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Three Decades of Minnesota Lamb Feeding Research

AGRICULTURAL EXPERIMENT STATION UNIVERSITY OF MINNESOTA

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Three Decades of Minnesota Lamb Feeding Research

During the 1920's and 30's, hundreds of Minnesota farmers fed out a carload or two of feeder lambs annually. Since the 1950's the number of lamb feeders had declined drastically, but the number of feeder lambs in the state annually still exceeds 200,000. Similarly, the number of sheep producers has declined from about 18,000 in 1958 to about 9,500 in 1970, according to scab eradication program data. An increasing number of these flock owners creep feed their lambs and now sell them as finished lambs instead of lightweight feeder lambs.

Research dealing with feedlot lambs has been conducted continuously at the West Central Experiment Station, Morris[1] since 1925. A publication, University of Minnesota Experiment Station Bulletin 306, Feeding Methods and Rations for Fattening Lambs, published in 1938 covered the early part of that work. Since that time considerable data have been obtained. The research has been focused on the development of rations and management schemes that would improve performance of lambs as well as profits to the feeders. Thus, the research has emphasized the following: first, evaluation of various feeds; second, the effect of processing feedstuffs (cooking, rolling, ensiling, pelleting); third, evaluation of feed additives (antibiotics, enzymes, tranquilizers, various hormones); fourth, management of lambs (starting lambs on feed, parasite control, shearing, initial lamb weights) and fifth, lamb feeding profit potentials and factors affecting them, such as fixed costs.

This publication attempts to consolidate data obtained from 1940 to 1970 in a more usable and effective form. While the lambs fed were purchased feeder lambs, fed out primarily in the fall and winter, the findings apply equally to a farm flock owner as to a large commercial lamb feeder. Tables include only the data judged essential to the evaluation of a given treatment. If the ration or feed additive affected feed intake or feed efficiency, then it is included. Where only number of lambs fed and average daily gains are given, the reader may conclude that other conditions (feed intake, days fed, feed required per unit of gain) were similar between treatments. Few dollar costs or values of lambs or feeds are included in any of the tables (except table 3 historic data) as the relative price of two different feeds changes. Unless stated, the hay fed was alfalfa.

Profit in lamb feeding may occur from two sources: selling lamb gains for more than they cost to produce, and margin – selling the finished lamb at a higher price per 100 weight than it cost as a feeder.

Based on feedlot trials and cost records involving purchase, sale, transportation, interest, housing, death loss, etc., table 1 expresses the total cost of finishing lambs in terms of feed; i.e., a lamb:feed ratio. Feed cost represents about 66 percent of the total cost and 34 percent of the cost is the non-feed costs mentioned (so-called fixed costs). The value of 12 pounds of lamb feed (8 pounds of lamb feed to produce 1 pound of gain and 4 pounds of lamb feed to cover the fixed costs) has been a rather accurate measure of whether the value of 1 pound of finished lamb would cover the costs of producing it. The table merely indicates whether or not the cost of producing 1 pound of gain will be covered by the value of 1 pound of lamb. It does not indicate whether the feeding enterprise will be profitable.

[1] Later referred to as the Station.

Table 1. Cost of finishing lambs (expressed in terms of feed)

70 pound feeder + 35 pound gain	= 105 pounds lamb weight
Feed costs — 66 percent	= 280 pounds feed
Miscellaneous costs — 34 percent (interest, transportation, death, depreciation, etc.)	= 140 pounds feed
Total cost	420 pounds feed per lamb 1,200 pounds feed/ 100 pounds gain

Lamb feed based on 50:50 grain and alfalfa hay ration.

Table 2 shows the effect of margin, when both feed costs and fixed costs are considered (labor cost excluded). As feed costs increase, the required necessary margin (difference in buying and selling price per 100 pounds required to just break even on the feeding operation) increases. Conversely the higher the cost of the feeder lamb per 100 pounds (with a given feed cost), the less the necessary margin. Why? Because with high lamb prices the cost of putting the gain on will usually be considerably less than the selling price of the gain. While the data in tables 1 and 2 are helpful in making a decision as to whether to feed lambs or not—again, they do not predict profit or loss.

Table 2. Effect of feeder lamb cost and feed prices on necessary selling price of finished lambs

Feeder lamb cost per 100 pounds	$16	$18	$20	$22	$24
Feed cost per 100 pounds	Necessary selling price				
$1.25	16.10	17.50	18.90	20.30	21.70
1.50	17.08	18.48	19.88	21.28	22.68
1.75	18.06	19.46	20.86	22.26	23.66
2.00	19.04	20.44	21.84	23.24	24.64

Feed represents 66 percent and fixed cost 34 percent of total cost 12 pounds lamb feed per pound gain to cover all costs.

Table 3 presents some historic data in the form of actual prices paid for feed and feeder lambs together with the actual selling prices of finished lambs. It includes margin returns over feed costs, and costs of marketing experienced with feedlot lambs at the University of Minnesota, during a 30-year period. The expression — profit or loss — means return over feed costs and excludes labor, interest, and equipment depreciation.

In all examples the lambs were hand-fed long alfalfa hay, shelled corn, protein supplement, minerals, and water. They were not necessarily the best nor the poorest performing lambs but are typical for the particular year fed. With few exceptions, they were fed during the fall months and marketed in January.

