each enclosure during 7 days and then transferred to another within a randomized pre-established scheme so that the effect of biomass variation among enclosures could be reduced.

Intake behavior was evaluated in October 2009 by following the animals' activities through continuous reports at every 5 minutes during 24h, according to methodology by Bürger et al. (2000). Time spent by animal in pasture, rumination, idle and trough (min. day^{-1}) activities was reported. Number of pasture periods (NPP) is the number of times the animal returns to pasture activities during the day. The number of rumination periods (NRP) is the number of times the animal returns to rumination during the day. The number of idle periods (NIP) is the number of times the animal return to idle activities during the day, whereas the number of trough periods (NTP) is the number of times the animal returns to feed from the trough during the day. Time per pasture period (TPP) = pasture time (min. day^{-1})/NPP, whereas time per rumination period (TRP) = rumination time (min. day^{-1})/NRP. Time per idle period (TIP) = idle time (min. day^{-1})/ NTP. Total feeding time (TFT, min. day^{-1}) = pasture time (min. day^{-1}) + trough time (min. day^{-1}). Total chewing time (TCT) = pasture time (min. day^{-1}) + rumination time (min. day^{-1}) + trough time (min. day^{-1}). Time per ruminated cake (TRC, sec. $cake^{-1}$) is the time spent by the animal to chew each cake after regurgitation.

Number of chews per cake (TRC, n $cake^{-1}$) is the number of times that the cake is chewed after regurgitation, TRC (n $cake^{-1}$) = total rumination time (sec/day)/ chewing time per cake (sec. $cake^{-1}$). Feeding efficiency of dry matter (g of DM $min.^{-1}$) = intake of DM (g day^{-1})/ TFT (min. day^{-1}); rumination efficiency of dry matter (g of DM $min.^{-1}$) = intake of dry matter (g day^{-1})/total rumination time (min. day^{-1}); feeding efficiency (g of FND $min.^{-1}$) = FND intake (g day^{-1})/TFT (min. day^{-1}); rumination efficiency of FND (g of FND $min.^{-1}$) = FND intake (g day^{-1})/total rumination time. Dry matter per ruminated cake (DMC, g DM $cake^{-1}$) = dry matter intake (g day^{-1})/NRC. Mean chewing number per ruminal cake (MBOL), mean time spent per rumination of each cake (TRC) and the number of ruminated cakes (NRC) were obtained by nine rates per animal, registered by digital chronometers, according to methodology by Bürger et al. (2000).

Results were statistically interpreted by regression equations using SAS (2002).

Results and discussion

Daily intake of total dry matter (6.2 kg day^{-1}) and the intake of dry matter for 100 kg of live weight (2.3%) were similar ($p > 0.05$) among treatments (Table 3).

Above results occurred because diets were formulated for the specific needs of growing heifers (NRC, 2000) for a mean daily gain of 0.70 kg day^{-1}, coupled to a limited quantity of concentrate (0.8% live weight) for heifers. According to Parsons et al. (2009), the inclusion of small amounts of glycerin (up to 5% in the diet) may be beneficent for animal growth. However, higher concentration than 5% may disturb rumen microbiota. Mach et al. (2009) similarly reported intake of matter at 8.18; 8.19; 8.53 and 8.19 kg day^{-1} for confined heifers fed at 0, 4, 8 and 12% glycerin levels, respectively.

Glycerin inclusion in heifer diet determined the linear decrease ($p < 0.05$) in grazing time (Table 4). Decrease in grazing time may be due to the metabolic route that glycerin develops in the rumen. Glycerin in the rumen is transformed into volatile fatty acids (VFAs) by bacteria.

Table 3. Food intake with respective regression equations and coefficients of determination (R^2).

Parameters	Glycerin levels, % ingested DM				Regression equation	CV(%)	R^2
	G0.0	G2.8	G6.1	G9.1			
ITDM (kg day^{-1})	6.47	6.43	5.89	5.99	$\hat{Y} = 6.20$	17.34	0.32
ITDM (% LW)	2.43	2.44	2.25	2.14	$\hat{Y} = 2.31$	14.12	0.26
FIND (kg day^{-1})	2.48	2.22	2.11	2.15	$\hat{Y} = 2.24$	21.84	0.28

Intake of total dry matter (ITDM), ITDM (% of LW), fiber in total neutral detergent (FTND), digestible energy (DE).

Table 4. Grazing, rumination, idle and trough time (minutes) with their respective regression equations and coefficients of determination (R^2).

