Effect of Rumensin on Performance Parameters of Lactating Dairy Cows Nine-trial Registration Summary

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Introduction

To remain competitive in the dairy industry, dairy producers must employ management practices and technology that are economically feasible. Income over feed costs must be optimized to maintain profitability of the dairy. One tool to help improve milk- production efficiency is the use of Rumensin. Rumensin is the first feed ingredient approved by the Food and Drug Administration (FDA) for increased milk production- efficiency (production of marketable solids-corrected milk per unit of feed intake) when fed to dairy cows. The primary objective of the trials was to determine the effects of Rumensin on milk production, milk composition and feed intake during lactation.

Materials and Methods

A series of 9 trials was conducted with six trial sites in the United States (Indiana, North Carolina, Michigan, New York, Florida, and California) and three trial sites in Canada (Ontario, Quebec, and Alberta). Nine hundred sixty six Holstein dairy cows, including 357 primiparous and 609 multiparous cows, were initially assigned to treatment. Rumensin was fed beginning 21 +/- 3 days before expected calving and continued through the full lactation cycle to 7 days in milk (DIM) of the second lactation at all trial sites. In addition, at the California, Florida, and New York trial sites, cows continued through 200 DIM +/- 3 days into their second lactation. The study employed a randomized complete block design. The four treatments were Rumensin at 0 g/ton (control), 7 g/ton, 15 g/ton and 22 g/ton (100% dry matter basis). Rumensin was fed continually throughout the entire trial.

Rations and Feed Ingredients

Rations were typical of the regions where the trials were conducted, and met or exceeded nutrient requirements (1989 National Research Council, Sixth Edition). Nutrient specifications of the diets fed are summarized in Table 1. All rations were designed to contain a minimum of 19% acid detergent fiber (ADF) or 25% neutral detergent fiber (NDF) on a dry matter basis. Cows were offered fresh feed once or twice daily with weights of refused feed recorded daily.

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Milk Yield and Composition

Cows were milked 2 times daily at all sites except at the Florida and Michigan locations where cows were milked 3 times daily. Milk weights were recorded at each milking for daily yield. Milk composition was determined weekly (excluding the first week following calving) and represented each milking from each cow during a 24-hour period. Components determined included percent fat, protein, lactose and total solids.

Feeding Management

The nutrient specifications for each total mixed ration (TMR) are listed in Table 1. Cows were fed TMR-1 from calving to at least 84 ± 3 days into lactation. The primary criteria for changing cows to TMR-2 was when body condition score (BCS) was greater or equal to 3.0 and daily milk production was less than 69 lb/day (multiparous cows) or less than 54 lb/day for primiparous cows. Cows were fed TMR-2 for a minimum of 28 days (unless dry off was indicated due to low milk production). Cows were changed from TMR-2 to TMR-3 when BCS was greater than 3.5. The TMR-3 was fed until the end of lactation. Rations were offered to achieve a 5 to 10 % feed refusal.

Body Weight and Body Condition Score

Both body weight and body condition score were determined according to the following schedule: at calving 1, at 28-day intervals until dry-off, at the change from far-off to close-up TMR, at calving 2 and at the end of treatment. In addition, body weights were collected at 14 ± 3 days in milk, and at 14-day intervals to 112 ± 3 DIM in milk.

At the Lactation 2 sites, body weights were determined at 14 ± 3 DIM, at 14-day intervals to 112 ± 3 DIM, at 28-day intervals until 203 ± 3 DIM or the end of treatment.

Statistical Analysis

Data from all the trial sites were pooled for statistical analysis. The minimum effective concentration was determined using a non-overlapping confidence interval technique from the dose-response relationship between monensin and SCM production efficiency during lactation 1.

Results and Discussion

Milk Production and Composition

Average daily production of milk, SCM, 3.5% FCM production and milk composition are summarized in Table 2. Adjusting milk yield to a SCM basis allowed comparison of milk containing different percentages of components on an equal energy basis. The equation used to calculate the amount of SCM was:

SCM = Milk, lb X [(12.24 X Fat%) + (7.10 X Protein %) + (6.35 X Lactose %) – 0.0761]

During lactation 1, there were no significant differences among treatment groups for milk production (SCM and 3.5% FCM). During early lactation, milk production was increased above controls in the Rumensin groups, while dry matter intake was unchanged. Milk fat percentage was not different at 7 g/ton compared to controls, but was reduced ($P<0.01$) in the 15 g/ton and 22 g/ton treatments. Daily yield of milk fat was not different from controls for any group.

