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Digestive development in neonatal dairy calves with either whole or ground oats in the calf starter[1]

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ABSTRACT

A series of 3 trials was conducted to determine effects of whole or ground oats in starter grain on reticulorumen fermentation and digestive system development of preweaned calves. Male Holstein calves (43.1 ± 2.3 kg at birth; n = 8, 9, and 7 for trials 1, 2, and 3, respectively) were housed in individual pens in a heated facility; bedding was covered with landscape fabric to prevent consumption of bedding by the calves. In trials 1 and 2 only, calves were fitted with rumen cannulas by wk 2 of life. In all trials, a fixed amount of starter (containing 25% oats either ground and in the pellet or whole) was offered daily; orts were fed through the cannula in trials 1 and 2. Calves were randomly assigned to an all-pelleted starter or pellets plus whole oats. Rumen contents (trials 1 and 2) were sampled weekly at −8, −4, 0, 2, 4, 8, and 12 h after grain feeding for determination of pH and volatile fatty acids. Calves were killed 3 wk (trial 1) or 4 wk (trials 2 and 3) after grain was offered; organs were harvested, emptied, rinsed, and weighed to gauge digestive organ development. Starter intake was not different between treatments. Weekly measurements of rumen digesta pH did not change and only subtle changes were observed in molar proportions of individual volatile fatty acids. Molar proportion of butyrate and pH linearly decreased with age, whereas acetate proportion increased. Reticulorumen weight and papillae length tended to be greater for calves fed pelleted starter, whereas abomasum weight was greater for calves fed pellets plus whole oats. Fecal particle size and starch content were greater for calves fed pellets plus whole oats. Under the conditions of this study, physical form of oats in starter grain did not affect rumen fermentation measurements; greater rumen weight and papillae length in calves fed pelleted starter may be the result of greater nutrient availability of ground oats. Under the conditions of this study with young calves on treatments for <4 wk, increasing particle size of the starter by feeding whole oats did not affect rumen fermentation nor did it improve digestive system development.

Key words: calf, rumen fermentation, whole oat

INTRODUCTION

A large variety of feedstuffs can be fed to neonatal dairy calves. In addition to diverse nutritive values, feed sources can be offered in various forms to provide differing physical and digestive functions in calf starters. The National Research Council (NRC, 2001) suggests that calves be restrained from eating long hay before weaning but recommends provision of feed with sufficient coarseness to avert impaction of particles between rumen papillae and prevent abnormal growth of papillae. Previous studies have shown that diets in which all ingredients were ground increased papillae keratinization and incidence of abnormal shape compared with diets with a greater particle size (Greenwood et al., 1997; Beharka et al., 1998). Feeding starter in a coarse mash form versus ground and pelleted increased DM digestibility at 8 wk of age, reduced the age at which calves started ruminating and increased time spent ruminating (Porter et al., 2007). Increasing time spent ruminating increases saliva production, which increases buffering capacity in the rumen (Krause and Oetzel, 2006). Higher rumen pH in response to greater particle size has been observed in diets containing hay (Greenwood et al., 1997; Beharka et al., 1998). Effects of particle size in calf starters on rumen fermentation have been previously studied, but starters contained hay (Greenwood et al., 1997; Beharka et al., 1998), calves were not prevented from consuming bedding (Lesmeister and Heinrichs, 2004), or fermentation was measured only at slaughter (Porter et al., 2007). Hay in the starter and consumption of bedding materials are confounding factors when assessing effects of grain particle size. Whole oats are approximately 10.27 mm in length (Doehlert et al., 2006), which is greater than the threshold particle size for particles leaving the ru-

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men in adult cattle and sheep (Maulfair et al., 2011). Thus, whole oats must be broken down mechanically by chewing, which should increase time spent chewing and slow the rate at which oat starch is available to rumen microbes, resulting in a more stable rumen environment and providing the necessary abrasion to prevent the buildup of keratin on the rumen epithelium.

The objective of this study was to evaluate whether increasing the particle size of calf starter by providing whole oats would affect rumen pH, rumen fermentation, and development of the digestive system. A secondary objective was to observe rumen fermentation at an early age. We hypothesized that whole versus ground oats in the starter would increase rumen development by providing a longer feed particle size that would improve digestion and rumen papillae growth.

MATERIALS AND METHODS

Protocols for this study were approved by The Pennsylvania State University Institutional Animal Care and Use Committee under IACUC #41010. Three trials were done as part of this experimental protocol.

