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# AN ALTERNATIVE METHODOLOGY OF DETERMINING FEED SORTING IN TRANSITION DAIRY COWS FED GLYCEROL

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**ABSTRACT**

The objective of this study was to compare the standard methodology with an alternative method to determine feed sorting in dairy cows during the transition period. Twenty-six Holstein multiparous cows were paired by expected calving date and fed diets containing either glycerol or high moisture corn from -28 through +56 days relative to calving (DRTC). Feed sorting was determined on -16, -9, +9, +15 and +51 DRTC in two different ways. Firstly, it was determined as the actual intake of each screen of the Penn State Particle Separator (PSPS) consumed between 0-4, 4-8, 8-12 and 12-24 hours post feeding, and expressed as a percentage of the predicted intake of that correspondent screen. Secondly, by measuring the particle size distribution of feed consumed between 0-4, 4-8, 8-12 and 12-24 hours post feeding. The total mixed ration (TMR) at feeding and at each time post feeding was separated by size using the 3-screen (19, 8, and 1.18 mm) Penn State Particle Separator (PSPS) to yield long (>19 mm), medium (<19, >8 mm), short (<8, >1.18 mm), and fine particles (<1.18 mm), respectively. Adding glycerol to the prepartum diet increased (P<0.05) the proportion of DM% retained as long particles (>19 mm) and reduced (P<0.05) the proportion of DM% retained as short (<8, >1.18 mm) and fine particles (<1.18 mm), but it did not alter (P>0.05) the proportion of DM% retained as medium particles (<19, >8 mm). Cows fed prepartum glycerol increased (P<0.05) the preference for long particles (>19 mm) according to the standard methodology (77.2 *vs*. 101.5%, control *vs*. glycerol) and also in the alternative methodology (9.2 *vs*. 17.8%, control *vs*. glycerol). Cows fed prepartum glycerol discriminated against (P<0.05) short particles (<8, >1.18 mm) in the standard methodology (102.6 *vs*. 94.2%, control *vs*. glycerol) as well as in the alternative methodology (42 *vs*. 37.3%, control *vs*. glycerol). There was no response (P>0.05) of diet on feed sorting of fine particles (<1.18 mm) according to standard methodology during the prepartum interval, but cows fed prepartum glycerol decreased (P<0.05) the preference for fine particles (<1.18 mm) in the alternative methodology (17.9 *vs*. 13.6%, control *vs*. glycerol). Cows fed postpartum glycerol increased (P<0.05) the preference for medium particles (<19, >8 mm) according to the standard methodology (108.6 *vs*. 116.5%, control *vs*. glycerol), but did not (P>0.05) according to the alternative methodology. Cows fed postpartum glycerol discriminated against (P<0.05) short particles (<8, >1.18 mm) according to the standard methodology (100.6 *vs*. 96.6%, control *vs*. glycerol), but did not (P>0.05) according to the alternative methodology. Feeding prepartum glycerol to transition dairy cows increases the preference for the long-stem forage particles of the diet. The alternative methodology proposed in this study is more reliable than the standard methodology to determine feed sorting.

KEYWORDS: Biodiesel, byproduct, particle size, preference.

**RESUMO**

METODOLOGIA ALTERNATIVA NA DETERMINAÇÃO DO CONSUMO SELETIVO EM VACAS LEITEIRAS NO PERÍODO DE TRANSIÇÃO ALIMENTADAS COM GLICEROL