Item	Glycerin levels (% of DM)				Regression equation	R^2	CV (%)
	G0.0	G2.8	G6.1	G9.1			
Grazing	457.78	430.00	429.44	377.22	$\hat{Y} = 459.944 - 7.274x$	0.86	7.33
Rumination	392.78	375.00	375.89	387.78	$\hat{Y} = 382.86$	0.21	7.40
Idle	520.56	575.00	547.22	623.33	$\hat{Y} = 524.44 + 8.425x$	0.68	6.87
trough	68.89	68.89	87.44	51.67	$\hat{Y} = 65.244 + 7.064x - 0.807x^2$	0.59	13.46

When glycerin intake is high, food intake may be inhibited for a certain period owing to the amount of energy given to the animal by fast fermentation of glycerin up to VFAs (TRABUE et al., 2007). VFAs in the ruminal liquid and then in the blood inhibit food intake. This fact may have determined decrease in pasture intake (BERCHIELLI et al., 2006).

On the other hand, glycerin levels in heifer diets did not have any effect ($p > 0.05$) on rumination time (Table 4). Decrease of grazing time due to glycerin levels in diets did not affect rumination time. As a rule cattle rumination is influenced by fiber rates in the diets. Maximum level for glycerin addition in heifers' diet decreased fiber intake only slightly (a decrease from 2.48 to 2.15 of FND per day for 0 and 9.1% glycerin levels in total diet). Silva et al. (2005) reported that rumination time was not influenced by supplementation levels of cattle in pasture. Similarly, the addition of glycerin in diet did not decrease intake of pasture (3.90 and 3.42 kg DM day^{-1} for glycerin levels 0 and 9.1%).

Inversely to what occurred in grazing time, idle time had an increasing linear behavior ($p > 0.05$) since these behavior activities were mutually excluding. Silva et al. (2005) reported a decreasing linear effect on daily idle time and attributed to a trough time increase without altering the grazing time, which may later be compensated at night with a more extensive idle time. Results agree with those registered by Pardo et al. (2003) who reported less rest time for non-supplemented animals. The above authors concluded that this type of behavior was due to less grazing time and probably to a less forage intake by supplemented animals, especially at higher supplementation levels. Fischer et al. (2002) reported that animals supplied with 0 and 1% LW in concentrates were idle at a mean period of 157 and 210 min., respectively.

Time spent at the trough had a quadratic effect ($p < 0.05$) with a peak at 4.38% glycerin in the diet (Table 4). It seems that low glycerin levels in the diet (up to 6.1%) may increase trough time due to the animals' difficulties to adapt themselves to glycerin. However, after a certain glycerin level intake, the animals would be adapted to the sweet taste of glycerin which may provide a faster intake of the concentrate. It should be emphasized that, even in the case of a trough time decrease with 9.1% glycerin levels in the diet, concentrate intake did not decrease. The high glycerin level in the diet actually stimulated a faster intake of the available concentrate.

Glycerin inclusion in diets of heifers in pasture did not alter ($p > 0.05$) the number of grazing and rumination periods (Table 5). However, the number of idle periods had a quadratic equation ($p > 0.05$) with the minimum point at 7.1% of glycerin in the diet. On the other hand, the number of trough periods decrease linearly ($p > 0.05$) according to the increase in glycerin levels in the diet. Although glycerin addition levels to pasture supplemented heifer diets decreased grazing time (in minutes), it did not have the same effects on the number of grazing periods. Consequently, intake behavior would be determined by grazing time rather than by the number of times the animal frequents the stand on the pasture. On the other hand, time and number of rumination periods are not affected by glycerin level in the diets, which is regulated by other types of mechanisms.

The number of idle periods had a quadratic influence ($p > 0.05$) on the glycerin level of heifer diets, with the lowest period at 7.1% glycerin. Glycerin inclusion in the diets of heifers in pasture caused a higher idle time and a decrease in the number of idle periods (Tables 4 and 5).

The number of time the heifers went to the trough (trough period) had a linear decrease ($p > 0.05$) when glycerin levels in the diets increased (Table 5). When glycerin was either 6.1 or 9.1% in the diet, the frequency was 3.3 times a day.

Table 5. Number of grazing (NPP), rumination (NRP), idle (NIP), trough (NTP) periods with their respective regress equations and coefficients of determination (R^2).

