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Effects of a completely pelleted diet on growth performance in Holstein heifers

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ABSTRACT

Forage neutral detergent fiber (NDF) content and particle size are important factors that affect rumen function. The aim of the current study was to evaluate the effects on rumen health, NDF digestibility, and animal performance of pelleting a forage-based diet. Eight Holstein heifers (age 336 ± 30 d, body weight 346 ± 35 kg) were randomly assigned to a repeated crossover design. Animals were housed in tie-stalls and fed for ad libitum intake. The study included 4 periods of 3 wk, the first 2 wk for adaptation to the diet and the last wk for data collection. Diets had the same ingredients but had a different physical form: total mixed ration (TMR) and pellet (diameter = 8 mm). The physically effective NDF (peNDF) differed between the 2 treatments (39.8 and 11.8% of NDF in the TMR and pellet diets, respectively). During the trial, dry matter intake (DMI), water intake, rumination time, rumen temperature, and pH were evaluated daily. Fecal samples were collected in wk 3 of each period to determine total-tract digestibility of the potential digestible (pd)NDF. Average daily gain and feed conversion ratio were calculated at the end of each period. With the pellet diet, DMI, DMI/body weight, and water consumption were higher. We observed no significant difference in average daily gain or feed conversion ratio. Rumination time was lower for the pellet diet than for the TMR diet (241 vs. 507 min/d, respectively). Diet had no effect on rumen temperature or rumen pH. The total-tract digestibility of the pdNDF was greater with the TMR diet than with the pellet diet (90.25 vs. 86.82% pdNDF, respectively). The results of the current study suggest that a complete-feed pellet diet was well accepted by the animals, as demonstrated by higher DMI. Rumination time was reduced with the pellet diet, but rumen pH was not different. The pdNDF digestibility was high for both diets, but significantly higher for the TMR diet. Given that animal performance was similar between the 2 diets, although they differed with respect to DMI and fiber digestion, we hypothesize that the 2 diets had different retention times, related to their physical form. A complete-feed pellet diet formulated to provide a sufficient level of NDF from forages could be fed to growing ruminants without apparent negative effects on rumen health and animal productivity, at least for a short period. More research over a longer growing period is needed before recommending this feeding strategy for growing heifers.

Key words: pellet, fiber particle size, potentially digestible neutral detergent fiber digestibility

INTRODUCTION

Fiber particle size and NDF content are important factors influencing rumen health (Allen, 1997; Krause et al., 2002; Kononoff et al., 2003). This has led to a new concept introduced by Mertens (2001) who estimated that physically effective NDF (**peNDF**) was the product of NDF concentration and physical effectiveness factor. The latter is the percentage of particles retained on a 1.18-mm sieve, considered highly resistant to passage out of the rumen (Poppi et al., 1985).

Fiber particle size influences chewing time and saliva secretion, affecting ruminal pH. Particle size might also affect the retention time in the rumen, and the extent of rumen fermentation and fiber degradation (Kaske et al., 1992; Teimouri Yansari et al., 2004; Kammes and Allen, 2012).

Reducing fiber particle size in feeds has been used as a way to increase DMI. Several studies have demonstrated the difference between 2 or more feed chop lengths for animal performance (Yang and Beauchemin, 2006, 2009; Kammes and Allen, 2012), but few trials have focused on pelleting as a strategy to achieve this effect (McCroskey et al., 1960; Cullison, 1961; Burt, 1966). Using this method, controlled amounts of pressure and heat are applied to the feed aggregate to increase its density (Mani et al., 2006). Pelleting offers many technical advantages, including improved stability (owing to very low moisture content), and easier handling, storage, and transportation.