Objetivou-se, nesta pesquisa, comparar a metodologia-padrão com um novo método alternativo na determinação do consumo seletivo em vacas leiteiras durante o período de transição. Vinte e seis vacas multíparas da raça Holandesa foram pareadas de acordo com a data prevista de parição e alimentadas com dietas contendo glicerol ou milho grão de alta umidade desde os -28 até +56 dias relativos à data de parição (DRDP). Determinou-se o consumo seletivo aos -16, -9, +9, +15 e +51 DRDP por duas maneiras. Na primeira, com o consumo real de cada peneira do Penn State Particle Separator (PSPS) entre 0-4, 4-8, 8-12 e 12-24 horas pós-alimentação, e expresso como a porcentagem do consumo predito da peneira correspondente. Na segunda maneira, por meio da mensuração da distribuição do tamanho de partículas do alimento consumido entre 0-4, 4-8, 8-12 e 12-24 horas pós-alimentação. Tanto no momento da alimentação quanto em cada tempo pós-alimentação, a ração foi separada por tamanho utilizando-se um conjunto com três peneiras (19, 8 e 1,18 mm) denominado Penn State Particle Separator (PSPS), gerando partículas longas (>19 mm), médias (<19, >8 mm), curtas (<8, >1,18 mm) e muito curtas (<1,18 mm), respectivamente. A adição de glicerol na dieta pré-parto aumentou (P<0,05) a proporção da %MS retida das partículas longas (> 19 mm) e reduziu (P<0,05) a proporção da %MS retida das partículas curtas (<8, >1,18 mm) e muito curtas (<1,18 mm), mas não alterou (P>0,05) a proporção da %MS retida das partículas médias (<19, >8 mm). Nas vacas alimentadas com glicerol no pré-parto, houve aumento (P<0,05) da preferência pelas partículas longas (>19 mm) na metodologia-padrão (77,2 *vs* 101,5%, controle *vs*. glicerol) e também na metodologia alternativa (9,2 *vs* 17,8%, controle *vs*. glicerol). As vacas alimentadas com glicerol no pré-parto discriminaram (P<0,05) as partículas curtas (<8, >1,18 mm) na metodologia-padrão (102,6 *vs* 94,2%, controle *vs*. glicerol) assim como na metodologia alternativa (42 *vs*. 37,3%, controle *vs*. glicerol). Não houve efeito (P>0,05) de tratamento sobre o consumo seletivo de partículas muito curtas (<1,18 mm) de acordo com a metodologia-padrão na fase pré-parto, mas nas vacas alimentadas com glicerol nessa fase houve diminuição (P<0,05) da preferência pelas partículas muito curtas (<1,18 mm) na metodologia alternativa (17,9 *vs*. 13,6%, controle *vs*. glicerol). Nas vacas alimentadas com glicerol na fase pós-parto, houve aumento (P<0,05) da preferência por partículas médias (<19, >8 mm) de acordo com a metodologia-padrão (108,6 *vs*. 116,5%, controle *vs*. glicerol), porém não houve efeito (P>0,05) de tratamento sobre o consumo seletivo de partículas médias (<19, >8 mm) na metodologia alternativa. As vacas alimentadas com glicerol no pós-parto discriminaram (P<0,05) as partículas curtas (<8, >1,18 mm) de acordo com a metodologia-padrão (100,6 *vs*. 96,6%, controle *vs*. glicerol), mas não houve resposta da dieta (P>0,05) sobre o consumo seletivo de partículas curtas (<8, >1,18 mm) na metodologia alternativa. A alimentação com glicerol para vacas leiteiras no período de transição aumenta a preferência por partículas longas (> 19 mm) da dieta durante o pré-parto. A metodologia alternativa proposta neste estudo é mais confiável do que a metodologia-padrão na determinação do consumo seletivo.

PALAVRAS-CHAVES: Biodiesel, preferência, subproduto, tamanho de partícula.

## INTRODUCTION

Cattle have the intrinsic ability to select specific and needed nutrients when feeds are offered separately (STRICKLIN & KAUTZ-SCANAVY, 1983). However, feeding dairy cows with rations in the form of a total mixed ration (TMR) is a preferred practice compared with component feeding systems on most dairy farms, but, despite the aim of providing feed as a homogenous mixture in TMR, dairy cattle have selectively consumed or sorted the grain component of a TMR and discriminated against the longer forage components (LEONARDI & ARMENTANO, 2003).

The periparturient or transition dairy cow has been defined when the cow is between three weeks prepartum and three weeks postpartum (GRUMMER, 1995). During this period of transition from gestation to lactation the cow is at greater risk for developing metabolic and infectious diseases than at any other time during its life (DRACKLEY, 1999). Therefore, special attention must be paid when formulating diets, as well as feeding and nutritional strategies to minimize the feed sorting behavior of dairy cows, which can result in the consumption of a ration with inconsistent nutritive value (STONE, 2004) and increasing risks of developing subacute ruminal acidosis (COOK et al., 2004; STONE, 2004), particularly when early lactating cows are fed low forage diets. Likewise, the feed sorting behavior leads to variations in nutritive values of the TMR in the feed bunk with a greater interval of time post feed delivery (DEVRIES et al., 2005), especially when dominant and subordinate cows are grouped together, where feed sorting by some groups of cows is also likely to impact the nutritional value of feeds available for other cows in the group, and may reduce the feeding value of the ration (KRAUSE & OETZEL, 2006).

Several additions to rations fed as a TMR have been investigated in an attempt to reduce feed sorting. The addition of water to a TMR has been investigated to reduce feed sorting by decreasing discrimination against long particles and reducing the preferential consumption of short particles (LEONARDI et al., 2005a). However, a more recent study (MILLER-CUSHON & DEVRIES, 2009) demonstrated that the addition of water decreased DM intake and increased sorting against long particles and increased preference for short and fine particles. Molasses has been recognized for its property to conglomerate small feed particles to larger particles. The addition of molasses to corn silage based diets decreased feed sorting, suggesting that molasses might be beneficial to enhance uniformity of TMR consumption for group-fed cows (OELKER et al., 2009), and addition of molasses reduces the percentage of fine particles found in calf starter (LESMEISTER & HEINRICHS, 2005).

Glycerol is a byproduct of the biodiesel industry that has been currently produced by a reaction that utilizes a base-catalyzed transesterification of oil in the formation of methyl and ethyl fatty acid esters in the production of biodiesel (THOMPSON & HE, 2006), and is a main byproduct of ethanol fermentation processing (MICHNICK et al., 1997). For each 100 g of soybean oil input, there is a yield of 12.25 g of glycerol (THOMPSON & HE, 2006). Furthermore, glycerol has been recently demonstrated to be a suitable primary feed ingredient to replace corn grain in rations fed to mid-lactating dairy cows (DONKIN et al., 2009).