Item	Glycerin levels (% DM)				Regression equation	R^2	CV (%)
	G0.0	G2.8	G6.1	G9.1			
NPP	13.44	13.33	12.22	12.67	$\hat{Y} = 12.92$	-	10.93
NRP	15.44	15.44	15.44	15.11	$\hat{Y} = 15.36$	-	16.73
NIP	30.56	29.11	25.56	27.89	$\hat{Y} = 30.956 - 1.198x + 0.085x^2$	0.76	7.24
NTP	5.00	5.56	3.33	3.33	$\hat{Y} = 5.389 - 0.217x$	0.66	18.46

The addition of 9.1% of glycerin in the dry matter to heifer diets determined less trough time (51.67 min.) and thus, a lower number of visits (3.3 times day^{-1}). The above rates show that glycerin addition to diets increases the diet's palatability. The latter's increase may be due to the sweetened taste and astringency of glycerin.

Glycerin inclusion in heifer diets did not alter ($p > 0.05$) the time per grazing and rumination period (Table 6). The addition of glycerin determined less time on grazing and did not influence the number of grazing periods (13 times day^{-1}) and the time per grazing period (33 min.). On the other hand, the addition of glycerin to heifer diets up to 9.1% of total dry matter did not influence rumination parameters (time = 382.6 min.; number of periods = 15.4; time per period = 25.5 min.). Silva et al. (2005) did not report any effect on supplementation levels on diurnal rumination time calculated at a mean rate of 10.47 min.

Time during the idle period (minutes) increased ($p < 0.05$) linearly with the increase of glycerin levels to heifer diets (Table 6). Idle time also increased with glycerin increase in diets (Table 4). Silva et al. (2005) too registered a supplementation effect on the time of the idle period. Levels ranging between 15 and 25% of glycerin in ruminants' diet are metabolized during the first 6h up to VFAs (BERGNER et al., 1995). However, when lower glycerin levels (200 g day^{-1}) are added, 85% of glycerin vanishes in the first 2h after feeding (KIJORA et al., 1998). Metabolized glycerin in the rumen up to VFAs is absorbed by the rumen wall and in the blood flow, with negative feedback on food intake. The process may explain the high idle period in ruminants, since the behavior variables are excluding: less time on pasture means more idle time.

The time heifers spent at the trough (in minutes) during each visit had a quadratic effect ($p < 0.05$) with maximum rate 5.47% of glycerin in the diets. Increase in trough time may be related to the number of visits since these decreased when glycerin level in diets increased (Table 5). Time spent during the trough period was similar to that reported by Silva et al. (2005), or rather, 25, 19, 34 and 36 min. for different supplementation levels. Similarly, time spent at the trough for glycerin-less diets is very close to the period given by Bürger et al. (2000), with mean 14.80 min. per period a day. Decrease of time in trough period with 9.1% glycerin in the diet may have been caused by the palatability and sweetness of the diet which stimulated fast intake.

Feed and total chewing time, in minutes, showed linear reduction ($p > 0.05$) with an increase in glycerin levels to diet (Table 7). Decrease in feeding and total chewing time may be due to a decrease in grazing and trough time. Heifers fed on high glycerin levels had less time for grazing and trough (Table 4). Less grazing and trough time caused less feeding and total chewing time since both variables are related. Based on the results of 32 experiments, Allen (1997) reported a mean daily rate of 668 min. for total chewing time, and thus very close to rates reported in current experiment.

Glycerin inclusion in diets of heifers in pasture had a quadratic effect ($p < 0.05$) on the number of chewing per ruminated cake and on the time per ruminated cake (Table 7).

Table 6. Time per grazing (TPP), rumination (TRP), idle (TIP) and trough (TTP) period, in minutes, with their respective regression equations and coefficients of determination (R^2).

Item	Glycerin levels (% DM)				Regression equation	R^2	CV (%)
	G0.0	G2.8	G6.1	G9.1			
TPP	34.67	32.54	35.29	29.98	$\hat{Y} = 33.12$	0.26	12.67
TRP	26.48	25.00	24.42	26.39	$\hat{Y} = 25.57$	0.22	19.13
TIP	17.09	19.84	21.54	22.42	$\hat{Y} = 17.573 + 0.531x$	0.95	9.83
TTP	14.37	12.73	26.74	15.92	$\hat{Y} = 12.347 + 2.627x - 0.207x^2$	0.32	21.69

Table 7. Total feeding time (TFT), total chewing time (TCT), number of chewing per cake (MBOL), time for each ruminated cake (TRC), efficiency of dry matter feed (EDMF), efficiency of dry matter rumination (EDMR), efficiency of FND feeding (EFDNF), efficiency of FND rumination (EFNDR), number of ruminated cakes a day (NRC), dry matter per ruminated cake (MSC) and FND per ruminated cake (FNDC) with regression equations and coefficients of determination (R^2).

