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Effect of early exposure to mixed rations differing in forage particle size on feed sorting of dairy calves

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ABSTRACT

Feed sorting of dairy cattle is influenced by dietary forage particle size. The objective of this study was to determine the effect of early exposure to rations differing in forage particle size on development of feed sorting in dairy calves. Twenty Holstein bull calves were exposed for 8 wk to 1 of 2 mixed rations containing (on a dry-matter basis) 90% crumb starter concentrate and either (1) 10% coarsely chopped (3- to 4-cm) grass hay (CRS; n = 10) or (2) 10% finely ground (2-mm) grass hay (FN; n = 10), both offered ad libitum. Calves received 8 L of milk replacer/d (1.2 kg of dry matter/d), with the amount progressively reduced after 5 wk, to facilitate weaning by the end of wk 7. At the beginning of wk 9, all calves received the CRS diet and were followed for 3 wk. Intake was recorded daily and calves were weighed twice per week. Samples of fresh feed and orts were taken on d 1 to 4 of wk 9 and 11 for analysis of feed sorting. Sorting of the ration was assessed through analysis of nutrient intake. Actual intake of each nutrient was expressed as a percentage of predicted intake of that nutrient, based on the concentration in the fresh sample. Daily dry matter intake (DMI) was similar between treatments after transition to the common CRS ration (3.20 kg/d, standard error = 0.25 kg/d). However, feed efficiency was subject to a treatment-by-week interaction, with calves previously fed the FN diet having an initially greater gain-to-feed ratio than those fed the CRS diet [in wk 9, 0.60 vs. 0.47 kg of average daily gain (ADG)/kg of DMI] and similar feed efficiency in the following weeks (in wk 10, 0.43 vs. 0.43 kg of ADG/kg of DMI). A corresponding tendency was observed for ADG and body weight to evolve differently, depending on treatment, with calves previously fed the FN diet having greater ADG initially (in wk 9, 1.60 vs. 1.32 kg/d) but similar ADG to those fed the CRS diet in the following weeks (in wk 10, 1.39 vs. 1.33 kg/d and in wk 11, 1.32 vs. 1.31 kg/d). Calves previously fed the FN diet consumed less neutral detergent fiber as a percentage of predicted intake and tended to consume less acid detergent fiber and more nonfiber carbohydrates, as a percentage of predicted intakes, than calves previously fed the CRS diet. Given the nutrient compositions of hay and concentrate, this indicates that calves previously fed the FN diet were sorting for concentrate. These results indicate that the pattern and extent of feed sorting may be affected by early experience with rations differing in forage particle size.

Key words: dairy calf, feed sorting, forage presentation, learning

INTRODUCTION

It is commonly reported that dairy cows sort TMR, selecting in favor of short particles and against long particles (Leonardi and Armentano, 2003; Miller-Cushon and DeVries, 2009). Selection in favor of the short particle fraction is likely due to the concentration of highly palatable grain in this particle fraction (Hosseinkhani et al., 2008; DeVries and von Keyserlingk, 2009), as well as the greater rate at which cattle can ingest small particles compared with large forage particles (Campling and Morgan, 1981). Due to the effects of feed sorting on nutrient composition and consistency of the ration, various recent studies have addressed factors that influence feed sorting. These factors include frequency of feed delivery (DeVries et al., 2005), dietary DM concentration (Leonardi et al., 2005a; Miller-Cushon and DeVries, 2009), and proportion and particle size of forage in the ration (Leonardi and Armentano, 2003). In general, rations containing long forage particles encourage sorting in favor of short particles (Leonardi et al., 2005b), possibly due to increased ease of sorting against the long particles in the ration. Interestingly, however, sorting in favor of long particles has been reported to increase to attenuate low rumen pH (DeVries et al., 2008), suggesting that feed sorting may be affected by individual requirements for physically effective fiber.

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Little work has examined factors that may influence feed sorting of young calves. Calves are typically provided concentrate and hay as their initial exposure to solid feed. Consumption of concentrate provides energy for growth (Hill et al., 2008) and promotes development of rumen papillae (Warner et al., 1956; Sander et al., 1959), whereas hay intake increases muscular development of the rumen (Tamate et al., 1962). Evidence also exists that intake of hay improves feed efficiency (Coverdale et al., 2004) and rumen environment (Suárez et al., 2007; Khan et al., 2011). When provided hay and concentrate as a mixed ration, calves have been reported to sort in favor of the concentrate component (Miller-Cushon and DeVries, 2011), a pattern of feed sorting similar to that seen in adult cattle (Leonardi and Armentano, 2003). As reported in adult cattle, particle size of the ration may also affect feed sorting of young calves.