Feed sorting has been previously measured according to LEONARDI & ARMENTANO (2003) and several authors have also used later the same methodology (LEONARDI et al., 2005a; LEONARDI et al., 2005b; DEVRIES et al., 2007; BHANDARI et al., 2008; DEVRIES et al., 2008; HOSSEINKHANI et al., 2008). The objective of this study was to compare the methodology according to LEONARDI & ARMENTANO (2003) with an alternative method to determine feed sorting in periparturient dairy cows.

## MATERIAL AND METHODS

Twenty-six Holstein multiparous were paired by expected calving date and housed in individual tie stalls at the Purdue Dairy Research and Education Center. Cows were randomly assigned to diets containing either high moisture corn (control) or glycerol, and fed diets formulated to meet or exceed the NRC (2001) guidelines for 600 kg dairy cattle from -28 through +56 days relative to calving (DRTC). The experiment was conducted between May/28/09 and October/23/09 and was approved by the Purdue Animal Care and Use Committee.

The ingredients and nutrient composition of the pre- and post-partum diets are presented in Table 1. The diets were adjusted weekly to account for forage DM fluctuation. The addition of soybean meal in the prepartum diet and the higher participation of this ingredient in the postpartum diet were intended to adjust for the protein that was removed with high moisture corn. Diets were offered once daily from 06:30 to 07:30 for ad libitum intake (10 to 15% weight backs). Feed refusals were measured daily and feed intake was determined by difference.

Samples of corn silage, alfalfa haylage and TMR were collected weekly, dried in a forced-air oven for 72 h at 55ºC and ground using a Willey mill to pass a 1-mm screen. Composite samples were formed monthly and analyzed by a commercial laboratory (Dairy One, Ithaca, NY) for DM, crude protein (CP), acid detergent fiber (ADF), starch and minerals by wet chemistry following AOAC (2000) procedures, and for NDF following the method of GOERING & VAN SOEST (1970).

Feed sorting was determined at -16, -9, +9, +16 and +51 DRTC (targeted days) by two methodologies. In both, samples of diets were taken at 0, 4, 8, 12 and 24 hours after feed delivery and frozen at -20ºC. Upon thawing, samples were separated using the 3-screen (19, 8, and 1.18 mm) Penn State Particle Separator (PSPS) to yield long (>19 mm), medium (<19, >8 mm), short (<8, >1.18 mm) and fine (<1.18 mm) particles (LAMMERS et al., 1996). Post separated materials were then dried in a forced-air oven for 72 h at 55ºC. Feed sorting was determined according to LEONARDI & ARMENTANO (2003) as the actual intake of each screen of the PSPS consumed between 0-4, 4-8, 8-12 and 12-24 hours post feeding, and expressed as a percentage of the predicted intake of that correspondent screen. The actual intake for each individual particle size equals the product of the DMI between 0-4, 4-8, 8-12 and 12-24 hours post feeding multiplied by the particle size distribution within the same intervals, whereas the predicted intake for each individual particle size equals the product of the DMI between 0-4, 4-8, 8-12 and 12-24 hours post feeding multiplied by the particle size distribution of the offered TMR. The final outcome is that values equal to 100% indicate no sorting, <100% indicate selective refusals (sorting against), and >100% indicate preferential consumption (sorting for). In the alternative methodology proposed in this study, feed intake of the individual particle sizes during each interval was determined by subtracting the particle size distribution available at the beginning of each interval from the particle size distribution remaining at the end of the interval, and feed sorting was determined by measuring the particle size distribution of feed consumed between 0-4, 4-8, 8-12 and 12-24 hours relative to feed delivery.

The data were analyzed using the MIXED procedure (SAS, 1999). The model accounted for the effects of treatments, DRTC and times post feeding (4, 8, 12 and 24 h), as well as the interaction effect of treatment by DRTC, treatment by time, DRTC by time and treatment by DRTC by time. Means were different if $P<0.05$ and values are reported as least square means and associated standard errors.

