Effects of Lasalocid and Undegradable Protein on Growth and Body Composition of Holstein Heifers

T. M. STEEN,[1] J. D. QUIGLEY, III,[2] R. N. HEITMANN, and J. D. GRESHAM[3]
Department of Animal Science
University of Tennessee
Knoxville 37901-1071

ABSTRACT

Effects of lasalocid (0 or 200 mg/d per head) and undegradable intake protein (32 vs. 42% of CP in concentrate) on growth and body composition were evaluated using 32 Holstein heifers (253 kg initial BW, SE = 4). Heifers were housed in an open barn in eight pens of 4 heifers and fed 12.7 kg per pen daily of experimental concentrate with medium quality fescue hay for ad libitum consumption for 12 28-d periods. Body measurements were taken every 28 d; ultrasonic fat and muscle depths at the 13th rib, empty body fat, and protein were measured every 84 d. Heart girth and fat and muscle depth at the 13th rib increased when lasalocid and undegradable protein were fed individually, but not in combination. Rates of average daily gain and feed efficiency were not increased significantly when lasalocid and undegradable protein were fed. Data suggest that the combination of lasalocid and undegradable protein may have impaired microbial protein synthesis in the rumen, thereby influencing changes in body composition.
(**Key words**: heifers, undegradable protein, lasalocid)

Abbreviation key: **DIP** = degradable intake protein; **EBF** = empty body fat; **EBP** = empty body protein; **H0** = high undegradable protein, 0 mg/d of lasalocid; **H200** = high undegradable protein, 200 mg/d of lasalocid; **L0** = low undegradable protein, 0 mg/d of lasalocid; **L200** = low undegradable protein, 200 mg/d of lasalocid; **UIP** = undegradable intake protein.

INTRODUCTION

Ionophores have been shown to increase rates and efficiency of gain in dairy (3) and beef (4, 9, 27) cattle. Ionophores appear to shift ruminal fermentation toward increased concentrations of propionate and decreased acetate (4). The ionophore, monensin, depressed bacterial synthesis (7, 21), and lasalocid reduced protozoal numbers (4). Although there is evidence that monensin increases carcass fat in beef steers (25) and dairy bulls (15), a review by Goodrich et al. (9) indicated little consistent effect on body composition. Meinert et al. (18) recently reported no significant effect of monensin on rate or composition of gain in Holstein heifers fed 200 mg of monensin daily. However, little is known about effects of the ionophore lasalocid on rate and composition of gain in dairy heifers. Composition of gain in replacement heifers is important, particularly during the prepubertal period (23). Heifers fed for rapid growth may deposit intramammary adipose tissue at the expense of secretory tissue, which could result in decreased lifetime milk yield (23, 26). Excessively conditioned heifers also are subject to dystocia and other metabolic disorders (16).

Inclusion of undegradable intake protein (UIP) has been recommended in dairy heifer rations (19) and may increase rates of gain, although results have been equivocal (17, 24, 28). Because ionophores exert a protein-sparing effect (4, 20, 21), use of lasalocid in combination with UIP feeding may influence rate or composition of gain. Patterson et al. (20) reported an interaction of UIP and lasalocid in growth of lambs; growth responses to lasalocid were dependent upon type of protein fed. Thus, our objective was to determine

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[1]Countrymark Cooperative, Indianapolis, IN.
[2]Reprint requests.
[3]University of Tennessee, Martin.

TABLE 1. Ingredient composition of experimental feeds.

Item	Treatment[1]			
	L0	L200	H0	H200
	(% as fed)			
Corn, ground	31.4	31.3	49.3	48.9
Wheat middlings	30.0	30.0	3.1	3.1
Urea	.5	.5	...	...
48% CP Soybean meal	5.1	5.1	...	...
Cottonseed meal	...	...	9.5	9.5
Meat and bone meal	...	...	3.1	3.0
Fish meal	...	...	1.7	1.7
Soybean hulls	24.1	24.2	25.3	25.8
Molasses	2.5	2.5	2.5	2.5
Fat	1.0	1.0	.9	.9
Vitamins and minerals[2]	5.4	5.4	4.5	4.6
Lasalocid	...	.04	...	.04

[1]Treatments: L0 = 32% undegradable intake protein (UIP), 0 mg of lasalocid; L200 = 32% UIP, 200 mg of lasalocid; H0 = 42% UIP, 0 mg of lasalocid; H200 = 42% UIP, 200 mg of lasalocid.