Returns over feed costs. A profit (up to $6.11 per lamb) was made in 23 of the 30 years. The decade from 1950 to 1959 was the least favorable with five losses occurring during that 10-year period. The decade from 1940 to 1949 was the most favorable with a profit occurring each year.

Margin. The difference between buying and selling price per hundredweight, is not a fixed value and has far less bearing than usually expected on whether the feeding operation is profitable. For example, during the decade 1940 to 1949, finished lambs sold for less per hundredweight than feeders, in six of the 10 years. However, a profit over feed costs (range from 52 cents to $6.11 per lamb) was made each of the 10 years. From 1950 to 1959, a negative margin (−$1.07 to −$6.34 per hundredweight) existed during eight of the 10 years, but a profit (2 cents to $4.65 per lamb) occurred in five of the 10 years. During the years 1960 to 1969, a negative margin occurred in eight of the 10 years (−41 cents to −$6.20 per hundredweight) but a profit over feed costs occurred (30 cents to $3.19 per lamb) in eight of the 10 years.

When the cost (largely feed) of producing a unit of gain is less than the expected selling price of the finished lamb, lamb feeders tend to bid up the price of feeder lambs over the selling price of finished lambs since they expect to recoup any loss on the purchase price per hundredweight (negative margin) by producing the increase weight gains for less than they sell them for per hundredweight. Apparently during this 30 year period lamb feeders did expect to produce the gains for enough less than the anticipated selling price per hundredweight to make the feeding venture enticing and profitable. The fact that a loss occurred during seven of the 30 years suggests that too great a negative margin resulted due to too high a price paid for the feeder lamb or a greater decline in the price of finished lamb occurred during the feeding period than was anticipated.

There are two major factors that affect feed costs per hundred pounds of gain: first, the cost of the lamb feed per hundredweight and second, the number of pounds of feed required to produce a pound of gain. The second point is determined largely by

the amount of feed eaten in relation to the amount of gain produced. Which factor will have the greatest bearing on costs of gain is determined by the magnitude of difference between them. If feed prices per ton are 10 percent greater for one ration than another, then 10 percent greater gains must be obtained on the same intake of feed. Because this can often be accomplished, it provides the reasoning behind the feeding of more nutritious and usually more costly rations. The important point is that the feeder through his management and feeding program has more influence over rate of gain, and hence cost per unit of gain, than he does over feed costs.

In only one year of the 30 did the sale price per hundred pounds of finished lamb fail to exceed the cost of producing a hundred pounds of gain — though that relationship does not assure a profitable operation. During the most recent period, 1960 to 1969, feed prices have been somewhat static, while the cost of the feeder lamb and the sale price of the finished lamb have increased. Usually the feed cost of producing a hundred pounds of gain approximates 50 to 60 percent of the selling price of the finished lamb. Relatively low feed prices (corn, $1 per bushel and hay, $20 per ton), resulting in feed costs (per hundred pounds of gain) that are appreciably lower than the selling price of finished lambs

Table 3. Three decades of lamb feeding — prices, margins, profits and losses

Year	Lamb prices per 100 pounds[1]			Feed prices[2]		Feed costs per 100 pounds gain	Average daily gain, pounds	Marketing[1] costs (shrinkage, commission, transportation)	Returns over feed costs/lamb
	Purchase	Selling	Margin	Corn/bushel	Hay/ton				
1940	$ 8.43	$ 8.00	$— .43	$ .45	$ 6.00	$ 4.26	.48	$ .75	$ .86
41	8.62	8.30	— .32	.45	6.00	3.68	.46	.95	3.02
42	11.09	11.00	— .09	.65	8.00	5.80	.40	1.00	1.71
43	13.44	14.25	+ .81	.73	5.00	9.15	.29	1.00	1.71
44	15.70	14.57	—1.13	1.00	10.00	11.22	.33	1.18	.52
45	12.65	14.00	+1.35	1.12	6.00	11.95	.24	1.25	1.29
46	12.80	14.75	+1.95	.84	15.00	8.81	.40	1.25	1.95
47	14.26	13.80	— .46	.85	15.00	9.47	.40	1.20	1.10
48	18.00	21.50	+3.50	.95	15.00	11.65	.42	1.25	6.11
49	24.02	22.50	—1.52	1.25	20.00	13.45	.42	1.50	1.38
Average	13.90	14.27	+ .37	.83	10.60	8.94	.38	1.13	1.96
1950	24.22	23.00	—1.22	1.12	22.00	13.82	.35	1.75	2.17
51	26.75	31.40	+4.65	1.40	20.00	13.23	.38	2.10	4.65
52	32.91	26.57	—6.34	1.50	20.00	19.56	.34	2.24	—3.68
53	21.70	20.00	—1.70	1.40	20.00	15.91	.34	1.77	.02
54	16.39	18.31	+1.92	1.34	20.00	15.55	.31	1.69	2.01
55	19.94	18.25	—1.69	1.34	16.00	14.97	.36	2.00	— .37
56	18.18	17.11	—1.07	1.30	16.00	17.52	.35	1.64	—1.02
57	22.95	19.17	—2.78	1.10	15.00	11.28	.38	2.86	.15
58	22.03	18.06	—3.97	1.12	13.00	12.18	.48	2.44	— .72
59	19.07	15.40	—3.67	1.14	22.00	12.87	.46	1.85	—1.53
Average	22.41	20.73	—1.59	1.28	18.40	14.69	.38	2.03	+ .16
1960	16.42	14.65	—1.77	1.09	17.00	11.34	.46	1.85	— .20
61	15.21	15.47	+ .26	.95	20.00	8.96	.52	2.28	1.68
62	20.20	17.86	—2.34	.91	18.00	9.39	.42	1.09	2.05
63	17.21	16.80	— .41	.95	18.00	13.84	.31	2.15	.30
64	21.93	23.25	+1.32	1.12	25.00	11.79	.46	2.78	2.30
65	26.16	23.20	—2.96	1.10	16.00	8.96	.54	2.80	3.19
66	26.36	20.16	—6.20	1.22	20.00	11.32	.42	2.46	—1.66
67	22.95	21.68	—1.27	1.00	20.00	12.48	.42	2.05	1.78
68	27.42	23.77	—3.65	.97	20.00	10.23	.60	2.48	2.03
69	26.96	25.58	—1.38	1.01	18.00	11.54	.49	2.67	1.55
Average	22.08	20.24	—1.94	1.03	19.20	10.98	.46	2.26	1.32