**TABLE 1.** Ingredient and nutrient composition of the pre- and post-partum experimental diets

| Item | Prepartum | | Postpartum | |
|---|---|---|---|---|
| | Control | Glycerol | Control | Glycerol |
| Ingredient, % of DM | | | | |
| Corn silage | 35.4 | 35.4 | 39.0 | 39.0 |
| Alfalfa haylage | 8.0 | 8.0 | 15.5 | 15.5 |
| Grass hay | 13.0 | 13.0 | 3.5 | 3.5 |
| Wheat straw | - | - | 1.5 | 1.5 |
| Cotton seed hulls | 6.0 | 6.0 | - | - |
| Soybean hulls | 7.8 | 7.8 | 2.0 | 2.0 |
| High moisture corn | 14.0 | - | 12.5 | - |
| Glycerol | - | 11.5 | - | 10.8 |
| Soybean meal | - | 2.5 | 10.0 | 11.0 |
| Megalac R[1] | - | - | 0.7 | 0.7 |
| Protein blend[2] | - | - | 5.3 | 6.0 |
| Supplement[3,4] | 15.8 | 15.8 | 10.0 | 10.0 |
| Chemical composition[5] | | | | |
| DM, % | 50.9 | 49.4 | 46.8 | 46.0 |
| CP, % of DM | 16.6 (1.00) | 16.6 (1.35) | 18.2 (0.83) | 18.7 (1.00) |
| ADF, % of DM | 22.9 (1.75) | 25.5 (1.79) | 19.5 (1.77) | 20.8 (2.32) |
| NDF, % of DM | 38.0 (1.18) | 42.2 (1.35) | 31.4 (2.71) | 34.2 (1.67) |
| Starch, % of DM | 22.6 (2.64) | 15.0 (1.22) | 26.7 (1.73) | 19.2 (1.12) |
| NEL, Mcal/kg of DM | 1.58 (0.02) | 1.61 (0.05) | 1.65 (0.02) | 1.61 (0.02) |
| Ca, % of DM | 1.09 (0.17) | 1.02 (0.12) | 1.11 (0.07) | 1.11 (0.20) |
| P, % of DM | 0.36 (0.02) | 0.34 (0.02) | 0.43 (0.02) | 0.40 (0.04) |
| Mg, % of DM | 0.39 (0.04) | 0.36 (0.02) | 0.36 (0.04) | 0.35 (0.02) |
| K, % of DM | 1.22 (0.05) | 1.29 (0.09) | 1.47 (0.11) | 1.44 (0.03) |
| Na, % of DM | 0.15 (0.01) | 0.15 (0.01) | 0.32 (0.01) | 0.32 (0.02) |

[1] Church & Dwight Co., Princeton, NJ.

[2] Contained 44% Aminoplus®, 3% Menhaden fish meal, 53% ProvAAL STD 5000.

[3] Prepartum: contained 38.29% soybean meal, 25.65% Bio-Chlor® (Church & Dwight Co., Princeton, NJ), 5.4% $CaCO_3$, 2.16% dicalcium phosphate, 1.08% MgO, 1.08% NaCl, 1.65% mineral/vitamin premix (16.11% Ca, 2.11% S, 31,505 mg/kg Zn, 8,036 mg/kg Cu, 26,020 mg/kg Mn, 140 mg/kg Se, 473 mg/kg Co, 284 mg/kg I, 1,440 kg IU/kg vitamin A, 416 kg IU/kg vitamin D, 6,647 kg IU/vitamin E), 2.16% $MgSO_4$, 5.08% Magalac R (Church & Dwight Co., Princeton, NJ), 0.49% Niacinamide® (99.5% niacin), 2.62% yeast culture (Diamond V Mills, Cedar Rapids, IA), 1.8% vitamin E 20,000, 0.08% Rumensin 80®, 2.62% Omingen-AF (Prince-Agri Products, Quincy, IL), 1.08% urea, 4.38% blood meal, 3.81% Aminoplus®, 0.57% Menhaden fish meal.

[4] Postpartum: contained 25% dried molasses, 42.75% finely ground corn, 7.5% $CaCO_3$, 5% dicalcium phosphate, 6.2% $NaHCO_3$, 2% MgO, 2% DCAD plus, 0.5% potassium magnesium sulfate, 2.5% NaCl, 2.025% mineral/vitamin premix (16.11% Ca, 2.11% S, 31,505 mg/kg Zn, 8,036 mg/kg Cu, 26,020 mg/kg Mn, 140 mg/kg Se, 473 mg/kg Co, 284 mg/kg I, 1,440 kg IU/kg vitamin A, 416 kg IU/kg vitamin D, 6,647 kg IU/vitamin E), 0.25% Niacinamide® (99.5% niacin), 2% yeast culture (Diamond V Mills, Cedar Rapids, IA), 0.213% vitamin E 20,000, 0.062% Rumensin 80®, 2% Omingen-AF (Prince-Agri Products, Quincy, IL).

[5] Mean analysis for composite samples (n=5) and associated standard deviations (bracketed values).

## RESULTS

Twenty-three cows completed the study (12 in the glycerol group and 11 in the control group). Two cows were removed due to displaced abomasum just after parturition (3935, control group and 4090, glycerol group) and one cow (3846, control group) experienced uterine torsion 7 days prior to parturition. Data from these cows were used in the prepartum parameters. Actual means and associated standard deviations of feed sorting sampling days were -16 (±3.6), -9 (±3.7), +11 (±1.6), +18 (±2.4) and +53 (±1.8) DRTC. Feed intake did not differ (P>0.05) between treatments and was 14.7 ± 0.4 and 20.2 ± 0.5 kg/d for the pre- and post-partum intervals, respectively.

There was effect of treatments on the particle size distribution of the prepartum experimental diets. Adding glycerol increased (P<0.05) the proportion of DM% retained as long particles (>19 mm). Contrarily, the proportion of DM% retained as short (<8, >1.18 mm) and fine (<1.18 mm) particles was reduced (P<0.05) with glycerol inclusion. There was no response (P>0.05) to prepartum glycerol on the proportion of DM% retained as medium particles (<19, >8 mm) and no response (P>0.05) of treatments on the particle size distribution of the postpartum diets (Table 2).