Because pelleting reduces fiber particle size, it might promote an increased rate of passage out of the rumen,

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Table 1. Ingredients and chemical composition of pellet and TMR diets fed to heifers for ad libitum intake; the diets were formulated to be similar in chemical composition but different in physical form (evaluated as physical effectiveness factor and physically effective NDF)

Item	Diet		SEM
	Pellet	TMR	
Ingredients, % as fed			
Grass hay	41.8	41.8	—
Barley straw	27.4	27.4	—
Corn grain	16.4	16.4	—
Sunflower meal	13.7	13.7	—
Salt (NaCl)	0.7	0.7	—
Chemical composition,[1] % of DM			
DM, % as fed	92.0	88.0	1.02
CP	8.7	9.0	0.36
Ash	9.6	7.9	0.38
aNDFom	58.8	60.2	0.66
ADF	40.7	41.4	0.80
ADL	8.1	8.4	0.42
24-h IVNDFD	45.3	46.2	1.50
240-h IVNDFD	78.4	77.3	0.73
$uNDF_{240}$	12.4	14.1	0.61
Starch	15.7	15.6	1.07

[1]aNDFom = amylase- and sodium sulfite–treated NDF, corrected for ash residue; IVNDFD = in vitro NDF digestibility; $uNDF_{240}$ = unavailable NDF estimated via 240-h in vitro fermentation.

and a subsequent decrease in fiber digestibility (Van Soest, 1994). Conversely, reduced particle size might increase the surface area available for bacterial attachment (Miron et al., 2001), thereby increasing fiber digestibility. Reduction of fiber particle size could also affect rumen fermentation and promote the development of SARA (Khafipour et al., 2009).

The objective of this study was to evaluate the effects of a complete pelleted diet, formulated for growing heifers, on eating behavior, rumen fermentation, fiber digestibility, and animal performance. The hypothesis was that peNDF is not the only factor involved in maintaining a healthy rumen, and that a diet high in NDF content can overcome the risks of low pH due to a lack of coarse forage.

MATERIALS AND METHODS

Animals and Treatments

The experimental procedures were approved by the scientific ethical committee for animal experimentation at Bologna University. Eight Holstein heifers were used in a repeated crossover design. The duration of the study was 12 wk, made up of 4 periods of 3 wk. Heifers were adapted to a diet during the first 2 wk of each period, and samples and data were collected during the last wk (experimental wk). The heifers had similar age (336 ± 30 d) and BW (346 ± 35 kg) at the beginning of the experiment, and they were divided into 2 homogeneous groups.

Diet composition was the same for both treatments, but different in physical form (Table 1 and 2). Diet 1 was prepared as a TMR with a horizontal auger, trailer-type TMR feed-mixer (Zago 13 m^3; Zago srl, Padua, Italy). Diet 2 was produced as a complete-feed pellet diet, with the forages (grass hay and barley straw) chopped at 12 mm theoretical length and then incorporated with the other ingredients (corn meal, sunflower meal, NaCl), mixed, and pelleted (8 mm diameter).

Data and Sample Collection

Throughout the experiment, heifers were housed in tie-stalls bedded with sawdust, and fed their respective

Table 2. Physical characteristics and particle size distribution of pellet and TMR diets fed to heifers for ad libitum intake; the diets were formulated to be similar in chemical composition but different in physical form (evaluated as physical effectiveness factor and physically effective NDF)

Item	Diet		SEM	*P*-value
	Pellet	TMR		
Particle size distribution,[1] %				
6.70 mm	0	4.86	0.28	<0.01
4.75 mm	0	8.95	0.58	<0.01
3.35 mm	1.19	11.78	0.39	<0.01
2.36 mm	4.29	12.15	0.28	<0.01
1.18 mm	14.62	28.36	0.34	<0.01
0.15 mm	60.66	31.11	0.94	<0.01
Pan	19.23	2.77	0.27	<0.01
Physical effectiveness factor[2]	20.1	66.1	5.90	<0.01
peNDF,[3] % of DM	11.8	39.8	3.58	<0.01

[1]Particle size was measured using the Tyler Ro-Tap (W. S. Tyler, Mentor, OH).

[2]Physical effectiveness factor was determined as the proportion of fiber retained by the sieve with the 1.18-mm pore size.

[3]peNDF = physically effective NDF, measured as the NDF content of the forages (DM basis) multiplied by the physical effectiveness factor.