Item	Glycerin levels (% DM)				Regression equation	R^2	CV (%)
	G0.0	G2.8	G6.1	G9.1			
TFT	525.67	498.89	516.89	428.89	$\hat{Y} = 519.078 - 10.295x$	0.80	6.61
TCT	850.56	805.00	805.33	765.00	$\hat{Y} = 844.922 - 7.698x$	0.90	5.41
MBOL	27.11	33.11	45.56	38.00	$\hat{Y} = 25.789 + 4.408x - 0.306x^2$	0.81	15.44
TRC	45.22	51.00	55.56	41.89	$\hat{Y} = 44.372 + 4.216x - 0.438x^2$	0.87	14.79
EDMF	12.32	12.94	11.47	14.02	$\hat{Y} = 12.633 - 0.333x + 0.044x^2$	0.45	6.58
EDMR	16.54	17.22	15.79	15.51	$\hat{Y} = 16.940 - 0.135x$	0.57	7.68
EFNDF	4.72	4.47	4.09	5.33	$v = 4.794 - 0.251x + 0.027x^2$	0.78	6.55
EFNDR	6.33	5.94	5.66	5.56	$\hat{Y} = 6.527 - 0.260x$	0.94	7.66
NRC	524.24	443.29	410.81	603.04	$\hat{Y} = 533.51 - 55.402x + 0.616x^2$	0.93	22.81
MSC	12.45	14.67	14.65	10.87	$\hat{Y} = 12.376 + 1.207x - 0.135x^2$	0.99	17.16
FNDC	4.77	5.06	5.25	3.90	$v = 4.702 + 0.296x - 0.037x^2$	0.90	17.07

Inclusion of 6.1% glycerin to the diet had a greater number of chewing per cake (45.6). However, an increase in glycerin level causes a decrease in number of chewing (38.0). A similar behavior has been reported for ruminated cake time.

Feed efficiency of dry matter had a negative quadratic effect ($p < 0.05$) with the lowest point at 3.8% of glycerin in the diets (Table 7). On the other hand, rumination efficiency of dry matter had a linear decrease ($p < 0.05$) with the increase in glycerin to the diets (Table 7). Decrease in rumination efficiency of dry matter is due to the reduction of FND rates since glycerin replaced part of the fiber in the diet due to its lack of fiber.

FND feed efficiency decreased till glycerin reached 6.1% in the diet and then increased when levels were 9.1%. Adjustments were thus achieved to quadratic equation ($p > 0.05$) at the minimum point of 4.1% glycerin (Table 7).

Rumination efficiency of FND had a linear decrease ($p < 0.05$) due to increasing levels of glycerin to the diet (Table 6). Efficiency decreased perhaps due to the reduction of fiber rates in diets with a greater quantity of fibers. According to Van Soest (1994), food efficiency by which the animal retrieves food is related to the time for food intake and to the specific weight of the consumed food. Silva et al. (2005) stated that food efficiency depends on the variation magnitude of the diet's fiber component rates.

The number of ruminated cakes per day decreases with the inclusion of up to 6.1% of glycerin in the diet. However, in the case of 9.0 glycerin level, an increase in the number of ruminated cakes increased (Table 7). Data adjusted themselves to regression equation (quadratic) with minimum points at 4.5% glycerin. Decrease in the number of ruminated cakes may be due to a greater time in cake rumination. This may also be due to the fact that diets with high concentrate percentages have a greater weight and less fiber in neutral detergent. The latter makes the animal have a lesser number of chews per cake and, consequently, it ruminates a lesser number of cakes per day (MISSIO et al., 2010).

Dry matter and FND rates per ruminated cake had a quadratic effect ($p < 0.05$) with maximum points at 4.5 and 4.0% glycerin in heifer diets, respectively (Table 7). Highest glycerin level in diet determined low DM and FND rates per ruminated cake which may have altered the specific weight of the food due to a greater participation of concentrate and low rate of fiber in neutral detergent in the animals' diet when compared to those fed on lower glycerin levels (MISSIO et al., 2010).

Conclusion

The inclusion of glycerin in diets of heifers supplemented in pasture or finished in feedlot may be an alternative for decrease in production costs. This is due to the great availability of biodiesel production on the market. Glycerin used in current experiment (low purity) had a negative effect on the performance of heifers in growth and supplemented on *Brachiaria decuumbes* cv. Marandu pasture. However, although it did not impair the heifers' performance, it did not influence food digestibility. On the other hand, the inclusion of up to 9.1% glycerin in diet did not alter the heifers' behavior. Glycerin inclusion in diets of ruminants in supplementation or in feedlot depends on the quality of the product and on the process employed in obtaining it.

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