[2]Includes limestone, binder, dicalcium phosphate, Dynamate®, salt, and vitamin and mineral premix to provide a minimum of 50 ppm of Fe, .1 ppm of Co, 10 ppm of Cu, 40 ppm of Mn, 40 ppm of Zn, .25 ppm of I, .2 ppm of Se, 2200 IU/kg of vitamin A, 300 IU/kg of vitamin D, and 25 IU/kg of vitamin E.

effects of lasalocid and protein undegradability on rate and composition of gain in replacement heifers reared in confinement.

MATERIALS AND METHODS

Heifer Assignments and Feed Management

Thirty-two Holstein heifers (253 kg initial BW, SE = 4) were assigned randomly to a 2 × 2 factorial arrangement of treatments. Experimental concentrates were formulated to contain 32% UIP and to provide 0 (**L0**) or 200 (**L200**) mg/d of lasalocid or 42% UIP and 0 (**H0**) or 200 (**H200**) mg/d of lasalocid. Concentrates (Table 1) were prepared commercially, and UIP concentrations were formulated from NRC estimates (19). Heifers were housed in an open barn in eight pens of 4 heifers each for 12 28-d periods. Heifers were offered 12.7 kg of experimental concentrate per pen once daily, and medium quality fescue hay was offered for ad libitum consumption. Hay refusals were weighed daily, and amount of hay offered was increased when refusals were below approximately 5%. Feed samples were obtained weekly and composited monthly for analysis of total DM (2), ADF, NDF (8), Ca (atomic absorption spectrophotometry), and P (11). Degradabilities of concentrates and hay were estimated as described by Krishnamoorthy et al. (14), using an incubation time of 18 h (concentrate) or 48 h (hay). Experimental concentrates always were consumed completely. Fresh water was available at all times.

Body Measurements

At the beginning of the study and every 28 d thereafter, BW, height (at withers), length (point of shoulder to pins), heart girth, and hook width (exterior measurement of the tuber coxae) were measured. Fat and muscle depths at the 13th rib were determined ultrasonically (Dataline 3.5-MHz scanning ultrasound, General Electric Co., Fairfield, CT) at the beginning of the study and every 84 d afterward.

Body Composition

Estimates of empty body fat (**EBF**) and protein (**EBP**) on d 0 and every 84 d thereafter were determined using urea dilution (13). A 20% solution of urea N in 9% saline was infused via jugular catheter at 130 mg of urea/kg of BW during a 2-min period with a peristaltic pump. Approximately 10 ml of blood were collected via jugular catheter at 0 and 12 min after mean infusion time. Blood was added to 2 μl of sodium heparin and placed on ice until transported to the laboratory. Plasma was separated by centrifugation (3000 × g) and frozen (–20°C) until analyzed for urea N (urea kit number 640, Sigma Chemical Co., St. Louis, MO). Change in urea N concentration from 0 to 12 min was used to determine urea space (US), percentage of EBF, and percentage of EBP using models of Hammond et al. (10):

$$EBF = -5.9 + .14 \times US + .30 \times BW$$
$$EBP = 16.6 - .009 \times US + .005 \times BW.$$

Statistical Analyses

Data were analyzed as described by Allen et al. (1). Body measurements and estimates of body composition of each heifer were analyzed individually by linear or polynomial regression on months of age. Regression coefficients were analyzed subsequently by multivariate ANOVA using a completely randomized design. Single degree of freedom contrasts compared 0 versus 200 mg of lasalocid, low versus high UIP, and interaction. Regression coefficients also were used to predict body measurements and estimates of body composition at 20 mo of age (average age at termination of the study), which subsequently were analyzed as a completely randomized design. Intake and feed efficiency were analyzed as a split-plot design using pen within treatment as whole plot error. Significance at $P < .05$ was used throughout unless otherwise noted.

RESULTS AND DISCUSSION

Chemical composition of experimental concentrates and hay is in Table 2; crude protein was slightly lower in L0 than in others. The NDF of hay (66.5% of DM) was indicative of late vegetative stage cutting (19). The amount of lasalocid was slightly lower than the 63 ppm formulated in L200 and H200 treatments. Therefore, heifers on L200 and H200 averaged 184 and 187 mg/d of lasalocid, respectively. Trace amounts occasionally measured in control samples may have resulted from contamination of samples during feed preparation, sampling, or analysis.

Heifers were generally healthy throughout the experiment. Two cases of foul foot were reported and treated. Observation for signs of estrus was performed daily, and heifers were bred by AI at the first observed estrus after reaching 14 mo of age and 341 kg of BW. Body weights and heights (Table 3) of heifers used in the study were typical for heifers of similar ages (12).