**TABLE 2.** Effect of glycerol on the particle size distribution of the experimental diets

| Item | Treatments | | | P-values | | |
|---|---|---|---|---|---|---|
| | Control | Glycerol | SEM | Trt[1] | DRTC[2] | Trt × DRTC |
| | Prepartum | | | | | |
| % of DM retained on screen | | | | | | |
| >19 mm | 9.6 | 16.9 | 0.4 | <0.05 | 0.94 | 0.61 |
| <19, >8 mm | 31.0 | 31.5 | 0.7 | 0.58 | 0.82 | 0.23 |
| <8, >1.18 mm | 41.7 | 37.5 | 0.6 | <0.05 | 0.18 | 0.82 |
| <1.18 mm | 17.7 | 14.1 | 0.4 | <0.05 | <0.05 | 0.26 |
| | Postpartum | | | | | |
| >19 mm | 5.7 | 7.1 | 0.5 | 0.10 | <0.05 | 0.42 |
| <19, >8 mm | 36.8 | 37.7 | 0.9 | 0.47 | <0.05 | 0.98 |
| <8, >1.18 mm | 42.9 | 41.5 | 0.6 | 0.16 | <0.05 | 0.60 |
| <1.18 mm | 14.6 | 13.7 | 0.7 | 0.36 | 0.05 | 0.97 |

[1]Treatment.
[2]Days relative to calving (-16 and -9 days during the prepartum interval and +9, +16 and +51 days during the postpartum interval).

Results of feed sorting according to the methodology from LEONARDI & ARMENTANO (2003) are presented in Figures 1 and 2, whereas according to the alternative methodology proposed in this study are shown in Figures 3 and 4. Cows fed prepartum glycerol increased (P<0.05) the preference or sorting for long particles (>19 mm) according to the methodology by LEONARDI & ARMENTANO (2003) (77.2 *vs*. 101.5%, control *vs*. glycerol, Figure 1) and also in the alternative methodology (9.2 *vs*. 17.8%, control *vs*. glycerol, Figure 3). There was no response (P>0.05) of treatments on feed sorting of medium particles (<19, >8 mm) during the prepartum period in both methodologies (116 *vs*. 117.4%, control *vs*. glycerol, LEONARDI & ARMENTANO, 2003, Figure 1; 30.9 *vs*. 31.3%, control *vs*. glycerol, alternative methodology, Figure 3). Cows fed prepartum glycerol discriminated or sorted against (P<0.05) short particles (<8, >1.18 mm) in both methodologies (102.6 *vs*. 94.2%, control *vs*. glycerol, LEONARDI & ARMENTANO, 2003, Figure 1; 42 *vs*. 37.3%, control *vs*. glycerol, alternative methodology, Figure 3). Conversely, there was no response (P>0.05) of diet on feed sorting of fine particles (<1.18 mm) according to the methodology by LEONARDI & ARMENTANO (2003) (78.3 *vs*. 76.1%, control *vs*. glycerol, Figure 1), but cows fed prepartum glycerol decreased (P<0.05) the preference for fine particles (<1.18 mm) in the alternative methodology (17.9 *vs*. 13.6%, control *vs*. glycerol, Figure 3).

Feed sorting during the postpartum interval did not differ (P>0.05) between treatments in both methodologies for long particles (>19 mm) (98.6 *vs*. 108.9%, control *vs*. glycerol, LEONARDI & ARMENTANO, 2003, Figure 2; 5.8 *vs*. 7%, control *vs*. glycerol, alternative methodology, Figure 4). However, cows fed postpartum glycerol increased (P<0.05) the preference for medium particles (<19, >8 mm) according to the methodology by LEONARDI & ARMENTANO (2003) (108.6 *vs*. 116.5%, control *vs*. glycerol, Figure 2), but did not (P>0.05) according to the alternative methodology (36.1 *vs*. 37%, control *vs*. glycerol, Figure 4). Conversely, cows fed postpartum glycerol discriminated against (P<0.05) short particles (<8, >1.18 mm) according to the methodology by LEONARDI & ARMENTANO (2003) (100.6 *vs*. 96.6%, control *vs*. glycerol, Figure 2), and again did not (P>0.05) according to the alternative methodology (42.2 *vs*. 41.6%, control *vs*. glycerol, Figure 4). There was no effect (P>0.05) of diet on feed sorting of fine particles (<1.18 mm) in both methodologies (85.4 *vs*. 72.4%, control *vs*. glycerol, LEONARDI & ARMENTANO, 2003, Figure 2; 15.8 *vs*. 14.4%, control *vs*. glycerol, alternative methodology, Figure 4).