[1] Purchased price includes costs of transportation and shrinkage to Morris plus shearing, vaccination, etc. Selling price is the sale price per 100 pounds at the market less such items as transportation, shrinkage, yardage, and commission. The difference between price per 100 pounds at the feedlot (Morris) and the market price (South St. Paul) is termed marketing costs.

[2] Feed prices used are what was actually paid and are somewhat higher than a producer would have received on the cash market.

($22 to $28 per hundredweight), are apt to continue into the next decade. Lamb feeders very likely will continue to operate with a negative margin. However, feeders should recognize that the weight of a typical feeder lamb (75 pounds) is usually three times the weight of the salable gain (25 pounds). Therefore, if they pay 10 percent more per hundredweight for the feeder lamb than its likely sale price as a finished lamb, they must produce the weight gains for 70 percent of the selling price of the finished lamb to merely break even. This would leave nothing to cover death loss, interest, equipment depreciation, or labor costs.

Table 3 points up two other factors. First, lambs today are bigger-framed and tend to gain a little faster than 30 years ago. Second, while feed costs per hundred pounds of gain have not increased appreciably since the 1940's (variable during either decade) the marketing costs have tripled since the early 1940's. A major share of this is the cost of the shrinkage (valued at 18 to 25 cents per pound in the 1960's compared to approximately 8 to 15 cents per pounds in the 1940's). Shrinkage, transportation, yardage, and commission costs now constitute 20 to 25 percent of the cost of feeding lambs.

Research Results

Historically, lamb feeders have relied on rations with a relatively high proportion of forage since this is normally a low cost feed per ton. Feeders have recognized that the quality of forage, the amount fed and the form (long hay, chopped, or pelleted) have a significant bearing on lamb gains.

Feed Quality

Hay maturity affects lamb gains tremendously. This is true even though the hay appears to be high quality. In 1963 alfalfa hay was harvested at two dates: early-cut, June 4 to 11; and late-cut, June 25 to July 1. Each hay was baled at 35 to 40 percent moisture (no rain during harvesting) and artificially dried. Both cuts appeared to be very high quality; however, a chemical analysis (table 4) and two lamb feeding trials (table 5) proved otherwise. The higher fiber content of the late-cut hay reduced hay intake slightly and significantly reduced weight gains. In the experiment which restricted grain intake, late-cut alfalfa was worth only about 60 percent of the value of early-cut hay.

Grain quality, as determined by bushel weight, affects its cash market value disproportionately to its value as a livestock feed. Light-weight barley that is higher in protein and fiber and lower in nitrogen-free-extract than heavy barley (table 6) is not satisfactory for malting. However, as a feed for finishing lambs it is worth about 85 percent as much as heavy-weight barley (table 7). Table 7 also shows that shelled corn produces significantly faster gains than barley and that pelleting only the grain portion of the ration does not improve its feeding value.

No one wants light-weight grain, but if it happens don't sell it for a fraction of its feeding value—feed it to livestock instead.

Chopped Versus Long Hay

One of the early questions was whether chopped hay was superior to long hay. Table 8 summarizes two trials in which long and chopped alfalfa hay were compared as ration components for finishing lambs. Although there were two different forms of hay fed, the amounts fed were identical. This assured that form of hay (chopped or long) not quantity fed was the only influence on weight gained. The average from both 1938 and 1939 trials indicates little difference in rate of gain under these conditions; however, there was a saving in the amount of feed required per unit of gain with chopped rations. During the experiments, it was evident that lambs fed chopped hay took to it readily and would have eaten more.

It is concluded that chopping in itself does not enhance the nutrient availability of the hay but does increase feed intake. If the ration is to be mixed with grain and self-fed, chopping the forage would have some advantage. However, unless a sizable number of lambs are fed and facilities are available to chop hay in large quantities, the disadvantages of chopping (disagreeable, dusty, and power-consuming) may outweigh the advantages.