Use of ultrasound to determine subcutaneous fat depth was difficult during the first 3 to 6 mo of the study. Amounts of fat (1 to 2 mm) were at the minimum detectable limits of our equipment, making reliable measurement difficult. By the end of the study, however, measurement of fat depth was more reliable. Conversely, measurement of muscle depth generally was reliable throughout the study; muscle depth averaged 52 mm. Coefficients of variation were 36% for fat depth and 22% for muscle depth.

TABLE 2. Chemical composition of feeds.

	Treatment[1]									
Item	L0		L200		H0		H200		Hay	
	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE
DM, %	87.4	.4	87.4	.6	87.5	.4	87.5	.4	85.5	.8
CP, % of DM	15.5	.4	16.3	.2	16.6	.3	16.2	.2	12.0	.7
ADF, % of DM	16.3	.3	16.2	.3	16.6	.4	14.5	1.2	42.4	1.0
NDF, % of DM	31.5	.6	31.8	.8	29.9	.8	27.5	1.1	66.5	1.5
Ca, % of DM	1.2	.1	1.1	.1	1.1	.1	1.0	.1	.7	.1
P, % of DM	.7	.1	.7	.1	.7	.1	.7	.1	.4	.1
Lasalocid, mg/kg of DM	4.2	2.2	57.9	2.2	.9	.6	58.8	3.7	...	...
UIP,[2] % of total CP	32.4	1.6	32.8	1.7	44.3	1.8	42.6	1.7	33.7	1.8

[1]Treatments: L0 = 32% undegradable intake protein (UIP), 0 mg of lasalocid; L200 = 32% UIP, 200 mg of lasalocid; H0 = 42% UIP, 0 mg of lasalocid; H200 = 42% UIP, 200 mg of lasalocid. n = 9 per treatment.

[2]UIP = Undegradable intake protein. Estimated using method of Krishnamoorthy et al. (14).

TABLE 3. Descriptive statistics of data used in regression analyses.

Item	n	Minimum	Maximum	Mean	SE	Regression[1]		
						Type	r^2	SD
Age at start, mo	32	7.7	10.1	8.8	.1			
Age at breeding,[2] mo	28	14.9	18.2	16.0	.2			
BW, kg	416	209.8	553.0	368.7	3.6	L	.97	.01
Height, cm	416	105.4	137.2	123.6	.3	Q	.93	.03
Heart girth, cm	288	134.2	200.7	174.3	.5	Q	.83	.10
Hook width, cm	348	30.0	55.0	43.7	.2	L	.93	.06
Length, cm	287	114.3	162.6	145.0	.5	L	.74	.16
Fat depth, mm	160	1	13	7	.2	Q	.88	.13
Muscle depth, mm	158	30	71	52	.9	Q	.90	.09
Fat, % of empty BW	154	5.4	22.9	12.3	.2	L	.53	.28
Protein, % of empty BW	155	16.8	19.0	17.9	.0	L	.93	.05

[1]Type of regression: L = linear, Q = quadratic; r^2 for regression of variable on age, n = 32; SD = standard deviation of mean r^2.

[2]Four heifers failed to show signs of estrus or to conceive successfully.

Estimates of EBF ranged from 5.4 to 22.9%, and estimates of EBP ranged from 16.8 to 19.0% (Table 3). These estimates agree well with data of Hammond et al. (10); they reported a range of 5.4 to 14.3% for EBF and 16.6 to 19.5% for EBP in Holstein steers weighing 143 to 404 kg. Meinert et al. (18) also reported a range of 5.5 to 19.8% for EBF and 16.7 to 19.4% for EBP in Holstein heifers ranging in BW from 164 to 614 kg.

Regressions of dependent variables on age were described adequately by linear or quadratic terms (Table 3). Average r^2 ranged from .53 (EBF) to .97 (BW); only EBF and length had r^2 below .80. Means of coefficients are in Table 4. Although coefficients of BW and height were not significantly affected by treatment, slopes of BW regressions were increased by 4 and 6% when lasalocid and UIP were fed separately. However, when lasalocid and UIP were fed together, slope of the BW line increased only 1%. Slopes correspond to average daily gain of 636, 661, 674, and 644 g/d for heifers fed treatments L0, L200, H0 and H200, respectively.

