Recent Applications of Liquid Feed Supplements in Rations for Lactating Dairy Cows

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Liquid feed supplements **(LFS)** have a long history of use in dairy cattle feeding programs. Initially, LFS were used in lick tanks as a source of non-protein nitrogen **(NPN)** and molasses for dry cows and replacement heifers. They have also long been used as silage additives.

More recently, with the increased popularity of feeding total mixed rations **(TMR)**, LFS have been marketed with the following goals:

- safe and uniform delivery vehicle for micro-nutrients to TMR
- safe delivery vehicle for NPN to TMR
- improve NPN utilization
- delivery vehicle for molasses or rumen-fermentable carbohydrates to TMR
- reduce dustiness of concentrates and TMR
- reduce sorting of TMR in the feed bunk
- increase intake of TMR
- increase ruminal fiber digestion and microbial protein synthesis
- increase bulk density of TMR.

Recent research with LFS for dairy cattle has focused on their role as a novel delivery vehicle for supplemental fat, undegraded intake protein (UIP), and rumen-fermentable carbohydrates to TMR.

TMR Sorting

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

Martin (1999) determined particle size of TMR and bunk mix at 6-hour intervals post feeding on a commercial dairy. The percents on the top screen of the Penn State – Nasco shaker box 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. An on-farm evaluation of sorting should include particle size determination (Lammers et al., 1996) of TMR, bunk mix, and orts.

Factors that may make a TMR prone to sorting include:

- DM content of forage and mix
- particle size of forage and mix
- variation in bulk density of feed ingredients
- cobs in corn silage
- amount of hay added to mix
- quality of hay
- frequency of feeding
- bunk space
- feed access time.

If sorting is 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
- addition of LFS to TMR to tie up fines.

Although controlled and quantitative research is needed, reports from commercial dairies on the addition of LFS to TMR to reduce sorting have been positive. Use of LFS to increase uniformity of nutrient consumption has been evaluated in beef feedlot diets with positive results (Pritchard, 1993).

LFS for Dietary Fat Addition

Oldick et al. (1997) evaluated the efficacy of fat sources in LFS. Two feeding trials were conducted with 60 Holstein cows per trial during weeks 4 though 19 of lactation (trials were summarized by Firkins and Oldick, 1997). The LFS contained molasses, corn steep liquor, and either no fat **(LNF)**, animal fat **(T; LAF)**, animal fat plus urea **(LTU)**, or soy-oil refining lipid **(LSO)**. In Trial 1 LFS were added to concentrates that were mixed in TMR, while in Trial 2 LFS were added directly to TMR. Cows in both trials were fed individually in tie-stalls.

Trial 1 diet ingredient/nutrient composition and lactation performance data are presented in Tables 1 and 2, respectively. Trial 2 diet ingredient/nutrient composition and lactation performance data are presented in Tables 3 and 4, respectively. The LAF-Lo, -Mid, and -High diets fed in Trial 2 provided LFS intakes of 2, 4, and 6 lb. per cow per day (as-fed basis), respectively. The LNF and LSO diets fed in Trial 2 provided LFS intakes of 4 lb. per cow per day (as-fed basis), respectively.

Table 1. Diet ingredient and nutrient composition in Trial 1 of Oldick et al., 1997.

% of DM	**C**	**RB**	**T**	**LT**	**LTU**	**LSO**
Corn silage	25	25	25	25	25	25
Alfalfa silage	25	25	25	25	25	25
Gr. Corn -Soy Hulls	33	31	29	26	29	27
Rst. Soy Beans	--	8	8	8	8	8
Tallow	--	--	1.5	--	--	--
LFS	--	--	--	5	5	4
CP	17	17	17	17	17	17
Fatty acids	2.2	3.4	4.4	4.3	4.3	4.3
NDF	31	31	31	31	32	32
ADF	19	19	18	19	19	19
NEl, Mcal/lb.	.76	.78	.80	.79	.79	.79

Table 2. Lactation performance in Trial 1 of Oldick et al., 1997.