In trial 1, Holstein bull calves (n = 10) purchased from a single commercial herd were removed from their dams after birth, weighed, and fed 3.6 L of colostrum within 1 h of birth. Calves were then transported for 20 min to the experimental housing facility, where they were fed an additional 1.8 L of colostrum 6 to 8 h after the first feeding. Housing consisted of individual pens 2.1 × 1.6 m inside a mechanically ventilated, heated facility; bedding was covered with landscape fabric to avoid any consumption of bedding by calves. Water was offered free choice, and a medicated (decoquinate, 34 mg/kg) milk replacer powder containing 20% CP and 20% fat (Provimi North America, Brookville, OH) and reconstituted to 13% DM was fed at 12% of birth BW divided in 2 equal feedings per day at 0800 and 1930 h. All calves were ruminally fistulated with 28-mm (i.d.) rubber cannulas by the second week of age, when they were randomly assigned to treatments: an all-pelleted starter with ground oats in the pellet (**G**) or pellets plus whole oats (**W**; Table 1). Starters differed only in oats processing, with all ingredients coming from the same batch; a single batch of each starter was prepared and used for all 3 trials. Calf starter was fed once daily at 2000 h, after feeding of the milk replacer. Amount of starter offered was adjusted by age and was based on average intakes of calves fed similar milk replacer diets. To equalize intake, calves were fed a fixed amount of starter; orts, when present, were placed in the rumen through the cannula at 2000 h. Health was monitored twice daily, and sick calves were treated per veterinary recommendation.

Table 1. Ingredient and chemical composition and particle size of starters containing ground oats in a pelleted feed (G) or whole oats plus a pellet (W)

Item	G	W
Ingredient composition, % of DM		
Ground corn	37.00	37.00
Ground oats[1]	25.00	—
Whole oats[1]	—	25.00
Soybean meal, 48% CP	24.46	24.46
Wheat middlings	4.81	4.81
Dry molasses	3.00	3.00
Fat	2.00	2.00
Calcium carbonate	0.78	0.78
Premix[2]	0.75	0.75
Salt	0.60	0.60
Monocalcium phosphate	0.59	0.59
Decoquinate 6%	0.50	0.50
Pellet binder	0.50	0.50
Chemical composition, % of DM		
DM	88.07	87.66
CP	18.95	18.39
Starch	42.60	43.60
Fat	4.91	4.83
ADF	7.79	7.05
NDF	12.30	13.14
Ash	5.28	5.73
Ca	0.80	0.77
P	0.53	0.57
Particle size, mm		
X_{gm} retained[3]	1.23	1.84
S_{gm} retained[3]	1.15	1.18
X_{gm} total[4]	0.58	0.91
S_{gm} total[4]	1.56	1.72
% particles >1.18 mm[5]	41.00	65.78

[1]Contained (% of DM) 48.5 starch, 28.2 NDF.

[2]The premix contained (per kilogram) 160 g of Cu, 0.13 g of Co, 9.40 g of Fe, 0.14 g of I, 5.4 g of Mn, 0.04 g of Se, 6.70 g of Zn, 1,800 IU of vitamin A, 600 IU of vitamin D, 16 IU of vitamin E, 0.01 g of biotin, 2.93 g of cobalamin, 0.04 g of folic acid, 1.77 g of niacin, 1.32 g of pantothenic acid, 0.24 g of pyridoxine, 0.30 g of riboflavin, and 0.29 g of thiamin (Provimi North America, Brookville, OH).

[3]Geometric mean (X_{gm}) and standard deviation (S_{gm}) of particle length as calculated by ASABE (2007) using data from screens ≥0.15 mm. Particles retained on the top screen were assumed to be 4.7 mm long.

[4]Geometric mean (X_{gm}) and standard deviation (S_{gm}) of particle length as calculated by ASABE (2007) using data from all particle fractions. Particles retained on the top screen were assumed to be 4.7 mm long.

[5]Cumulative proportion of particles retained on the 1.18-mm sieve or above.

Rumen contents were sampled 1 d/wk starting 1 wk after starter was offered at −8, −4, 0, 2, 4, 8, and 12 h after starter feeding. Contents (about 40 mL) were strained through 2 layers of cheese cloth, and pH of the fluid fraction was immediately determined by using a hand-held pH meter (pHTestr 10, Eutech Instruments, Vernon Hills, IL). Rumen fluid (5 mL) was then placed into tubes containing 1 mL of 25% metaphosphoric acid and 1 mL of 6% 2-ethyl butyric acid (internal standard) and stored at −20°C until analyzed for VFA and NH_3. Feces were collected from the landscape fabric over a 22-h period at the time of rumen sampling and stored at −20°C for later analysis.