Interaction of lasalocid and UIP was significant in heart girth, and a trend ($P < .10$) for lasalocid × UIP interaction was noted for fat and muscle depth (Table 4). Also, estimate of EBP tended to be influenced by the interaction of lasalocid and UIP ($P = .13$). Generally, heifers fed L200 and H0 maintained larger heart girth and greater fat and muscle depths at the 13th rib, particularly during the first 6 mo of the study.

Collectively, these data imply a slight alteration of growth of heifers fed lasalocid and UIP in combination. It is possible that ruminal degradation of protein required for microbial synthesis was impaired in heifers fed H200. Ionophores exhibit a protein- or N-sparing effect (4, 21) and may decrease microbial protein synthesis as much as 42% (4). Ruminal NH_3 concentrations are reduced with additions of monensin that decrease deaminative or proteolytic enzymes or reduce the overall numbers of bacteria in the rumen (5). Microbial protein usually constitutes most of the protein reaching the small intestine (6). Lasalocid fed in addition to higher UIP in concentrate may have impaired ruminal microbial protein synthesis because of insufficient ruminal N.

Estimates of degradable intake protein (**DIP**) and UIP were calculated using mean pen BW and average daily gain. Requirements of heifers for DIP and UIP were calculated using formulas from NRC (19). Estimates of DIP averaged 133, 128, 117, and 123% of NRC requirement for heifers fed L0, L200, H0, and H200 treatments, respectively, over the 12-mo study. However, during the first 2 mo of the study, DIP averaged 130, 127, 102, and 110% of requirement in heifers fed L0, L200, H0, and H200 treatments, respectively. Reduced degradation of DIP in the rumen caused by lasalocid may have decreased N available for microbial synthesis, thereby reducing total protein available for intestinal absorption.

Intake of feeds and nutrients (Table 5) was unaffected by treatment. Although ad libitum intakes were lower than those in other reports (22), the high forage ration and limited digestibility of fescue hay probably limited intake. Feed efficiency was not significantly affected by treatment.

Age at breeding tended to be influenced by the interaction of lasalocid and UIP ($P < .11$). Four heifers that failed to conceive or to show estrus were not included in calculation of age at breeding. Average ages at first breeding were 16.2, 15.5, 16.1, and 16.4 mo (covariately adjusted for age at the start of the study; SE = .3) for heifers on treatments L0, L200, H0, and H200, respectively. The reduction of .7 mo is consistent with data of Meinert et al. (18), who

TABLE 4. Regression coefficients of body measures in heifers fed 32 or 42% undegradable intake protein (UIP) in concentrate and 0 or 200 mg/d of lasalocid.

	Treatment[1]					Contrasts[2]		
Item	L0	L200	H0	H200	SE	1	2	3
BW, kg						NS[3]	NS	NS
Intercept	97.865	98.219	94.793	99.495	6.432			
Linear	17.8017	18.5123	18.8703	18.0419	.5385			
Height, cm						NS	NS	NS
Intercept	80.272	85.370	82.762	84.977	3.791			
Linear	4.4789	3.6761	4.0792	3.5664	.5069			
Quadratic	–.0986	–.0712	–.0797	–.0627	.0167			
Heart girth, cm						NS	NS	*
Intercept	40.353	32.038	28.318	–6.920	34.983			
Linear	13.7113	15.1725	15.5895	18.5159	3.8686			
Quadratic	–.3369	–.3874	–.3933	–.4622	.1054			
Hook width, cm						NS	†	NS
Intercept	27.754	30.068	29.442	30.290	.759			
Linear	1.0492	.9575	.9891	.8820	.0448			
Length, cm						NS	NS	NS
Intercept	99.607	100.681	104.9389	106.653	3.674			
Linear	2.7230	2.6009	2.4262	2.3019	.2094			
Fat depth, mm						NS	NS	†
Intercept	–13.465	–19.753	–21.942	–17.600	3.001			
Linear	2.3759	3.3552	3.7918	3.0326	.4384			
Quadratic	–.0645	–.0952	–.1130	–.0863	.0144			
Muscle depth, mm						NS	†	†
Intercept	–6.099	–13.057	–24.771	–8.841	10.541			
Linear	6.4688	7.2008	8.4116	5.8923	1.5185			
Quadratic	–.1627	–.1680	–.2014	–.1205	.0502			
Body fat, % of BW						NS	NS	NS
Intercept	6.573	4.680	6.819	8.246	1.209			
Linear	.3900	.4853	.3693	.2915	.0793			
Body protein, % of BW						NS	*	NS
Intercept	16.402	16.598	16.338	16.268	.0823			
Linear	.1010	.0933	.1099	.1096	.0049			

[1]Treatments: L0 = 32% UIP, 0 mg of lasalocid; L200 = 32% UIP, 200 mg of lasalocid; H0 = 42% UIP, 0 mg of lasalocid; H200 = 42% UIP, 200 mg of lasalocid.