Milk protein percentage was not different from controls for the 7 g/ton and 15 g/ton treatments, but was reduced ($P<0.05$) in the 22 g/ton treatment. Average daily milk protein yield was at the 7 g/ton dose ($P<0.05$) compared to controls, but was unchanged at the 15 g/ton dose and the 22 g/ton dose. During lactation 2 (200 ± 3 DIM), no statistical differences existed for milk yield or any of the milk components compared to controls.

Dry Matter and Net Energy Intakes

Average daily dry matter and NE_L intake are presented in Table 3. Dry matter intake for the 7 g/ton treatment group was not different from controls. Dry matter intake compared to control was reduced ($P<.05$) from treatment start to calving 1 (22 g/ton), during lactation 1 (15 g/ton and 22 g/ton) and from dry-off to calving 2 (22 g/ton). During lactation 1, intake was reduced 1.1 lbs/day (2.5 percent) and 1.6 lbs/day (3.5%) for both the 15 g/ton and 22 g/ton doses, respectively, compared to controls. During both dry periods, intake was reduced (1.1 lb/day in dry period 1 and 1.7 lb/day in dry period 2) at the 22 g/ton level ($P<0.05$), but equaled controls at 7 g/ton and 15 g/ton. No differences in dry matter intake or NE_L intake were observed between treatments during lactation 2 (200 ± 3 DIM). Dry matter intake during the first 14 weeks of lactation 1 was not different for any Rumensin dose compared to controls.

Body Weight and Body Condition Score

Body weight and body condition score data are presented in Table 4. Average BCS did not differ during any study period. During lactation 1, the change in BCS from calving to the lowest measured score during the first 203 days of lactation was less ($P<.05$) in the 7 g/ton, 15 g/ton, and 22 g/ton dose groups compared to controls. The results demonstrated that cows fed Rumensin maintained higher body condition compared to control cows. However, these differences (less than 0.10 units) are not biologically meaningful because they are below the smallest discernable difference in BCS in this study, which was 0.25 units (1-5 scale). There were no significant differences on body weight or body weight change among dose groups during any part of lactation or the dry period.

Milk-Production Efficiency

Milk-production efficiency (MPE) is expressed as lbs marketable SCM per Mcal NE_L intake corrected for changes in body weight. Energetics of body-weight change were considered according to the following formula (1989 National Research Council, Sixth Edition):

$$MPE = \frac{\text{SCM, lb}}{NE_L - (k \times \text{Change in Body Weight, lbs})}$$

If body weight increased, k = 2.32
If body weight was lost, k = 2.23

As shown in Figure 1, MPE increased linearly with dose of Rumensin during lactation 1, with the 15 g/ton and 22 g/ton doses being greater than the 0 g/ton dose. Figure 2 shows that MPE was improved in a consistent manner by increased doses of Rumensin at each trial site.

What is the Effective Dose of Rumensin?

To determine the minimum effective dose of Rumensin, the confidence region for the dose response curve was estimated using the approach shown in Figure 3. The minimum effective dose was defined to be the lowest non-zero concentration for which the lower limit of the 95% confidence interval did not overlap with the upper limit of the 95% confidence interval for the 0 g/ton or control dose. This approach was performed with non-overlapping confidence intervals around the 0 g/ton dose group and 15 g/ton dose group, which was the lowest effective dose that was a defined dose in the study. The minimum effective dose was determined to be 11 g/ton.

Thus, Rumensin is expected to significantly increase milk-production efficiency within the dose range of 11 g/ton to 22 g/ton (dry matter basis).

Key Points

When Rumensin was fed to dairy cows:

- The efficiency of milk production was increased within the dose range of 11g/ton to 22 g/ton (dry matter basis).
- Production of marketable solids-corrected milk (SCM) or marketable 3.5% fat-corrected milk (FCM) did not change when dry matter intake was reduced.
- Dry matter intake was not affected in early lactation but was reduced at 15 g/ton and 22 g/ton during the second half of lactation.
- Milk fat percent was not affected by 7 g/ton dose but was reduced at 15 g/ton and 22 g/ton.
- Milk protein percent was not affected by the 7 g/ton and 15 g/ton levels but was reduced at the 22 g/ton dose.

- Milk fat and milk protein daily yields were maintained equal to controls.
- Body weight was not different from controls during lactation.

