Livestock Science 151 (2013) 179–187

Contents lists available at SciVerse ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Eating behavior, ruminal fermentation, and milk production in lactating dairy cows fed rations that varied in dry alfalfa hay and alfalfa silage content ☆

D.D. Maulfair [1], A.J. Heinrichs *

Department of Dairy and Animal Science, The Pennsylvania State University, 324 Henning Building, University Park, PA 16802, USA

ARTICLE INFO

Article history:
Received 6 February 2012
Received in revised form
9 November 2012
Accepted 12 November 2012

Keywords:
Chewing
Particle size
Rumination
Sorting

ABSTRACT

The objective of this experiment was to evaluate effects of various inclusion levels of dry chopped alfalfa hay and alfalfa silage in lactating dairy cow rations on eating behavior, rumen fermentation, milk yield, and components. Eight multiparous Holstein cows (79 ± 11 d in milk initially; 647 ± 36 kg body weight) were randomly assigned to replicated 4×4 Latin squares; one square of rumen canulated animals. During each of the 4 periods, cows were fed 1 of 4 diets that were chemically similar but varied in dry chopped alfalfa hay level. Forage dry matter (DM) consisted of 50% corn silage and 5%, 10%, 20%, or 40% dry chopped alfalfa hay. The remaining forage DM was alfalfa silage (45%, 40%, 30%, and 10% respectively). It was determined that sorting did not change with increasing alfalfa hay content and that dry alfalfa hay can be included in the ration up to 23.5% of ration DM with no negative effects on DM intake, milk yield, and rumen fermentation. Small decreases in milk fat and protein content occurred with increasing dry hay inclusion. Despite changes in total mixed ration refusal particle size distribution throughout the day, by 24 h after feeding, no significant ration sorting occurred when measured either by selection indices or actual consumption of various particle size fractions (>19.0, >8.0, >1.18 mm, and pan). Data from the Penn State and Ro-Tap particle separators produced different particle size distributions from the same sample. This indicates that data obtained from these 2 methods of particle separation are not directly comparable and that the method of particle separation should be considered when interpreting experimental results.

1. Introduction

Ration sorting has generally been considered a problem in lactating dairy cows. It is believed that ration sorting can lead to sub-acute ruminal acidosis because cows usually sort against longer particles and for shorter particles (DeVries et al., 2007; Kononoff et al., 2003b; Leonardi and Armentano, 2003). This type of sorting behavior could lead to decreased NDF intake and physical effectiveness of the diet while starch intake is increased. All dairy cows have a need for effective fiber, and a decrease in effective fiber can be detrimental to cows being fed energy dense rations that rely on chewing and saliva secretion to help buffer the rumen (Allen, 1997; Krause et al., 2002; Nocek, 1997). However, Maulfair et al. (2010) determined that drastic ration sorting, when determined by changes in TMR refusal particle size distributions, can occur in diets without any negative effects

☆ This research was a component of NC-1042, Management Systems to improve the economic and environmental sustainability of dairy enterprises.

* Corresponding author. Tel.: +1 814 863 3916; fax: +1 814 865 7442.
E-mail address: ajh@psu.edu (A.J. Heinrichs).
[1] Current address: Red Dale Ag Service, Lebanon, PA, USA.

1871-1413/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.livsci.2012.11.007

on milk production, milk components, and rumen fermentation under certain feeding conditions. The authors suggested that actual consumption of particle size fractions, NDF, and starch should be considered when measuring ration sorting. Therefore there is a need to study ration sorting in greater detail to understand what factors interact to cause negative effects in the cow and how to limit them.

A main component of forage particle size research is the particle separating equipment. The Penn State particle separator (PSPS) was developed as an inexpensive and easy to use device to characterize particle size distribution of TMR and forages in the field (Kononoff et al., 2003a; Lammers et al., 1996). The PSPS has been increasingly used in research to describe particle size distribution of treatment diets and for estimation of physically effective NDF (peNDF) by using the proportion of sample particles retained above the 1.18-mm sieve multiplied by their NDF content. The PSPS uses as-fed samples and a horizontal shaking motion to separate the particles. This is in contrast to the Ro-Tap particle separator (RTPS), which uses dried samples and vigorous vertical shaking to separate particles. The RTPS is important to forage particle size research because Mertens (1997) used it to develop the laboratory assessment of peNDF, where particles retained on a 1.18-mm sieve after shaking are multiplied by the sample NDF content. One major factor that creates a difference between the PSPS and the RTPS is that vertical shaking tends to separate particles by their minimum cross-sectional dimension, whereas horizontal shaking tends to separate particles by their length (Mertens, 1997, 2005). Understanding these differences is important when interpreting studies using one or more different methods.