Particle size of the ration affects the rumen environment, with finely ground diets resulting in decreased rumen pH (Beharka et al., 1998) and decreased nutrient digestibility (Montoro et al., 2013). Montoro et al. (2013) reported that calves sorted a mixed ration in favor of concentrate when the ration contained finely ground forage and sorted in favor of hay when the ration contained coarsely chopped hay. Those authors concluded that feed sorting of young calves was influenced by preference for the forage component, which depended on particle size.

Although feed sorting of cattle is influenced by feed and management factors, substantial individual variability has been reported in the pattern and extent of feed sorting (Leonardi and Armentano, 2003). Factors that may contribute to individual differences in feed sorting are poorly understood. Evidence exists, however, that early feed experiences influence development of certain aspects of feeding behavior, including motor skills and feed preferences (Arnold and Maller, 1977; Nolte et al., 1990). Therefore, it is possible that factors that influence feed sorting early in life may have an effect on the development and long-term expression of the behavior. Miller-Cushon and DeVries (2011) reported that calves provided either hay or concentrate before weaning initially sorted in favor of the familiar feed component once transitioned to a mixed ration containing hay and concentrate postweaning. However, those authors reported that differences in pattern of feed sorting were only observed in the first week of exposure to a common diet. Further research is required to determine whether early feed management factors may exert a long-term effect on feed sorting.

Therefore, the objective of this study was to determine the effect of early exposure to diets differing in forage particle size on development of feed sorting of dairy calves. The hypothesis of this study was that differences in feed sorting between calves offered a ration containing finely ground hay, compared with calves offered a ration containing coarsely chopped hay, would persist once all were transitioned to the mixed ration containing coarsely chopped hay. Specifically, it was hypothesized that, once all calves were transitioned to the ration containing coarsely chopped hay, calves previously provided the mixed ration containing finely ground hay would sort against the longer forage particles and for the concentrate to a greater extent than calves previously exposed to the ration containing coarsely chopped hay.

Given the high degree of individual variability in feed sorting noted in adult cattle (Leonardi and Armentano, 2003), a secondary objective was to assess the degree of variability between calves in the extent of feed sorting. It was hypothesized that young calves would vary within treatment in the pattern and degree of feed sorting, with previous feed experiences not necessarily having a consistent response on later feed sorting.

MATERIALS AND METHODS

Animals and Housing

Twenty Holstein calves were used in this study. Within 24 h of birth, calves were placed in individual pens (1.2 × 1.8 m; width × depth) at the University of Guelph Kemptville Campus Dairy Education and Research Centre (Kemptville, ON, Canada). Calves were managed according to the standard operating procedures of this research station, in accordance with guidelines set by the Canadian Council on Animal Care (CCAC, 2009). The interior of each pen was bedded with wood shavings. The front of each pen had 2 openings for access to pails (diameter = 25.4 cm; height = 23.0 cm; capacity = 8 L) mounted on the outside. Water was provided ad libitum in one pail and solid feed was provided ad libitum in the second pail. Pens were located under a 3-sided, roofed shelter to protect from excessive exposure to the elements.

Experimental Design and Diets

For the first 7 wk of life, calves received milk replacer by artificial teat, as described by Montoro et al. (2013). In brief, calves received 8 L/d (1.2 kg of DM/d) of 22% CP, 18% fat Shur-Gain high-performance milk replacer (Nutreco Canada Inc., Guelph, ON, Canada), and were weaned progressively during wk 6 and 7. Calves received no milk during wk 8. Daily milk allotment was provided in 2 daily feedings at 0800 and 1600 h.