Conclusion

Rumensin is effective and approved by FDA for use in dairy cows to increase Milk-production efficiency (production of marketable solids-corrected milk per unit of feed intake) at doses at or in between 11 g/ton and 22 g/ton on a 100% dry matter basis.

Table 1. Nutrient Specification Ranges of Total Mixed Rations

Ration	**NE_L[a,b] Mcal/lb**	**Crude Protein[a] %**	**Calcium[a,c,d] %**	**Phosphorus[a] %**
Far-Off Dry	0.50-0.67	12.0-18.0	0.40-0.75	0.24-0.50
Close-Up Dry	0.68-0.76	13.0-16.5	0.40-0.75	0.35-0.50
TMR 1	0.76-0.80	17.5-19.0	0.70-1.20	0.48-0.66
TMR 2	0.70-0.76	15.0-17.5	0.60-1.20	0.40-0.50
TMR 3	0.64-0.70	13.0-16.5	0.60-1.20	0.35-0.50

[a]Ranges based on National Research Council (NRC, Nutrient Requirements of Dairy Cattle, 6th Edition), 1989.
[b]Net energy for lactation.
[c]Lactation rations with added fat contained a minimum of 0.9% calcium.
[d]Calcium specifications could be exceeded for locations using dietary cation-anion difference (DCAD) in the close-up TMR.

Table 2. Marketable Milk Production and Composition

	Dose of Monensin				
Variable	**0 g/ton LSMean[a]**	**7 g/ton LSMEAN**	**15 g/ton LSMEAN**	**22 g/ton LSMEAN**	**SE[b]**
Lactation 1					
Marketable milk yield (lb/d)	63.1	64.6	64.6	65.5[e]	1.80
Fat (%)[c]	3.65	3.59	3.49[d]	3.38[d]	0.08
Fat Yield (lb/day)	2.34	2.38	2.29	2.27	0.04
Protein (%)[c]	3.15	3.16	3.13	3.10[e]	0.02
Protein Yield (lb/day)	2.04	2.10[e]	2.08	2.09	0.07
Lactose (%)	4.83	4.79	4.80	4.81	0.03
Solids Non-Fat (%)[c]	8.73	8.69	8.68	8.66[e]	0.04
Total Solids (%)[c]	12.38	12.29	12.17[e]	12.04[d]	0.09
Marketable SCM (lb/day)[f]	58.1	58.9	58.0	58.0	1.32
Marketable 3.5% FCM[f]	62.9	63.8	62.7	62.7	1.32
Lactation 2					
Marketable milk yield (lb/d)	72.3	71.2	75.0	73.9	2.90
Fat (%)	3.65	3.65	3.66	3.50	0.15
Protein (%)	3.03	3.01	3.01	3.00	0.04
Lactose (%)	4.73	4.65	4.75	4.77	0.07
Solids Non-Fat (%)	8.50	8.41	8.48	8.49	0.10
Total Solids (%)	12.15	12.07	12.14	11.99	0.21
SCM (lb/day)	66.7	65.3	69.1	67.5	3.3
3.5% FCM (lb/day)	73.5	72.6	76.6	74.1	4.0

[a]Least-squares mean.
[b]Standard error.
[c]Linear decrease with increasing dose of monensin ($P<0.05$).
[d]Different from 0 g/ton dose group ($P<0.01$).
[e]Different from 0 g/ton dose group ($P<0.05$).
[f]Calculation of SCM and 3.5% FCM was based only on that part of milk and component yields that quality as marketable milk.

Table 3. Dry Matter (lb/day) and Net Energy of Lactation Intake (Mcal/day)

	Dose of Monensin				
	0 g/ton LSMEAN[a]	**7 g/ton LSMEAN**	**15 g/ton LSMEAN**	**22 g/ton LSMEAN**	**SE[b]**
Treatment Start to Calving 1					
DM Intake (lb/d)	24.2	24.2	24.0	23.1[e]	0.4
NE_L Intake (Mcal/d)	17.2	17.1	17.0	16.3[e]	0.7
Lactation 1					
DM Intake (lb/d)[c]	43.9	44.1	42.8[e]	42.3[f]	0.9
NE_L Intake (Mcal/d)[c]	33.8	33.9	32.9[e]	32.6[f]	0.9
Dry Off to Calving 2					
DM Intake (lb/d)[c]	28.2	27.6	27.6	26.5[f]	0.9
NE_L Intake (Mcal/d)[c]	18.7	18.1	18.2	17.5[f]	0.7
Lactation 2 (200 days)[d]					
DM Intake (lb/d)	48.3	48.9	48.3	46.3	2.0
NE_L Intake (Mcal/d)	38.0	38.6	38.1	36.4	1.9