The objective of this experiment was to study effects of replacing alfalfa haylage with dry chopped alfalfa hay in the ration on sorting activity and to determine if any negative effects on rumen fermentation, milk production, or milk composition could be detected. In addition, a second objective of this study was to compare results of the PSPS and RTPS for the same TMR samples and to determine effects of separation method on particle size distribution.

2. Materials and methods

2.1. Diets, cows, and experimental design

Cows used in this experiment were cared for and maintained according to a protocol approved by The Pennsylvania State University Institutional Animal Care and Use Committee. Eight (4 rumen canulated) lactating, multiparous, Holstein cows (79 ± 11 d in milk initially; 656 ± 83 kg BW) were randomly assigned to replicated 4×4 Latin squares. There were 4 periods of 21 d with 13 d of adaptation and 8 d of sample collection. Cows were fed 1 of 4 rations each period that were chemically similar and varied only in concentration of chopped alfalfa hay (replacing alfalfa haylage). Hay was chopped with a Case IH moidel 8610 bale processor (Case IH, Racine, WI, USA). Particle size generally ranged from 2–10 cm. Since the hay was moderately mature based on CP and NDF, every effort was made to mix leaves and stems after chopping and each day to feed a uniform feedstuff. Dry alfalfa inclusion rates were 5%, 10%, 20%, or 40% of forage DM, representing 2.9%, 5.8%, 11.7%, and 23.5% of total ration DM. Ration ingredients, other than dry chopped alfalfa hay and alfalfa silage, remained similar for all diets except the 40% hay diet. This diet had a decreased amount of canola meal and 0.5% of urea added to maintain similar levels of rumen degradable protein among all rations. Cows were housed in individual tie-stalls in a mechanically ventilated barn and milked twice/d at 0700 and 1900 h. They were fed once/d at 0730 h for ad libitum consumption and a 10% refusal rate to allow maximum opportunity to sort. Feed was pushed up 3 times/d at 1230, 1730, and 2400 h. Rations were balanced to meet or exceed National Research Council (2001) requirements and water was available for ad libitum consumption.

2.2. Feed, refusal, and particle size analysis

Offered TMR and refusals were weighed daily for the duration of the study. On d 20 and 21 of each period, feed bunk contents were weighed and sampled at 0, 2, 4, 8, 12, 16, and 24 h after feeding to determine particle size distribution and DM content of remaining feed. Particle size distributions of samples were determined with the PSPS according to Kononoff et al. (2003a). Samples were then dried in a forced air oven at 55 °C for 48 h to determine DM content. Samples of each TMR and forage were collected on d 16 and 19 of each period, composited by period and analyzed by Cumberland Valley Analytical Services, Inc. (Hagerstown, MD) for CP (Association of Official Analytical Chemists, 2000), ADF (Association of Official Analytical Chemists, 2000), NDF (Van Soest et al., 1991), ash (Association of Official Analytical Chemists, 2000), NFC (Van Soest et al., 1991), and NE_L (National Research Council, 2001). There were 2 procedures used to calculate peNDF: $peNDF_{8.0}$ = % of particles > 8.0 mm × NDF of whole sample (top 2 sieves of PSPS) and $peNDF_{1.18}$ = % of particles > 1.18 mm × NDF of whole sample (top 3 sieves of PSPS; Kononoff et al., 2003a). The RTPS was used to separate 95 dried TMR samples comprised of 4 treatment diets and 0 and 24 h time points to compare to PSPS results. Approximately 0.6 L of dried sample was placed on the top of the sieve stack, which contained sieves of 9.5, 8.0, 6.7, 4.75, 3.35, 2.36, 1.70, 1.18, 0.60, and 0.15 mm. The RTPS was run for 10 min and particles retained on each sieve were then weighed to determine the proportion of sample DM retained on each sieve.

2.3. Chewing activity

On d 14 to 18 of each period, eating and ruminating behavior were recorded using Institute of Grassland and Environmental Research Behavior Recorders and Graze Jaw Movement Analysis Software (Ultra Sound Advice, London, UK) as described by Rutter (1997, 2000). Chewing was measured for all cows for two 24-h periods including while cows were being milked. These recorders analyze jaw movements of cattle, and the software can determine