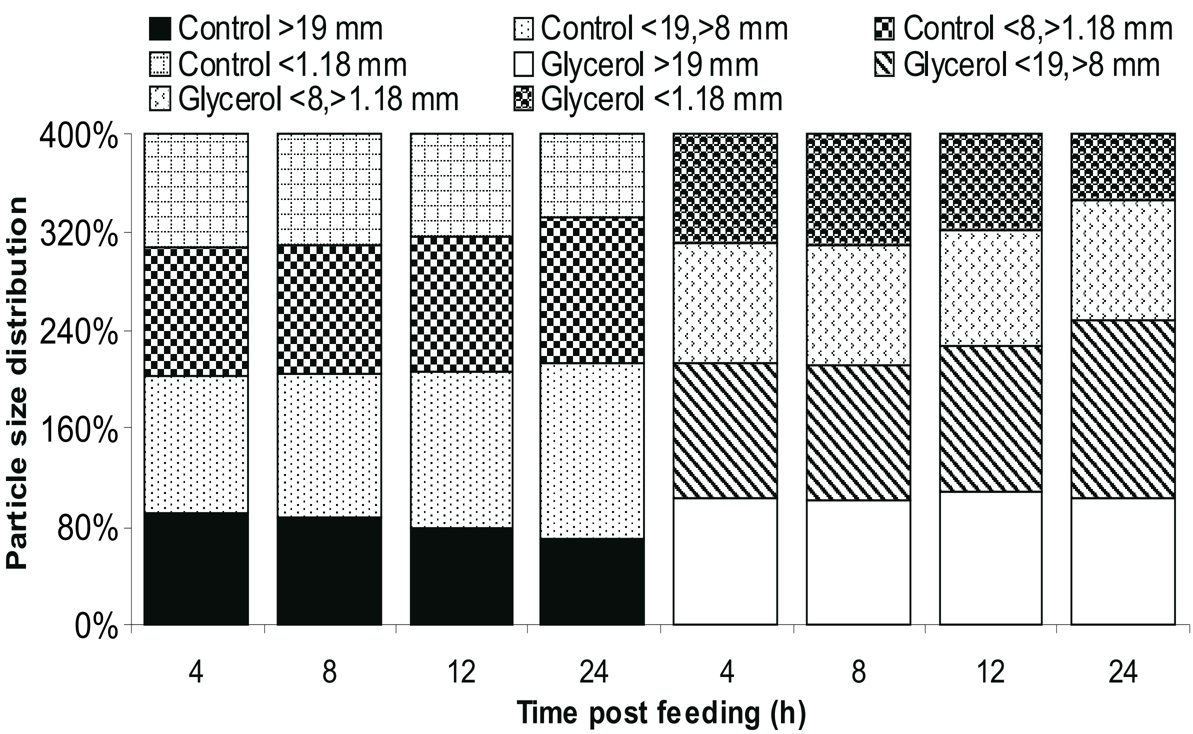


**FIGURE 1.** Feed sorting of transition dairy cows fed control (bars 1 through 4) or glycerol (bars 5 through 8) during the prepartum interval according to LEONARDI & ARMENTANO (2003). Long particles (>19 mm) – pooled SEM = 3.5. Treatment (P<0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P<0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Medium particles (<19, >8 mm) – pooled SEM = 3.05. Treatment (P>0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Short particles (<8, >1.18 mm) – pooled SEM = 1.67. Treatment (P<0.05), DRTC (P>0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P<0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Fine particles (<1.18 mm) – pooled SEM = 4.13. Treatment (P>0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05).

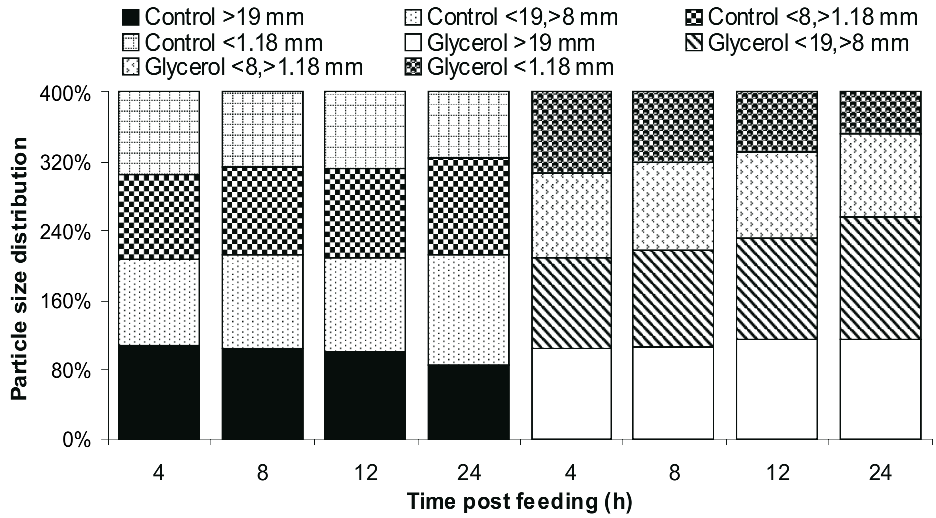


**FIGURE 2**. Feed sorting of transition dairy cows fed control (bars 1 through 4) or glycerol (bars 5 through 8) during the postpartum interval according to LEONARDI & ARMENTANO (2003). Long particles (>19 mm) – pooled SEM = 6.46. Treatment (P>0.05), DRTC (P<0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Medium particles (<19, >8 mm) – pooled SEM = 2.44. Treatment (P<0.05), DRTC (P<0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P<0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Short particles (<8, >1.18 mm) – pooled SEM = 1.36. Treatment (P<0.05), DRTC (P<0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P<0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Fine particles (<1.18 mm) – pooled SEM = 5.69. Treatment (P>0.05), DRTC (P<0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P<0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05).