For the first 8 wk of life, calves were exposed to 1 of 2 experimental diets differing in forage particle size,

according to Montoro et al. (2013). The treatment diets were mixed rations containing (on a DM basis) either (1) 90% crumb starter concentrate (Shur-Gain; Nutreco Canada Inc.) and 10% coarsely chopped (3- to 4-cm) grass hay (coarse, **CRS**; n = 10) or (2) 90% crumb starter concentrate and 10% finely ground (2-mm) grass hay (fine, **FN**; n = 10). The hay in the CRS diet was chopped using a New Holland 355 grinder-mixer (New Holland Inc., New Holland, PA) to pass through a 4-cm mesh screen, whereas the hay in the FN diet was ground using a Wiley mill (Arthur H. Thomas CO., Philadelphia, PA) to pass through a 2-mm mesh screen (Montoro et al., 2013). The chopped hay in the CRS diet was considered physically effective, as it was >8 mm and contained in the top 2 screens of the Penn State Particle Separator (Yang and Beauchemin, 2006). In contrast, the ground hay in the FN diet was not considered physically effective.

As reported by Montoro et al. (2013), no effect of treatment was observed on ADG (average of 0.92 kg/d) in wk 1 to 8. Overall DMI in wk 1 to 8 was also similar between treatments (1.43 kg/d), but was subjected to a treatment-by-week interaction, with calves fed the CRS diet having greater DMI in wk 8 than those fed the FN diet (Montoro et al., 2013). At the beginning of wk 9, the BW of calves was similar between treatments (98.0 kg, SE = 2.57; $P = 0.91$).

Immediately following the 8-wk period of exposure to their respective treatment diet, all calves were offered the CRS diet. Calves were followed for 3 wk while consuming this common ration. Fresh feed was provided daily at 1000 h in sufficient quantities to ensure ad libitum intake (target: approximately 20% orts). Orts were removed daily immediately before delivery of fresh feed. Feed intake was recorded daily by weighing the amount of feed offered and the amount refused. Calves were weighed at the same time on 2 consecutive days each week to obtain an accurate weekly weight and to account for day-to-day variability.

Feed Sampling and Analysis

For determination of DM content of the feed and assessment of daily DMI of the calves, fresh feed was sampled weekly and individual orts from each calf were sampled daily on d 1 and 4 of each week. To obtain a representative sample, orts were thoroughly mixed by hand before collecting the sample. Additional fresh and orts samples were taken for feed sorting analysis on d 1 to 4 of wk 9 and 11. All samples were immediately frozen at −20°C until they were further analyzed.

As described by Montoro et al. (2013), the particle size distribution of the experimental diet did not allow for analysis of feed sorting of different particle size fractions using the Penn State Particle Separator, as is commonly performed (Leonardi and Armentano, 2003). The particle distribution of the fresh mixed diet was 0.00 ± 0.00% long particles (>19 mm), 0.52 ± 0.24% medium (<19 but >8 mm), 94.42 ± 0.86% short (<8 but >1.18 mm), and 5.04 ± 0.89% fine (<1.18 mm) particles. The particle distribution of the orts was (mean ± SD) 0.00 ± 0.00% long particles, 0.26 ± 0.23% medium, 87.20 ± 6.67% short, and 12.51 ± 6.77% fine particles. Given that the majority of particles of the ration (both forage and concentrate) fell in the short-particle fraction (<8 but >1.18 mm), analysis of the particle size distribution of the feed samples would not have provided insight into whether calves were sorting for or against a feed component. However, because the mixed diet contained only 2 feed components with distinct nutrient compositions (Table 1), analysis of sorting for individual nutrients provided a clear indication of dietary selection. Thus, nutrient analysis was obtained for all fresh and orts samples taken for sorting analysis.

Samples obtained for DM and nutrient analyses were oven dried at 55°C for 48 h. Samples taken for chemical analyses were ground to pass through a 1-mm screen (Wiley mill; Arthur H. Thomas Co.) and then pooled by week and calf. Pooled samples were sent to Cumberland Valley Analytical Services Inc. (Maugansville, MD) for analysis of DM (135°C; AOAC International, 2000; method 930.15), ash (535°C; AOAC International, 2000; method 942.05), ADF (AOAC International, 2000; method 973.18), NDF with heat-stable α-amylase and sodium sulfite (Van Soest et al., 1991), and CP (N × 6.25) (AOAC International, 2000; method 990.03; Leco FP-528 nitrogen analyzer; Leco Corp., St. Joseph, MI).