Table 4. Chemical analysis of early and late cut alfalfa hay

	Early		Late
Date cut	June 4-11, 1963		June 25-July 1, 1963
	%	Hay fed	%
Dry matter	91.4		89.4
Crude protein	20.7		17.0
Crude fiber	26.4		35.5
	%	Hay refused	%
Dry matter	93.0		91.2
Crude protein	8.9		9.5
Crude fiber	48.6		50.4

Table 5. Effect of hay maturity on feed lot performance of lambs

	High grain rations				Low grain rations	
Type of hay[1]	Early	Late	Early	Late	Early	Late
Number of lambs	14	14	13	13	8	9
Average daily gain, pounds	44.5	44.6	43.3	47.3	82.6	87.4
Initial average weight, pounds	.42[a]	.34[b]	.41[a]	.35[b]	.35[b]	.18[c]
Average daily feed consumption, pounds						
Grain	1.13	1.10	1.11	1.12	.68	.67
Hay	.92	.82	.92	.87	2.22	2.01
Protein supplement	.10	.10	.10	.10	.11	.11
Feed/100 pounds gain, pounds						
Grain	272.4	311.6	273.1	320.0	193.5	364.8
Hay	220.2	238.6	225.8	246.9	633.2	1110.1
Protein supplement	23.8	28.6	24.5	28.4	32.4	61.4

[1] Amount of hay fed was limited to minimize feed refusal. Level of grain feeding was equalized among the first four lots and the last two lots. Lambs were fed for 56 days.

[2] Values having different letter superscripts are significantly ($P < .01$) different from one another.

Table 6. Chemical composition of light-, medium and heavy-weight barley (dry matter basis)

Barley	Light	Medium	Heavy
Bushel weight, pound	35.5	44.0	52.0
Crude protein, percent	14.82	11.87	11.36
Ether extract, percent	1.75	1.97	2.09
Crude fiber, percent	9.11	7.23	6.11
Ash, percent	3.66	3.47	2.88
Nitrogen free-extract, percent	70.66	75.46	77.56

Table 7. Feedlot performance of lambs fed shelled corn or whole or pelleted barley of three different bushel weights

		Whole			Pelleted		
Treatment[1]	Shelled corn	Heavy barley	Medium barley	Light barley	Heavy barley	Medium barley	Light barley
Initial average weight, pound	61.2	61.7	62.0	61.5	62.2	62.2	61.5
Final average weight, pound	102.3	97.3	94.0	91.2	86.2	87.0	86.5
Average daily gain, pound[2]	0.42[a]	0.36[b]	0.33[bc]	0.30[cd]	0.24[d]	0.25[d]	0.26[d]
Gain index, percent	100	86	79	71	57	60	62
Average daily feed consumption, pound							
Grain	1.41	1.41	1.41	1.32	1.12	1.23	1.23
Hay	1.36	1.36	1.37	1.37	1.37	1.36	1.36
Protein supplement	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Feed per 100 pound gain, pound[2]							
Grain	336	387	431	437	455	487	482
Hay	324	374	419	452	557	538	533
Protein supplement	22	27	31	33	41	40	39
Total	682[a]	788[ab]	881[bc]	922[bc]	1053[c]	1065[c]	1054[c]

[1] Treatments were replicated with two lots of 12 lambs each and fed an equal amount of excellent quality alfalfa-brome hay, soybean meal and a full feed of the different types of grain.

[2] Mean values having different superscripts are significantly ($P < .01$) different from one another.

Table 8. Long hay versus chopped hay for finishing lambs

Type of ration	Number of lambs	Average daily gain, pounds	Feed per 100 pounds gain, pound	
			Corn	Hay
Hand-fed				
		1938		
Long hay and corn	30	.30	515	340
Chopped hay and corn	30	.33	470	310
Long hay, corn and linseed meal	30	.34	503	303
Chopped hay, corn and linseed meal	30	.38	422	264
		1939		
Long hay, corn and linseed meal	30	.43	343	350
Chopped corn and linseed meal	30	.42	345	330
Long hay and corn	30	.38	330	410
Chopped hay and corn	30	.39	320	400

Hand-feeding Versus Self-feeding

A number of trials comparing hand- versus self-feeding were conducted with chopped hay and grain, long hay and grain, and finally a complete pelleted ration. Experiments in 1938, 1939, and 1941 trials compared chopped rations that were hand-fed with chopped self-fed rations; experiments in 1969 and 1970 trials compared long hay and shelled corn, either hand-fed or self-fed. The data in table 9 illustrate two basic points. First, lambs, self-fed usually gained 8 to 10 percent faster, primarily because they ate 10 to 15 percent more feed. Second, if fed for the same period of time, self-fed lambs were heavier at marketing. Therefore, self-feeding should be viewed as a means of reducing labor and feed bunk space and since the lambs gain faster, it increases the number of lambs that can be fed per year.

Concentrate:Forage Ratios

In the past, death loss due to enterotoxemia (over eating disease) was the curse of the lamb feeder. For this reason he used a relatively high proportion of forage and felt compelled to combine chopped grain and hay to realize a planned proportion of grain and forage in the ration. With the current effective vaccines for the partial control of enterotoxemia, high forage rations are not as essential.