[2]Contrasts of multivariate ANOVA: 1 = lasalocid versus no lasalocid; 2 = high UIP versus low UIP; 3 = interaction.

[3]$P > .10$.

†$P < .10$.

*$P < .05$.

TABLE 5. Least squares means of intake and gain to feed ratio by pen[1] in heifers fed 32 or 42% undegradable intake protein (UIP) in concentrate and 0 or 200 mg/d of lasalocid.

	Treatment[2]				
Item	L0	L200	H0	H200	SE
DMI, kg/d	8.8	8.6	8.7	8.6	.1
Concentrate	2.8	2.8	2.8	2.8	.0
Hay	6.0	5.8	5.9	5.8	.1
CP Intake, g/d	107	108	108	108	1
ADF Intake, kg/d	3.0	2.9	3.0	2.9	.1
NDF Intake, kg/d	5.0	4.9	4.9	4.8	.1
Gain:feed, g/kg	81.1	87.2	88.4	84.9	3.7

[1]n = 8; data are expressed on a per heifer basis.

[2]Treatments:L0 = 32% UIP, 0 mg of lasalocid; L200 = 32% UIP, 200 mg of lasalocid; H0 = 42% UIP, 0 mg of lasalocid; H200 = 42% UIP, 200 mg of lasalocid.

reported a reduction of 25 d in heifers fed monensin. Age at calving was unaffected by treatment and averaged 25.4, 24.8, 25.1, and 25.4 mo (covariately adjusted for starting age) in heifers fed L0, L200, H0, and H200, respectively.

A trend ($P < .10$) for UIP to influence hook width was observed (Table 4). Heifers fed high UIP tended toward smaller slope, suggesting that rate of increase in hook width may have been reduced slightly. The smallest slope was in heifers fed H200, which averaged .882 cm/28 d, compared with 1.049 cm/28 d in heifers fed L0.

Prediction of measurements at 20 mo of age (end of the study; Table 6) generally reflected observed changes in growth reported in Table 5. Only predicted muscle depth was affected by treatment, and it was greater when lasalocid and UIP were fed individually.

CONCLUSIONS

Increased UIP and lasalocid, fed individually, caused slight changes in body composition that were consistent with increased rates of gain in moderately growing heifers (600 to 700 g/d). The combination of lasalocid and UIP may have limited microbial protein synthesis, thereby reducing growth, as indicated by several body measures. Age at breeding was reduced when lasalocid was fed alone. Further research is indicated to determine the

TABLE 6. Predicted body measures at 20 mo of age in heifers fed 32 or 42% undegradable intake (UIP) protein in concentrate and 0 or 200 mg/d of lasalocid.

	Treatment[1]					Contrasts[2]		
Item	L0	L200	H0	H200	SE	1	2	3
BW, kg	453.9	468.5	472.2	460.4	8.8	NS[3]	NS	NS
Height	130.4	130.4	132.5	131.2	.8	NS	NS	NS
Heart girth, cm	179.8	180.5	182.8	178.5	1.6	NS	NS	NS
Hook width, cm	48.7	49.2	49.2	47.9	.5	NS	NS	NS
Length, cm	154.1	152.7	153.5	152.7	1.2	NS	NS	NS
Fat depth, mm	8.3	9.3	8.7	8.5	.4	NS	NS	NS
Muscle depth, mm	58.2	63.8	62.9	60.8	1.5	NS	NS	**
Fat, % of BW	14.4	14.4	14.2	14.1	.6	NS	NS	NS
Protein, % of BW	18.4	18.5	18.5	18.5	.1	NS	NS	NS

[1]Treatments: L0 = 32% UIP, 0 mg of lasalocid; L200 = 32% UIP, 200 mg of lasalocid; H0 = 42% UIP, 0 mg of lasalocid; H200 = 42% UIP, 200 mg of lasalocid.

[2]Contrasts: 1 = lasalocid versus no lasalocid; 2 = high UIP versus low UIP; 3 = interaction.

[3]$P > .10$.

**$P < .01$.

effects of lasalocid and UIP on microbial protein synthesis and composition of gain in rapidly growing heifers.

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