Calculations and Statistical Analyses

Weekly ADG was calculated as the difference between weights obtained 1 wk apart divided by 7. The percentage of orts was calculated as the amount of feed refused as a percentage of the amount of feed offered. Actual feeding level (% orts) was compared between treatments to ensure that treatment was not confounded with feeding level, which may affect degree of feed sorting (Leonardi and Armentano, 2007; Miller-Cushon and DeVries, 2010).

Sorting activity was assessed by analyzing actual intake of NDF, ADF, CP, and NFC expressed as a percentage of the predicted intake of that nutrient (Leonardi and Armentano, 2003). The actual intake of each nutrient was calculated as the difference between the DM amount of each nutrient in the offered feed and that in the refused feed. The predicted intake of each

Table 1. Chemical composition[1] of feed components and the coarse mixed ration (mean ± SD; DM basis)

Item	Hay[2]	Concentrate	Mixed ration[3]
DM, %	88.5 ± 1.13	89.2 ± 0.75	89.3 ± 0.30
CP, % of DM	11.33 ± 0.30	24.67 ± 0.60	22.23 ± 0.53
ADF, % of DM	44.29 ± 1.38	11.12 ± 0.37	14.3 ± 0.91
NDF, % of DM	64.82 ± 1.27	20.97 ± 0.90	25.3 ± 0.59
NFC, % of DM	9.13 ± 2.92	41.67 ± 0.83	38.93 ± 0.79
ME, Mcal/kg of DM	1.69 ± 0.08	2.81 ± 0.01	2.69 ± 0.01

[1]Values were obtained from chemical analysis of feed samples. NFC = 100 − (% CP + % NDF + % fat + % ash); ME = TDN × 0.04409 × 0.82 [calculated according to NRC (2001) equations].

[2]Hay was a second-cut rye-grass hay. Dairy calf crumb starter was supplied by Shur-Gain (Nutreco Canada Inc., Guelph, ON, Canada).

[3]Mixed ration contained, by weight, 90% concentrate and 10% hay (chopped at 3 to 4 cm).

nutrient was calculated as the product of total DMI multiplied by the DM percentage of that nutrient in the fed ration. Values equal to 100% indicate no sorting, <100% indicate selective refusals (sorting against), and >100% indicate preferential consumption (sorting for).

To assesses within- and between-calf variability in feed sorting, the standard deviation of feed sorting values was calculated within calves (across the 4 d/wk that feed sorting was evaluated) and between calves (within treatment, across 10 calves/treatment). To test whether calves were sorting the diet for each nutrient, sorting values for each calf were averaged by the week that samples were taken. Feed intake and orts percentage were summarized by calf and week. Preliminary screening of the data revealed that all dependent variables were normally distributed. Sorting values were transformed into a difference from 100% and tested against the null hypothesis that the difference was zero using *t*-tests within PROC MIXED of SAS (SAS Institute, 2008). All data (sorting, orts percentage, intake, BW, and ADG) were analyzed using PROC MIXED of SAS (SAS Institute, 2008), treating week as a repeated measure. The model included the fixed effects of week, treatment, week-by-treatment interaction, and the random effect of calf within treatment. Compound symmetry was selected as the variance-covariance matrix structure for the sorting and orts percentage data on the basis of best fit according to Schwarz's Bayesian information criterion. The autoregressive model was selected as the variance-covariance matrix structure for the intake, BW, and ADG data on the basis of best fit according to Schwarz's Bayesian information criterion. All values reported are least squares means. Significance was declared at $P \leq 0.05$, and trends reported if $0.05 < P \leq 0.10$.

RESULTS AND DISCUSSION

Prior exposure to rations differing in forage particle size did not affect DMI once calves were consuming the common CRS ration (Table 2). Daily orts were also similar between calves previously fed the FN diet and calves previously fed the CRS diet (in wk 9 to 11, average of 24.9 vs. 25.5% of offered DM, SE = 6.0%; $P = 0.8$). Feed efficiency was subject to a treatment-by-week interaction, with calves previously fed the FN diet having an initially greater gain-to-feed ratio than those fed the CRS diet (Table 2). There was a corresponding tendency for BW and ADG to evolve differently over time, with calves previously fed the FN diet having initially greater ADG than calves previously fed the CRS diet, but similar ADG during the following weeks (Table 2). No long-term effect on growth was observed; BW were similar between treatments at the end of the study (127.5 vs. 129.0 kg for CRS vs. FN, SE = 3.5 kg; $P = 0.62$).