In 1947, a trial was conducted to determine the most advantageous proportion of concentrate and roughage (from the standpoint of minimizing death loss and maximizing gain) for starting lambs on feed. Two replicates of 30 lambs each were fed as follows:

Treatment 1—10 percent ground corn and 90 percent chopped hay for seven days followed by an increase of 10 percent corn per week until the ration contained 60 percent corn and 40 percent hay;

Treatment 2—initially 20 percent corn and 80 percent hay gradually changed to 70 percent corn and 30 percent hay;

Treatment 3—initially 30 percent corn and 70 percent hay gradually changed to 80 percent corn and 20 percent hay;

Treatment 4—initially 40 percent corn and 60 percent hay gradually changed to 90 percent corn and 10 percent hay (table 10).

Since death loss was minimal in all lots, starting lambs on a self-fed ration containing 10 percent corn compared with 20, 30, or 40 percent corn showed no mortality advantage. Most commercial lamb feeders use a 25 to 30 percent grain ration as a starter ration to minimize the length of the feeding period. During the 56-day finishing period, rations with concentrate: forage ratios of 60:40, 70:30, or 80:20 resulted in comparable gains. However, when corn constituted 90 percent of the ration, feed consumption declined and rate of gain was appreciably lower. Furthermore, increasing the grain in the ration did not result in particularly favorable hay replacement values. For example, in comparing the 60:40 with the 70:30 rations, each added pound of corn replaced 1.7 pounds of hay; comparing 70:30 with 80:20, a pound of corn replaced only

.9 pound of hay; and 80:20 compared with 90:10 resulted in a pound of corn replacing only .17 pound of hay. This is just one trial, but normally increasing the grain proportion increases the rate of gain sufficiently so that a pound of grain replaces 2 to 3 pounds of hay (table 9, 1938, 1939, and 1941 trials).

The proportion of concentrate to forage needed in a self-fed ration for growing finishing lambs (normally 6 months of age at the start of the feeding period) has been long debated. Researchers at the Kansas Agricultural Experiment Station, using Southwest lambs fed during the fall and winter months, concluded that the best ration consisted of 55 percent forage and 45 percent concentrate. The data presented in tables 9 and 10, indicate that within the range of 60 to 80 percent concentrate, there is little difference in rate of gain and the best concentrate:forage ratio depends on the relative costs of the ration components and the feeding and management system. Rations containing as much as 90 percent concentrates have not produced as great or as efficient gains as the levels described above. Rations containing equal parts of concentrate and forage or 60 percent forage and 40 percent concentrate normally result in somewhat slower gains due primarily to a lower intake of energy. Since corn provides a much higher proportion of energy per unit of intake than hay, it is evident that this is the component with a very significant effect on average daily gain and on pounds of feed required per pound of lamb gain.

Table 9. A comparison of hand-feeding and self-feeding of rations based on corn and alfalfa

Feeding method	Concentrate: forage ratio	Number of lambs	Average daily gain, pounds	Feed per 100 pounds gain, pounds	
				Corn	Hay
			1938[1]		
Hand-fed					
Corn and alfalfa	60:40	30	.34	497	303
Self-fed					
Corn and alfalfa	40:60	30	.32	432	264
	50:60	30	.37	382	574
	60:40	30	.42	411	418
	70:30	30	.44	416	319
			1939[1]		
Hand-fed					
Corn and alfalfa	60:40	30	.42	386	305
Self-fed					
Corn and alfalfa	40:60	30	.38	299	448
	50:50	30	.47	334	334
	60:40	30	.52	379	265
	70:30	30	.53	422	211
			1941[1]		
Hand-fed					
Corn and alfalfa	55:45	30	.40	387	327
Self-fed					
Corn and alfalfa	45.55	30	.44	346	442
	50:50	30	.44	384	378
	55:45	30	.48	374	318
			1969[2]		
Hand-fed					
Corn and alfalfa		71	.57	498	
Self-fed					
Corn and alfalfa		71	.62	507	
			1970[2]		
Hand-fed					
Corn and alfalfa		72	.53	388	
Self-fed					
Corn and alfalfa		71	.59	410	

[1] Chopped alfalfa.

[2] Alfalfa not chopped; shelled corn self-fed.

Figure 1. The small, wooly faced, wrinkly skinned, Merino type feeder lambs are typical of the lambs fed by Minnesota lamb feeders during the 1920's, 1930's, and 1940's. They gain about .3 pound per day, weigh 55 to 70 pounds as feeders and are marketed at 85 to 90 pounds.

