Recent Applications of Liquid Supplements in Dairy Rations

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Introduction

Liquid feed supplements (LFS) have a long history of use in dairy cattle feeding. Initially, LFS were used in lick tanks as a source of non-protein nitrogen (NPN) and energy for dry cows and replacement heifers. More recently, with the increased popularity of feeding total mixed rations (TMR), LFS have been marketed with the following claims:

- safe and uniform delivery vehicle for micro-nutrients and NPN to TMR,
- improved NPN utilization,
- delivery vehicle for fat supplements,
- delivery vehicle for molasses or rumen-fermentable carbohydrate to TMR,
- reduced dustiness of concentrates and TMR,
- reduced sorting of TMR in the feed bunk,
- increased intake of TMR,
- increased ruminal fiber digestion and microbial protein synthesis, and
- increased bulk density of TMR.

Recent research with LFS for dairy cattle has focused on their role as an alternative delivery vehicle for supplemental fat (Firkins and Oldick, 1997; Maiga et al., 1995; Oldick et al., 1997), rumen undegraded protein (Wattiaux et al., 1994), and rumen-fermentable carbohydrate (Emanuele, 1997; Maiga et al., 1995) to TMR. Research results from University (Leonardi and Armentano, 2000; Burato et al., 2001; Leonardi et al., 2001) and field (Martin, 1999, 2000; personal comm.-L. Carver, Quality Liquid Feeds, Dodgeville, WI) trials suggest that sorting of TMR fed to lactating dairy cows can occur.

The use of LFS to increase the uniformity of ingredient and nutrient consumption in beef feedlot diets has been shown to be beneficial (Pritchard, 1993). Although controlled research trials with dairy cattle TMR evaluating the efficacy of LFS for ameliorating a sorting problem are lacking, the addition of LFS to dairy cattle TMR for this purpose is a growing practice on commercial dairy operations and reports from the field have been positive. This paper will focus primarily on the TMR sorting issue.

Sorting of Total Mixed Rations

Leonardi and Armentano (2000) and Martin (1999, 2000) observed extensive TMR sorting in the feed bunk in university and on-farm trials, respectively. Data on particle size of TMR and orts and DM intake indicated that cows sorted against the coarse particles (Leonardi and Armentano, 2000). This sorting against the coarse particles was more evident for the TMR
containing 40% compared to 20% alfalfa hay (DM basis), and the variation in sorting among cows was large (Leonardi and Armentano, 2000).

Martin (1999, 2000) determined the particle size of TMR and bunk mix at 6-h intervals post-feeding on a commercial dairy. The percentages on the top screen of the Penn State shaker box (Lammers et al., 1996) for TMR and bunk mix at 6-, 12-, 18-, and 24-hours post-feeding were 9.3, 13.7, 21.5, 27.5, and 58.7%, respectively. Cows sorted against the coarse particles. From a projection of the coarse particle intake at each time period, it appeared that intake of coarse particles was less than predicted during hours 0 – 12 post-feeding and more than predicted during hours 13 – 24 post-feeding.

Leonardi et al. (2001) reported that feeding oat silage with increasing particle size increased sorting against coarse TMR particles. Burato et al. (2001) reported that cows with the highest pretrial milk yield had increased sorting against the coarse TMR particle fraction. This response in feeding behavior reduced the original difference in particle size between their long- and short-chopped alfalfa hay diets resulting in no effect of diet particle size on feed intake or milk production.

Factors that may make TMR prone to sorting include: DM content and particle size of forage and mix, variation in bulk density of feed ingredients, large pieces of cobs and husks in the corn silage, amount and quality of hay added to mix, improper sequencing of ingredients into the mixer, frequency of feeding and push-up, availability of bunk space, and bunk access time. An on-farm evaluation of sorting should include particle size determination (Lammers et al., 1996) of TMR, bunk mix, and refusals.

If sorting is determined to be a problem, then one or more of the following options may need to be considered: feeding smaller amounts of TMR more frequently, adding less hay to the mix, processing hay finer, using higher quality hay, using hay that is more pliable, processing corn silage, addition of water to dry TMR, and addition of LFS to TMR.

Carver (personal comm.; Quality Liquid Feeds, Dodgeville, WI) determined the particle size of TMR, bunk mix, and refusals (Lammers et al., 1996) on commercial dairies. Data for TMR and refusals are presented in Table 1.

Table 1. Percentages of TMR and refusals on top screen of Penn State shaker box from five dairy farms (L. Carver, personal comm., QLF).