When all calves were provided the CRS ration, sorting of the feed, as assessed by nutrient composition of the fresh and refused feed, was influenced by prior exposure to forage particle size (Table 3). Calves previously fed the FN diet consumed less NDF, as a percentage of predicted intake, and tended to consume less ADF and more NFC, as a percentage of predicted intake, than calves previously fed the CRS diet. Intake of CP, as a percentage of predicted intake, was not significantly different between treatments, possibly because levels of CP in hay and concentrate did not differ as greatly as levels of NFC, ADF, and NDF (Table 1). The extent of feed sorting was similar over time (Table 3), indicating that differences in sorting patterns between treatments persisted for at least 3 wk after transition to the common ration. Despite differences in feed sorting between treatments, total nutrient intakes were not significantly different (Table 3), likely due to the degree of variability in DMI between calves. However, nutrient intakes as a percentage of DMI were affected by sorting (Table 3). Calves previously fed the FN diet tended to consume less NDF and ADF and more NFC as a percentage of DMI than calves previously fed the CRS diet. Given the nutrient compositions of hay and concentrate (Table 1), the pattern of consuming more NFC and less NDF and

Table 2. Intakes and weight gain of calves previously offered mixed diets differing in hay particle size[1,2,3]

	wk 9		wk 10		wk 11			*P*-value		
Item	Coarse	Fine	Coarse	Fine	Coarse	Fine	SE	W	T	W × T
DMI, kg	2.80	2.67	3.23	3.14	3.72	3.61	0.25	<0.001	0.52	0.91
BW, kg	98.3	97.8	107.5	109.1	117.2	118.4	2.82	<0.001	0.85	0.096
ADG, kg/d	1.32	1.60	1.33	1.39	1.31	1.32	0.061	0.34	0.12	0.069
Gain:feed (kg of ADG:kg of DMI)	0.47	0.60	0.42	0.43	0.38	0.42	0.019	<0.001	0.088	0.035

[1]Data are averaged by week for 10 calves on each treatment.

[2]Treatment (T): coarse = calves previously offered the coarse treatment diet (hay chopped to 3 to 4 cm; wk 1–8); fine = calves previously offered the fine treatment diet (hay ground to 2 mm; wk 1–8).

[3]W = week on trial (wk 9, 10, and 11).

ADF, as a percentage of predicted intake, indicates that calves previously fed the FN ration were sorting against hay and for concentrate to a greater extent than calves previously fed the CRS ration.

The variability in the extent of feed sorting between individual calves is depicted in Figure 1, which shows intake of NDF, as a percentage of predicted intake, as an indicator of sorting of the forage component of the ration (hay contained approximately 65% NDF, whereas concentrate contained 21%; Table 1). All calves previously fed the CRS diet consumed more NDF, as a percentage of predicted intake, except for 1 (average sorting value of 99.8%) and all calves previously fed the FN diet consumed less NDF, as a percentage of predicted intake, except 2 (average sorting values of 100.8 and 100.2%). Individual animals varied somewhat in the extent of their feed sorting between days. For example, sorting values for a calf previously fed the FN diet fluctuated between 88.2 and 99.3% on 2 consecutive days. Within-calf day-to-day variability was less, however, than variability between calves [0.86 ± 0.57% averaged across calves vs. 2.46 ± 0.78% by treatment; mean SD ± SD(SD)]. Leonardi and Armentano (2003) also reported that adult cattle varied in the extent to which they sorted their TMR, showing particular variability in the sorting of the long-particle fraction, which was mainly hay (ranging between <70 and >90%). Despite individual variability in sorting of hay in the present study (assessed through intake of NDF, as a percentage of predicted intake), previous experience with different forage particle sizes had a fairly consistent effect within each treatment. This suggests that forage particle size elicits a consistent response of feed sorting in young calves.