Table 10. Proportion of corn and hay for starting lambs on self-feeders

Ration		Number of lambs	Average daily gain pounds	Feed per 100 pound gain, pound	
Corn:Alfalfa				Corn	Hay
Inital	Ultimate				
10:90	60:40	60	.41	390	574
20:80	70:30	60	.41	439	488
30:70	80:20	60	.43	488	441
40:60	90:10	60	.37	541	432

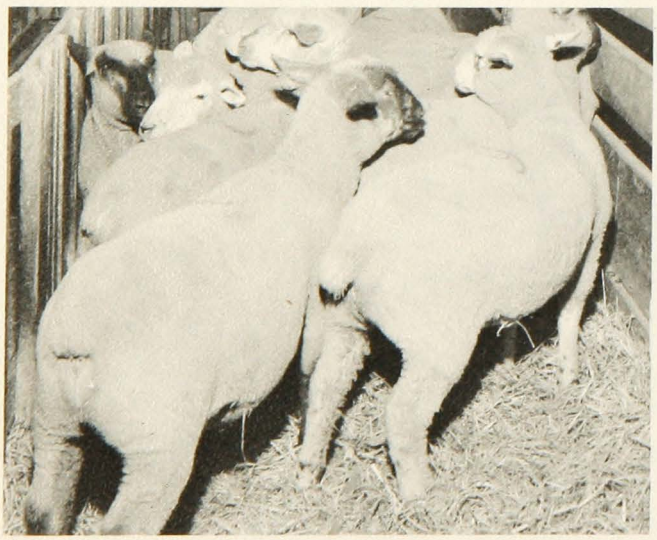

Figure 2. Typical feeder lambs of the late 1950's and 1960's are open faced, long bodied, and capable of gaining .6 to .7 pound per day. They normally weigh 70 to 80 pounds as feeders and when marketed, 105-120 pounds. The future may see meaty, lean, 150 pound lambs being marketed.

When shelled corn prices are about twice as high as hay, as they have been for the last decade, energy for sheep can be provided as inexpensively from grains as from forage. This fact, coupled with the need for greater mechanization of lamb feeding and the handling of less bulky rations, lead to the conclusion that if lamb feeders intend to self-feed a mixture of chopped hay and grain, a concentrate: roughage ratio of 60 to 80 percent concentrate will best meet requirements and usually result in more rapid gains. Such a recommendation should be coupled with as stringent control of enterotoxemia as possible via a double vaccination program.

Pelleted Rations

While a ration containing 60 to 80 percent grain may be satisfactory when fed in chopped and ground mixtures, pelleted mixtures normally require 50 to 70 percent forage to produce the greatest

gain and feed efficiency. Table 11 presents five trials involving pelleted rations. Pelleting did increase the average daily gain but had little effect on the amount of feed required per unit of gain. Usually, as the proportion of forage is increased in the pelleted ration, the rate of gain due to pelleting is increased. For example, in trial II, a pelleted ration containing 50 percent corn increased the average daily gain about the same amount as a pelleted ration containing 75 percent forage (average daily gain .57 versus .56, respectively).

To increase average daily gain, feed intake must be increased. In trial III, lambs fed a chopped ration containing equal parts of corn and hay gained somewhat faster than lambs fed the same mixture in a pelleted form because the lambs ate less of the pelleted ration. This may occur when a pelleted ration is relatively high in concentrate. Conversely, when the forage was increased to 75 percent, feed intake increased appreciably and average daily gain was as great as when a chopped ration of equal parts of corn and hay was fed.

Perhaps the best comparisons of pelleted rations are those in trial IV in which chopped and pelleted rations containing from 50 to 100 percent forage were compared (table 11). In all instances, pelleting increased average feed intake, average daily gain, and reduced the amount of feed required per unit of gain. As the proportion of forage was increased from 50 to 85 percent and up to as high as 100 percent, the gain due to pelleting increased. For example, when the ration contained equal parts of forage and concentrate, lambs fed chopped rations gained about 82 percent as fast as those fed pelleted rations; when the ration contained 85 to 100 percent forage, lambs fed chopped hay gained only about 62 percent as fast as their counterparts fed the same rations in pelleted form. To obtain maximum response from pelleting, the ration must contain a relatively high proportion of forage. It is this portion of a complete pelleted ration that is often costly due to the high cost of transportation and the power and labor required for grinding the forage.

Further evidence that pelleting high energy feeds is little value is presented in trial V, table 11. Pelleted ear corn actually resulted in slower gains than unpelleted ear corn. Lambs tired of pelleted ear corn and their feed consumption was less than that of lambs fed ground ear corn.

Table 11. Fattening lambs with corn-alfalfa pellets

Ration	Concentrate: forage ratio	Lambs	Average daily gain	Average daily feed	Feed per pound gain
		number	pounds	pounds	pounds
Trial I					
Long hay	58:42	30	.31	2.70	8.63
Pelleted	60:40	60	.37	2.81	7.62
Pelleted	53:47	30	.38	3.03	8.06
Trial II					
Long hay	50:50	12	.52	3.40	6.52
Pelleted	50:50	12	.57	3.72	6.58
Pelleted	25:75	12	.56	3.96	7.12
Trial III					
Ground hay	50:50	14	.48	3.79	7.92
Pelleted	50:50	14	.43	3.39	7.87
Pelleted	25:75	14	.48	4.24	8.77
Trial IV					
Ground hay	50:50	12	.46	3.39	7.44
Pelleted	50:50	12	.56	3.83	6.83
Ground hay	25:75	24	.45	4.02	8.99
Pelleted	25:75	24	.56	4.28	7.68
Ground hay	15:85	11	.36	3.76	10.47
Pelleted	15:85	10	.57	4.56	7.97
Ground hay	0:100	11	.30	3.83	12.67
Pelleted	0:100	11	.48	4.29	8.83
Trial V					
Shelled corn	...	20	.42	3.07	7.70
Ground ear corn	...	44	.37	3.15	8.98
Pelleted ear corn	...	44	.34	2.98	8.98