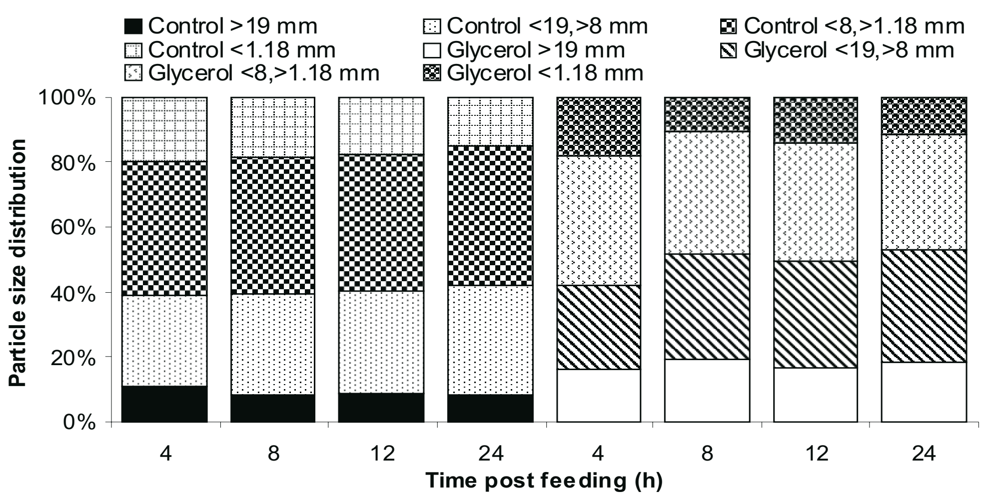


**FIGURE 3.** Feed sorting of transition dairy cows fed control (bars 1 through 4) or glycerol (bars 5 through 8) during the prepartum interval according to the alternative methodology proposed in this study. Long particles (>19 mm) – pooled SEM = 0.86. Treatment (P<0.05), DRTC (P>0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Medium particles (<19, >8 mm) – pooled SEM = 0.71. Treatment (P>0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Short particles (<8, >1.18 mm) – pooled SEM = 0.75. Treatment (P<0.05), DRTC (P>0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Fine particles (<1.18 mm) – pooled SEM = 0.65. Treatment (P<0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05).

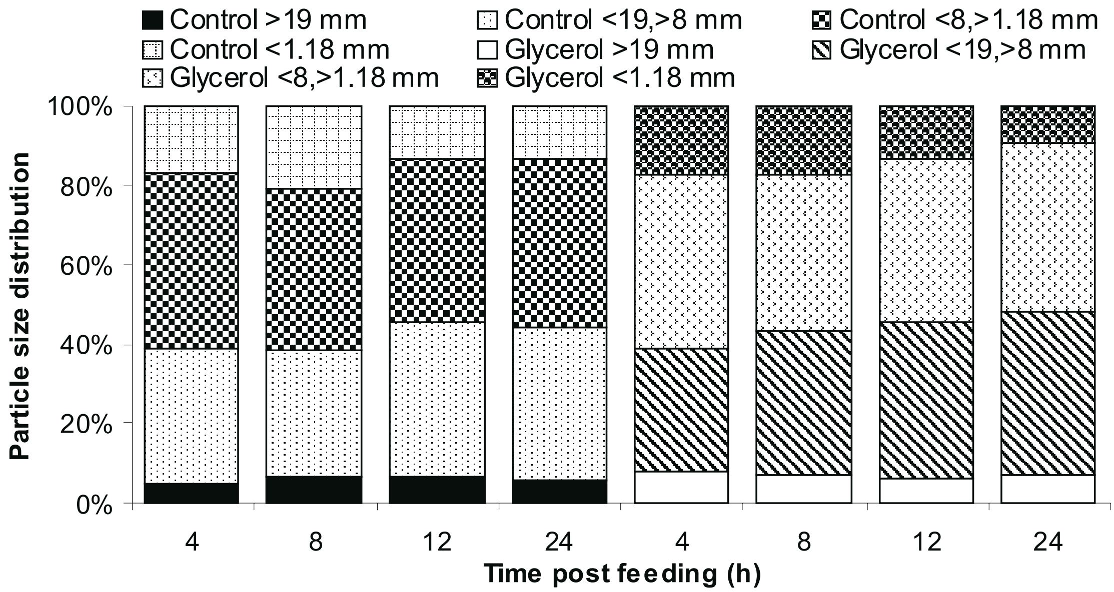


**FIGURE 4.** Feed sorting determined of transition dairy cows fed control (bars 1 through 4) or glycerol (bars 5 through 8) during the postpartum interval according to the alternative methodology proposed in this study. Long particles (>19 mm) – pooled SEM = 0.57. Treatment (P>0.05), DRTC (P<0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P<0.05), treatment × DRTC × time (P>0.05). Medium particles (<19, >8 mm) – pooled SEM = 0.84. Treatment (P>0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Short particles (<8, >1.18 mm) – pooled SEM = 0.68. Treatment (P>0.05), DRTC (P<0.05), time (P>0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P>0.05), treatment × DRTC × time (P>0.05). Fine particles (<1.18 mm) – pooled SEM = 0.73. Treatment (P>0.05), DRTC (P>0.05), time (P<0.05), treatment × DRTC (P>0.05), treatment × time (P>0.05), DRTC × time (P<0.05), treatment × DRTC × time (P>0.05).