Item	**C**	**RB**	**T**	**LT**	**LTU**	**LSO**
DMI, lb/d	50	50	51	50	47	50
Milk, lb/d	79	81	83	82	82	83
Fat, %	3.6	3.4	3.8	3.6	3.4	3.6
CP, %	3.16	3.10	3.04	2.99	3.02	2.97
Dig. OM, %	69	67	67	69	67	68

Table 3. Diet ingredient and nutrient composition in Trial 2 of Oldick et al., 1997.

% of DM	**C**	**LNF**	**LAF-Lo**	**LAF-Mid**	**LAF-Hi**	**LSO**
Corn silage	25	25	25	25	25	25
Alfalfa silage	25	25	25	25	25	25
Gr. Corn – Soy Hulls	35	32	33	30	28	31
Soybean meal	9	9	9	9	9	9
CGM-60/BM	4.5	4.5	4.5	4.5	4.5	4.5
LFS	--	3.5	2.5	5.0	7.5	4.0
CP	17.5	17.5	17.5	17.5	17.5	17.5
UIP, % of CP	39	39	39	39	39	39
Ether Extract	3.3	3.2	4.0	4.7	5.3	4.7
NDF	33	32	32	32	32	32
NEl, Mcal/lb.	.76	.76	.77	.79	.81	.78

Table 4. Lactation performance in Trial 2 of Oldick et al., 1997.

% of DM	**C**	**LNF**	**LAF-Lo**	**LAF-Mid**	**LAF-Hi**	**LSO**
DMI, lb/d	47	46	49	49	46	50
Milk, lb/d	72	75	78	79	79	79
FCM, lb/d	69	70	74	75	75	71
Fat, %	3.8	3.7	3.7	3.7	3.6	3.4
CP, %	3.23	3.27	3.14	3.25	3.12	3.17

In Trial 1, feeding supplemental fat increased milk yield and reduced milk CP percent with inconsistent effects on milk fat percent. There were no statistically significant intake, milk yield, or milk composition advantages to supplementing tallow in LFS versus alone. Digestibilities of organic matter, NDF, and fatty acids were unaffected by treatments (Firkins and Oldick, 1997). The primary advantage to feeding tallow in LFS versus alone was in product handling (Firkins and Oldick, 1997).

In Trial 2, feeding the no-fat LFS at 3.5% of diet DM increased milk and FCM yields 3.0 and 1.0 lb per cow per day, respectively, compared to the control. Increasing dietary ether extract content from 3.2% to 4.0%-5.3% (DM basis) using LFS increased milk and FCM yields an additional 3-4 and 4-5 lb per cow per day, respectively. Adding LFS directly to TMR may have improved the response in Trial 2 compared to Trial 1 where LFS were added to concentrates that were mixed in TMR. The 6 lb per cow per day level of LFS (as-fed basis) appeared to be too high, based on reduced DM intake for this treatment.

In lactating dairy cows grazing orchardgrass-clover pasture, Polan et al. (1995) evaluated concentrate mixtures containing either ground corn-soybean meal (**C**), C partially substituted with molasses-animal fat LFS plus corn gluten meal (**MFGM**), C partially substituted with molasses-animal fat LFS plus fish meal (**MFFM**), or C partially substituted with whole cottonseed plus fish meal (**WCFM**). Cottonseed or animal fat supplied fat equal to 1.0 lb per cow per day. Milk yield was 3.3 and 5.1 lb per cow per day higher for MFGM and MFFM, respectively, than WCFM treatments.

LFS for Dietary Fat and Carbohydrate Addition

Maiga et al. (1995) evaluated four diets during weeks 4 through 16 of lactation in 40 Holstein cows. Diets were fed as TMR containing 25% corn silage, 25% alfalfa hay, and 50% concentrate (DM basis). Treatments were no supplemental fat **(C)**, 2% animal fat **(T)**, 2% animal fat from LPS containing molasses and condensed whey **(LPS-T)**, and 2% animal fat plus dried whey **(DWT)**. Results are summarized in Table 5.

Table 5. Lactation response to dietary fat and carbohydrate addition (Maiga et al., 1995).