<table>
<thead>
<tr>
<th>Dairy</th>
<th>No LFS TMR (%)</th>
<th>No LFS Refusals (%)</th>
<th>LFS TMR (%)</th>
<th>LFS Refusals (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9.6</td>
<td>26.7</td>
<td>15.8</td>
<td>8.5</td>
</tr>
<tr>
<td>B</td>
<td>3.1</td>
<td>16.7</td>
<td>7.8</td>
<td>8.1</td>
</tr>
<tr>
<td>C</td>
<td>16.5</td>
<td>53.5</td>
<td>34.7</td>
<td>27.2</td>
</tr>
<tr>
<td>D</td>
<td>33.5</td>
<td>52.8</td>
<td>26.7</td>
<td>21.8</td>
</tr>
<tr>
<td>E</td>
<td>25.0</td>
<td>55.0</td>
<td>33.0</td>
<td>25.0</td>
</tr>
</tbody>
</table>
There was sorting against the coarse particle fraction for TMR with no LFS added, as shown by the increased percentages retained on the top screen of the Penn State shaker box for refusals. The increased percentages retained on the top screen of the Penn State shaker box for TMR with LFS added compared to TMR with no LFS added likely reflects the binding of fines to the coarse particle fraction by the LFS. This retention of fine particles on the top screen of the Penn State shaker box for TMR with LFS added should be considered when using the top screen as a measure of adequacy of dietary effective fiber. It is important that a baseline TMR particle distribution be determined prior to LFS being added to the ration. Addition of LFS to TMR appeared to alleviate the problem of sorting against the coarse particle fraction, as shown by the lack of increase in percentages retained on the top screen of the Penn State shaker box for refusals. Particle size data from bunk mix samples taken at various intervals between feeding and push-out were in agreement with refusal data presented in Table 1. It should be noted that these would not be considered to be dry TMR, as they averaged about 55% DM across the farms with a range of 51 to 58% DM. A 2 lb. LFS/cow/day TMR inclusion appeared to be more effective than a 1 lb. LFS/cow/day TMR inclusion. Adding LFS as the final ingredient in TMR was more effective for reducing sorting than adding LFS to forage, which was more effective than adding LFS to concentrates. An added potential benefit of adding LFS to TMR to prevent sorting is the addition of rumen-fermentable carbohydrate to the diet through molasses and (or) whey.

Addition of Sugars to Total Mixed Rations

Hoover and Webster (1997) suggested that dairy cows might benefit from the feeding of sugar supplements. Morales et al. (1989) evaluated the lactation response to dietary addition of cane molasses. Thirty-six mature Holstein cows in mid- to late-lactation were used. Molasses was substituted for ground corn in TMR at 0, 4, or 8% of diet DM. With 35% alfalfa silage diets, 8% added molasses depressed DMI, milk yield, and milk fat and CP percentages compared with control and 4%-added molasses diets. Milk fat test was increased 0.2 percentage units with 4%-added molasses compared with the control. With 65% alfalfa silage diets, 8%-added molasses increased DMI and reduced milk CP percentage. There was no effect ($P > 0.10$) of 4%-added molasses in 65% alfalfa silage diets. With 30% cottonseed hull diets, molasses addition at both levels increased milk yield and milk fat percentage. The efficacy of molasses in the diet depended on the type and amount of roughage fed and the concentration of molasses in the diet. Also, adding molasses directly to TMR for cottonseed hull diets may have improved the response to molasses compared with the alfalfa silage diets where molasses was added to concentrates that were then mixed in the TMR.

Direct addition of dietary sugar did not improve lactation performance either as 1.5% brown-sugar product in TMR (Murphy et al., 1997) or as 1.5% sucrose in TMR (Nombekela and Murphy, 1995). Partial substitution of dietary starch with sucrose has been found to increase ruminal microbial protein production (Huhtanen, 1988; Khalili and Huhtanen 1991a), but ruminal and total-tract fiber digestion may be reduced (Khalili and Huhtanen 1991b).

Results of a study by Broderick et al. (2000) are presented in Table 2. Diets contained 40% alfalfa silage, 20% corn silage, 20.5% rolled high-moisture shelled corn, 9% soybean meal, 2% fat, 1% vitamin-mineral supplement, and 7.5% of a non-structural carbohydrate (NSC) supplement (DM basis), and were fed as TMR to two sets of 24 Holstein cows averaging 90 lb.
of milk per day that were blocked by days in milk. The NSC supplement was comprised of cornstarch and (or) sucrose. A 2-week covariate period was followed by an 8-week experimental period. There were linear increases ($P < 0.05$) in DMI and milk fat percentage and yield as sucrose replaced corn starch in increasing proportions in the NSC supplement. Controlled research is needed to evaluate the sugar aspect of the use of LFS in diets for lactating dairy cows.

Table 2. Effect of replacing supplemental starch with sucrose on lactation performance by dairy cows (Broderick et al., 2000).

<table>
<thead>
<tr>
<th>Item</th>
<th>% sucrose</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
</tr>
<tr>
<td>DMI, lb/d</td>
<td>53.9</td>
</tr>
<tr>
<td>Milk, lb/d</td>
<td>85.6</td>
</tr>
<tr>
<td>FCM, lb/d</td>
<td>89.1</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.81</td>
</tr>
<tr>
<td>lb/d</td>
<td>3.23</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.24</td>
</tr>
<tr>
<td>lb/d</td>
<td>2.73</td>
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</tbody>
</table>

References


Burato, G. M., J. A. Voelker, and M. S. Allen. 2001. Effects of pretrial milk yield on feed intake, production, and feeding behavior responses to forage particle size by lactating cows. J. Dairy Sci. 84(Suppl.1):(abstr.)