Table 3. Effect of prior exposure to forage particle size on dietary selection assessed through nutrient intakes[1]

	wk 9		wk 11			*P*-value		
Item	Coarse	Fine	Coarse	Fine	SE	W	T	W × T
Nutrient intake,[2] % of predicted intake								
NDF	100.68	98.01*	100.43	98.46*	0.75	0.74	0.043	0.54
ADF	100.24	98.26*	100.28	98.76†	1.06	0.81	0.09	0.84
NFC	100.63	101.28*	100.85†	101.67*	0.67	0.64	0.08	0.94
CP	100.28	100.68†	99.96	100.12	0.56	0.45	0.29	0.50
Nutrient intake, kg/d								
DMI	2.80	2.67	3.72	3.61	0.135	<0.001	0.513	0.90
NDF	0.70	0.66	0.95	0.91	0.037	<0.001	0.32	0.99
ADF	0.40	0.38	0.54	0.51	0.024	<0.001	0.29	0.89
NFC	1.07	1.03	1.46	1.43	0.05	<0.001	0.63	0.77
CP	0.66	0.63	0.83	0.80	0.029	<0.001	0.48	0.90
Nutrient intake, % of DMI								
NDF	24.3	23.9	25.5	25.2	0.23	<0.001	0.076	0.93
ADF	14.2	13.97	14.45	14.08	0.22	0.47	0.090	0.81
NFC	38.19	38.56	39.23	39.69	0.27	0.0029	0.061	0.89
CP	23.4	23.4	22.2	22.2	0.14	<0.001	0.96	0.78

[1]Treatment (T): coarse = calves previously offered the coarse treatment diet (hay chopped to 3 to 4 cm; wk 1–8); fine = calves previously offered the fine treatment diet (hay ground to 2 mm; wk 1–8).

[2]Calculated as 100 × (actual nutrient DMI/predicted nutrient DMI). Values equal to 100% indicate no dietary sorting, <100% indicate selective refusals of feed components high in that nutrient (sorting against), and >100% indicate preferential consumption of feed components high in that nutrient (sorting for). Data are averaged over 7 d for each of 2 recording weeks (W) postweaning from milk for 10 calves on each treatment.

*†Difference in sorting values from 100% expressed as $*P \leq 0.05$ and $†P \leq 0.1$.