Item	C	T	LPS-T	DWT
DMI, lb/d	51	54	54	54
Milk Yield, lb/d	70	74	74	74
Fat, %	3.48	3.65	3.52	3.40
CP, %	3.00	2.98	2.91	2.86

Feeding supplemental fat increased DMI and milk yield 3.0 and 4.0 lb per cow per day, respectively. There were no intake, milk yield, or milk composition advantages to supplementing animal fat in LFS versus alone. Intake of LFS was 6.5 lb. per cow per day, which may have been too high for an optimal response. The feeding rate of corn was reduced for LPS-T and DWT-T treatments compared with treatment T, and DM intake and milk yield were unaffected.

LFS for Dietary Carbohydrate Addition

Holden et al. (1995) evaluated LFS in grazing dairy cows. Control cows were fed 10 lb dry concentrate per cow per day in the barn. Treatment cows were substituted with ad libitum access to LFS in lick tanks. Consumption averaged 10 lb DM per cow per day. Cows were in mid to late lactation and the trial lasted 6 weeks. Results are summarized in Table 6.

Table 6. Lactation response to LFS in grazing dairy cows (Holden et al., 1995).

Item	Control	LFS
Milk Yield, lb/d	46	44
Fat, lb/d (%)	1.8 (3.9%)	1.7 (3.8%)
CP, lb/d (%)	1.5 (3.3%)	1.4 (3.2%)

There were no significant differences in milk or component production between dry-concentrate and LFS supplemented cows. When economical, LFS in lick tanks may provide a convenient option for supplementing grazing dairy cows.

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. Results are summarized in Table 7.

With 35% alfalfa silage diets, 8%-added molasses depressed DMI, milk yield, and milk fat and CP percentage. Milk fat test was increased with 4%-added molasses. With 65% alfalfa silage diets, 8%-added molasses increased DMI and reduced milk CP percentage. There was no affect of 4%-added molasses in

65% alfalfa silage diets. With 30% cottonseed hull diets, molasses addition 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 to alfalfa silage diets where molasses was added to concentrates that were then mixed in TMR.

Table 7. Lactation response to dietary molasses addition (Morales et al., 1989).

Item	0% Molasses	4% Molasses	8% Molasses
35% Alfalfa Silage Diets			
DMI, lb/d	51	53	49
Milk Yield, lb/d	58	57	54
Fat, %	3.4	3.6	3.1
CP, %	3.3	3.3	3.1
65% Alfalfa Silage Diets			
DMI, lb/d	45	44	48
Milk Yield, lb/d	51	50	52
Fat, %	3.6	3.6	3.4
CP, %	3.2	3.3	3.1
30% Cottonseed Hull Diets			
DMI, lb/d	53	55	55
Milk Yield, lb/d	57	59	59
Fat, %	2.6	2.7	3.0
CP, %	3.3	3.1	3.3

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 output (Huhtanen, 1988; Khalili and Huhtanen, 1991a), but ruminal and total-tract fiber digestion may be reduced (Khalili and Huhtanen, 1991b).

LFS for Dietary UIP Addition

Wattiaux et al. (1994) evaluated the lactation response to UIP from animal-protein byproducts (APB) in LFS. Six diets were fed to 60 mature Holstein cows during weeks 4 through 17 of lactation. Diets containing 60% alfalfa silage were formulated to contain 18.5% CP with either 5.0, 5.6, 6.2, or 6.8% UIP (DM basis). Diets were formulated using soybean meal, APB, urea, or a combination. The APB were provided in LFS. Results are summarized in Table 8.

Cows fed animal-protein based LFS consumed less DM and produced less milk than cows fed soy-based dry supplement. The APB from LFS comprised 2.7 to 7.0% of diet DM. It appears that use of LFS was unable to overcome the depressing effects on DMI of high-level supplementation of APB in early-lactation cows. The high levels of APB fed in this trial may have precluded a better response to LFS. Also, the high concentrations of APB used in these LFS caused mixing, suspension, and handling problems.

Table 8. Lactation response to UIP from animal-protein byproducts in LFS (Wattiaux et al., 1994)

Item	**Soybean Meal Based Dry Supplement**	**Animal-Protein Based LFS**
Cows, no.	19	38
DMI, lb/d	58	55
Milk, lb/d	89	86
Fat, %	3.42	3.53
CP, %	2.84	2.82

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