Lambs were self-fed pelleted grains (no hay included in the pellet) with a high fiber content (oats and barley) in a trial presented in table 12. A complete pelleted ration self-fed resulted in greater gains than when corn and hay were hand fed. However, self-feeding pelleted oats or barley resulted in low intakes of either of these feeds, especially during the first two weeks of the trial, and the overall gains during the entire trial were less than when shelled corn was fed. This trial also cast some light on the value of the ingredients in a ration. Self-feeding pelleted ration containing 40 percent corn, 40 percent cob, and 20 percent alfalfa did not produce nearly as efficient or as rapid gains as the self-feeding of a pelleted ration containing alfalfa as the forage.

Since the value in pelleting seems to be in pelleting the forage portion of the ration, pelleted forage fed together with grains should produce satisfactory results, (table 12). It made little difference how finely the forage was ground, although there was a tendency that pellets made from hay, ground through a half inch screen, resulted in greater gain than pellets made from a finer grind. Feeding a pelleted forage together with a limited amount of grain always resulted in appreciably greater gains than hand feeding corn and baled hay. Further, pelleted hay fed with shelled corn resulted in as rapid gains as when a complete pelleted ration was fed.

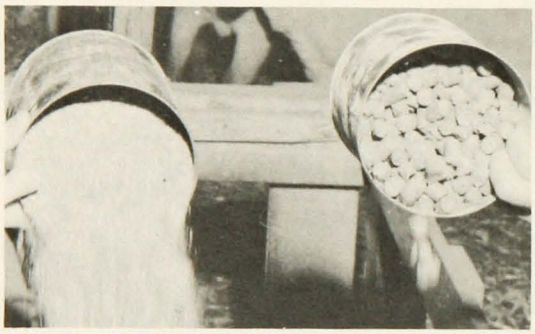

Figure 3. Pelleted rations increase feed intake and weight gains, but the $6 to $14 per ton added cost often negates its advantages.

Table 12. Pelleted grains, hay, corn cobs and complete pelleted rations for finishing lambs

Ration	Number of lambs	Average daily gain—pounds	Feed per 100 pounds gain—pounds		
			Corn	Hay	Pellet
		1961			
Control-corn and hay hand-fed[1]	12	.46	401	386	
Pelleted oats and hay[1]	12	.42		184	684
Pelleted barley and hay[1]	12	.42		179	925
Pelleted ration (Corn 40 percent, corn cob 40 percent and alfalfa hay 20 percent)	12	.53			919
Pelleted ration (65 percent alfalfa and 35 percent corn)	12	.60			797
		1962			
Control-corn and hay hand-fed[1]	24	.52	292	364	
Limited shelled corn with self-fed:					
Pelleted hay ½ inch grind[2]	24	.61			517
Pelleted hay ¼ inch grind	24	.58			542
Pelleted hay ⅛ inch grind	24	.56			558
Complete pelleted ration (60 percent alfalfa, 40 percent corn)	24	.58			685

[1] The hay was baled alfalfa of good quality and from the same stack as used in the pelleted rations. All pelleted feeds were self-fed.

[2] Pellets were ⅜ inch diameter.

Starting Lambs on Feed

One of the main reasons for the popularity of pelleted rations is to get lambs on feed in a short time and to reduce early death loss due to enterotoxemia. Table 13 includes two years of data (each treatment replicated) in which a portion of the lambs were: (1) hand-fed a control ration of corn and hay; (2) self-fed a complete pelleted ration during the entire trial; or (3) self-fed a complete pelleted ration during only the first 14 days of the trial.

Table 13. Feedlot gain and feed conversion efficiency of lambs started on feed by hand-feeding corn and hay or by self-feeding a complete pelleted ration

Ration	Number of lambs	Average daily gain—pounds	Feed per 100 pounds gain—pounds		
			Corn	Hay	Pellet
		1961			
Control: corn and hay hand-fed	24	.46	401	386	
Pelleted ration (65 percent alfalfa and 35 percent corn) Self-fed entire trial	24	.60			797
Pelleted ration (same as above) Self-fed 14 days then lambs self-fed shelled corn and hay	24	.51	368	239	132
		1962			
Control: corn and hay hand-fed	24	.52	292	364	
Pelleted ration (60 percent alfalfa and 40 percent corn) Self-fed entire trial	24	.58			686
Pelleted ration (same as above) Self-fed 14 days then lambs self-fed shelled corn and hay	24	.54	314	155	152

Lambs in treatment (3) became accustomed to feed and then were switched from a complete pelleted ration to a free-choice feeding system in which they were self-fed shelled corn in a trough and long hay in a hay rack. This cross-over was accomplished by gradually substituting shelled corn for the complete pelleted ration during the last seven days of the 14-day period, until the ration consisted of nothing but shelled corn and long hay. Feeding a complete pelleted ration resulted in rapid gains, though the amount of feed required per unit of gain was not necessarily reduced.