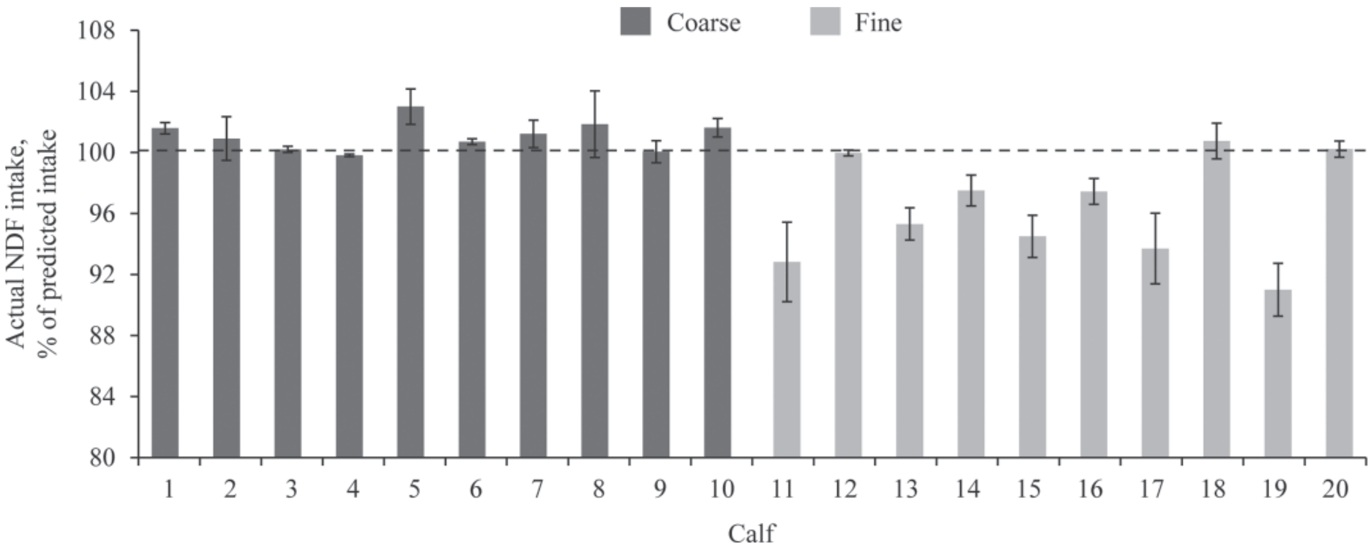

Figure 1. Feed sorting for hay, as indicated by actual intake of NDF, as a percentage of predicted NDF intake (mean ± SD), of calves previously fed a mixed ration containing concentrate and coarsely chopped (3–4 cm) forage (coarse) or concentrate and finely ground (2 mm) forage (fine). Sorting values equal to 100% indicate no sorting, <100% indicate selective refusals (sorting against), and >100% indicate preferential consumption (sorting for). Data are averaged over 8 d of data collection/calf during wk 9 and 11.

Several factors may have contributed to differences observed in feed sorting. Neophobic responses are commonly reported when animals are provided with a novel food (Thorhallsdottir et al., 1987; Squibb et al., 1990;) and could influence diet selection. Although hay itself was not novel, the larger particle size may have resulted in minor neophobia initially after transition to the common ration in calves previously fed the FN ration. Neophobia is typically short-lived as animals learn about the novel food and increase intake rapidly over a period of several days (Thorhallsdottir et al., 1987; Burritt and Provenza, 1989). Therefore, it is unlikely that neophobia would have been the underlying cause of the consistent differences in feed sorting observed over time.

Alternatively, differences in nutrient digestibility may have influenced feed sorting. In wk 8, calves fed the FN diet had lower apparent DM, CP, NDF, and ADF digestibility than calves fed the CRS diet, indicating that forage particle size in the ration affected the rumen environment (Montoro et al., 2013). If lower nutrient digestibility in calves previously fed the FN diet persisted, these calves may have been sorting in favor of the highly digestible concentrate to meet nutrient and energy demands. Nutrient digestibility was not assessed beyond wk 8; thus, it is not clear how quickly the calves previously fed the FN ration adapted to the CRS ration. However, evidence exists that the rumen environment of a calf adapts readily to dietary changes. Stobo et al. (1966) noted that apparent digestibility of different nutrients was similar in calves that had been fed markedly different diets 3 wk previously. Upon transition to the CRS ration, intake of larger forage particles likely rapidly improved the rumen environment of calves previously fed the FN ration, resulting in improved nutrient digestibility. The tendency for greater gain-to-feed ratio in calves previously fed the FN ration (Table 2) also suggests that nutrient utilization was not hindered by low digestibility. Rather, sorting in favor of NFC and the corresponding tendency for greater NFC intake as a percentage of DMI would have provided more energy for growth (Khan et al., 2007) and facilitated greater gain-to-feed ratio.

Given the persistent differences in feed sorting throughout this study, different patterns and extent of sorting may be a result of learning due to early experience. As reported by Montoro et al. (2013), in wk 7 and 8, calves provided the FN ration sorted for concentrate to a greater extent than calves provided the CRS ration. Thus, calves previously fed the FN ration maintained this pattern of sorting after transition to a ration with larger forage particles. Once calves previously fed the FN ration were adept at sorting their feed in favor of concentrate, sorting may have become a habit that persisted despite the ration change, resulting in calves previously fed the FN ration sorting in favor of concentrate to a greater extent than calves previously fed the CRS ration. The persistence of this pattern of feed sorting may be related to differences in development of motor skills or relative preference for the different feed components. Both foraging motor skills and feed preferences have been found to differ, depending

on prior exposure to different feed types (Arnold and Maller, 1977; Flores et al., 1989). Further research is encouraged to explore the longevity of differences in feed sorting resulting from early feed experience.

CONCLUSIONS

Exposing preweaned dairy calves to either a ration containing finely ground or coarsely chopped forage affected feed sorting once all calves were provided with the ration containing coarsely chopped forage. Previous exposure to a ration containing finely ground forage encouraged a pattern of sorting in favor of concentrate and against hay after transition to the ration containing coarsely chopped forage. In contrast, calves previously fed the ration containing coarsely chopped forage did not sort. These results indicate that prior exposure to a ration containing finely ground forage may increase feed sorting when later fed a ration containing coarsely chopped forage. Thus, provision of rations containing finely ground hay to milk-fed calves may increase feed sorting and result in imbalanced intake of nutrients after weaning.

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