## DISCUSSION

The response to prepartum glycerol on the preference for long particles (>19 mm) in both methodologies can be explained by the fact that the proportion of DM retained as long particles (>19 mm) in the prepartum glycerol diet was increased compared with the prepartum control diet (Table 2). This happened because the glycerol adhesive property increased the weight only of the long particles (>19 mm) of the prepartum diet, but not of the medium (<19, >8 mm), short (<8, >1.18 mm) and fine particles (<1.18 mm), and yet, no effect of glycerol coating was observed on the particle size distribution of the postpartum diet. Thus, it can be inferred that the greater response to glycerol coating on the long particles (>19 mm) was related to a higher proportion of long-stem forage in the glycerol prepartum diet (13% of hay of the total DM ration) compared with the glycerol postpartum diet (3.5% plus 1.5% of hay and straw of the total DM ration, respectively), which may have resulted in a greater density of the long particles (>19 mm) due to more surface exposure for glycerol coating on the long-stemmed forage.

As mentioned previously, several authors (LEONARDI & ARMENTANO, 2003; LEONARDI et al., 2005a; LEONARDI et al., 2005b; DEVRIES et al., 2007; BHANDARI et al., 2008; HOSSEINKHANI et al., 2008) reported that dairy cows have an intrinsic behavior to discriminate against long (>19 mm) and sort for fine particles (<1.18 mm) of the diet. Taking into account only the results obtained according to the methodology by LEONARDI & ARMENTANO (2003), cows in this study discriminated against fine particles (<1.18 mm) regardless of diets consumed, during both the pre- and post-partum intervals. This finding is rather difficult to explain, but DEVRIES et al. (2007) speculated that the reason why dairy cows were more eager to increase the preference for short particles (<8 mm) was the forage:concentrate ratio of the diets. In that study, one group of cows was fed a lower forage diet (50.7% forage:49.3% concentrate; DM basis), while the other group was fed a higher forage diet (62.3% forage:37.7% concentrate; DM basis). The authors reported that cows from both groups demonstrated preference for short particles (<8 mm), but the degree of sorting was more pronounced in cows fed the lower forage diet, simply because the concentrate content was more accessible and easier to sort. However, in the present study the forage:concentrate ratios of the pre- and post-partum diets in both treatments (56.4:43.6 and 59.5:40.5 of the total DM, respectively) were closer to the forage:concentrate ratio of the higher forage diet used by DEVRIES et al. (2007), but cows in this study had a high degree of discrimination against fine particles (<1.18 mm), indicating that this result was not related to the forage:concentrate ratio of diets.

Overall, discrepancies of determinations of feed sorting between methodologies occurred three times. During the prepartum stage, there was no effect of treatments on feed sorting of fine particles (<1.18 mm) according to the methodology by LEONARDI & ARMENTANO (2003), but cows fed glycerol decreased the preference of those particles according to the alternative methodology. During the postpartum interval, cows fed glycerol increased the preference for medium particles (<19, >8 mm) according to the methodology by LEONARDI & ARMENTANO (2003), but did not according to the alternative methodology, as well as cows fed glycerol discriminated against short particles (<8, >1.18 mm) according to the methodology by LEONARDI & ARMENTANO (2003), and again did not according to the alternative methodology.

Finally, it can be stated that the alternative methodology proposed in this study is more reliable than the standard methodology based on the fact that feed sorting was determined as the particle size distribution relative to feed intake of the individual particle sizes during each interval, and considering the amount of feed that was available to the cow exclusively in the beginning of each interval as a baseline to determine feed sorting in the end of each interval. However, LEONARDI & ARMENTANO (2003) considered the predicted intake as a baseline to determine feed sorting, and the problem is that cows will always sort for or against the different components of the diet over the course of the day, and consequently alter the particle size profile of the TMR, thereby impacting the results of feed sorting in the end of the first interval and also in the following intervals. Another strong reason to corroborate that the alternative methodology may be more accurate is that cows fed prepartum glycerol had significant differences on feed sorting only when there were significant variations on the particle size distribution of the experimental diets (Table 2). As reported previously, the addition of prepartum glycerol increased the DM proportion of long particles (>19 mm) and decreased the DM proportion of short (<8, >1.18 mm) and fine (<1.18 mm) particles. Likewise, cows fed prepartum glycerol increased the preference for long particles (>19 mm) and decreased the preference for short (<8, >1.18 mm) and fine (<1.18 mm) particles. The same pattern was observed during the postpartum interval, when there was neither effect of diet on the particle size distribution of the experimental diets, nor on feed sorting according to the alternative methodology. Nonetheless, additional research is needed to investigate whether or not the alternative methodology proposed in this study will bring the same kind of results through experiments using cows fed ingredients other than glycerol that do not have adhesive properties on long-stemmed forage particles.

## CONCLUSIONS

The glycerol adhesive property enhanced the preference for the long particles (>19 mm) of the diet during the prepartum interval, which may prove to be beneficial to rumen health.

The alternative methodology proposed in this study is more reliable than the standard methodology in the determinations of feed sorting.

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