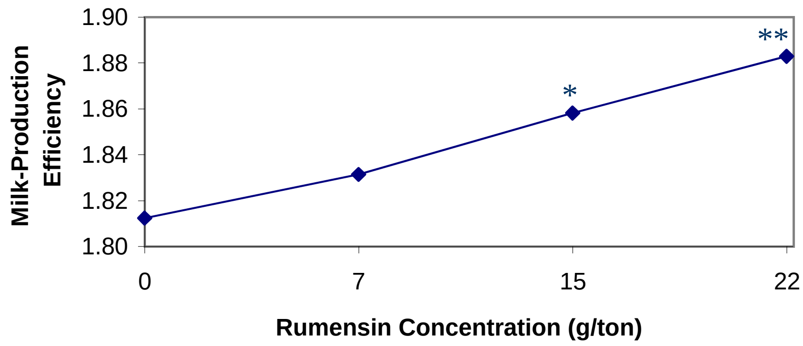
[a]Least-squares mean.
[b]Standard error.
[c]Linear decrease with increasing dose of monensin (P<0.01).
[d]Includes cows only from California, Florida, and New York locations.
[e]Different from 0 g/ton dose group (P<0.05).
[f]Different from 0 g/ton dose group (P<0.01).

Table 4. Body Weight and Body Condition Score

	Dose of Monensin				
	0 g/ton LSMEAN[a]	**7 g/ton LSMEAN**	**15 g/ton LSMEAN**	**22 g/ton LSMEAN**	**SE[b]**
Lactation 1					
Average BCS	3.01	3.01	3.05	3.04	0.05
Change in BCS	-0.13	-0.04[c]	-0.05[c]	-0.06[d]	0.08
Average BW	1318	1323	1325	1329	14.0
Change in BW	134	156	143	154	9.0
Dry-Off to Calving 2					
Average BCS	3.39	3.36	3.42	3.39	0.07
Change in BCS	0.09	0.06	0.08	0.04	0.04
Average BW	1594	1592	1603	1598	24.0
Change in BW	-15	-18	-13	-31	11.0
Lactation 2 (200 days)[e]					
Average BCS	2.89	2.88	2.97	2.91	0.06
Change in BCS	-0.32	-0.27	-0.22	-0.30	0.08
Average BW	1322	1313	1344	1344	6.0
Change in BW	-53	-35	-18	-31	8.0

[a]Least-squares mean.
[b]Standard error.
[c]Different from 0 g/ton dose group (P<0.01).
[d]Different from 0 g/ton dose group (P<0.05).
[e]Includes cows only from California, Florida, and New York locations.

Figure 1. Milk-Production Efficiency (lb Marketable SCM/Mcal NE_L)



* P< 0.05
** P < 0.01

Figure 2. Milk-Production Efficiency by Trial Site (lbs marketable solids-corrected milk/Mcal NEL consumed, adjusted for body weight change)

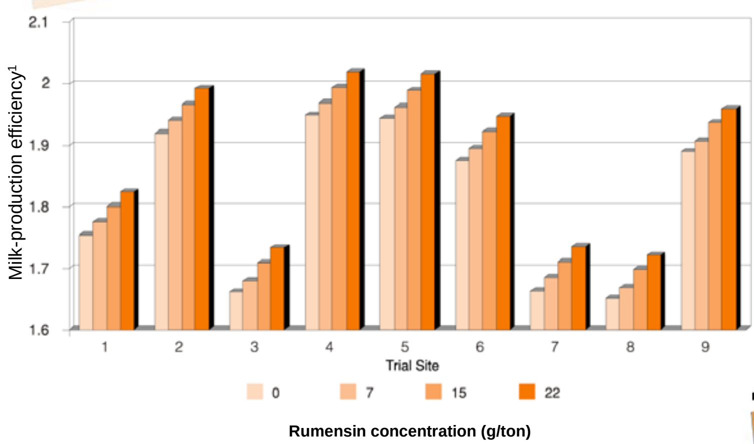


Figure 3. Determination of lowest significant dose of Rumensin for Milk-Production Efficiency (kg/Mcal NE_L)