Switching lambs from pellets to corn and hay decreased gains for about two weeks, but during the entire trial gains were somewhat greater than those of lambs hand-fed a corn and hay ration. While there was little problem with enterotoxemia, it was obvious that the change from self-feeding a pelleted ration to self-feeding corn and long hay increases the chance of death loss from enterotoxemia. Thus, an effective vaccination program must be used. Other methods have been employed at the Station to start lambs on feeds, such as self-feeding beet pulp pellets and switching to corn and hay, or mixing corn and salt and gradually reducing the salt until the lambs are self-feeding on shelled corn.

These comments on self-feeding and pelleted rations suggest that self-feeding pelleted rations may minimize death loss, reduce labor, increase rate of gain, and make it possible to feed relatively large amounts of forage. It is also apparent that feeding a pelleted ration does not always result in greater feed efficiency. The greater rate of gain is the result of an increase in feed intake.

The moot question is – do pelleted rations pay? Experienced feeders know that rate of gain is not the only factor that determines profit, but the cost of putting the gain on is of paramount importance. The cost of manufacturing pellets (grinding, mixing, and transporting feeds) is normally $6 to $14 per ton. The feeder can offset these costs primarily

by an increase in feed efficiency, a greater or more rapid turnover in the feedlot, incorporating in the pelleted ration a higher percent of inexpensive and sometimes unpalatable feedstuffs, reducing feed bunk space, reducing skilled labor, and reducing death loss. Death loss, labor costs, feedlot turnover, etc., are rather nebulous and vary considerably from feedlot to feedlot. The data in table 14 show how great an increase in feed efficiency must be obtained and how much less roughage must cost than grain to offset these pelleting costs.

Table 14 is based on the following assumptions: first, 800 pounds of a lamb ration consisting of equal parts of alfalfa hay and shelled corn are required to produce 100 pounds of gain, and second, the pelleted ration consists of 75 percent forage and 25 percent concentrate. Couple these assumptions with the cost of hay and corn and it is a simple matter to calculate the cost per pound of ration and the cost of producing 100 pounds of lamb gain. For example, if hay costs $20 per ton and corn $1 a bushel, a ration of equal parts of hay and corn costs $1.39 per 100 pounds or $11.12 for the 800 pounds of lamb ration required to produce 100 pounds of gain. Similarly 800 pounds of pelleted ration, consisting of 75 percent roughage and 25 percent corn, costs $1.20 per hundred or $9.60 for the 800 pounds of feed required to produce 100 pounds of gain.

How much does the pelleting increase the cost of the 800 pounds of pelleted ration? If the pelleting costs $8 a ton, it increases the cost of the 800 pounds of pelleted ration from $9.60 to $12.80. The next question is how much more efficient or how much feed must be saved per 100 pounds of gain to pay for this added cost. At these prices, 140 pounds of feed must be saved or a 17.5 percent increase in feed efficiency is necessary to offset the $1.68 ($12.80 minus $11.12) added cost of the gain produced by feeding a pelleted ration. This is necessary to equate costs to the cost of gain produced by a conventional long hay-shelled corn ration.

Table 14 illustrates that the cost of hay in relation to the cost of grain and general feed price levels are the dominant factors in determining whether a pelleting charge is actually high or low. For example, with hay at $15 a ton and corn at $1.25 per bushel, it is less expensive to pay $10 per ton for pelleting than $4 a ton pelleting charge when hay is $15 a ton and corn is only 75 cents a bushel.

The next point to resolve is how much more efficient gains are when lambs are fed a complete pelleted ration. A summary of nine trials, involving many types of pelleted rations, including timothy hay and conducted at various experiment stations, suggests a 20 percent increase might be expected. In the Minnesota data, increases in efficiency range from 0 to about 40 percent. A realistic figure in feed efficiency or feedlot performance is about 20 percent. If death loss and labor charges are unreasonably high, the break-even point on feed efficiency may be in the neighborhood of 25 percent.

Based on the table 14 feed charges, pelleting costs and feed efficiency values that **are below the dotted line** are considered greater than could be recouped from the feeding of a pelleted ration. Each $2 increase in pelleting costs requires about an 8 to 10 percent increase in feed efficiency to offset it. With current inexpensive grain prices in relation to forage prices, coupled with a need to feed farm-grown feeds, $8 to $10 a ton seems to be about the maximum to pay for pelleting.

Management

During warm weather, shearing definitely increases feed intake and rate of gain sufficiently to reduce feed required per unit of gain. Conversely, during cold weather, while lambs eat more, their gains are not increased appreciably by shearing, and unless shelter is available, shearing is a risky practice. Spring (March-April) is one other season of the year when lambs should normally be sheared. At that time the weather is mild enough so the increased feed intake with shearing results in greater gain and it is easier to keep sheared lambs dry and from bogging down in the mud during spring thaws.

Does it pay to drench feedlot lambs for the control of internal parasites? The data in table 15 illustrate that strong healthy lambs, full-fed nutritious rations in drylot, do not gain faster following an anthelmintic drench. The problem is to decide whether the lambs are actually heavily infested with parasites. In contrast to drylot conditions, lambs under pasture conditions literally are bled to death by constantly heavy parasite reinfestations.

Sex, initial weight of the lambs, and the source (western or native) of the lambs are usually considered important factors in determining lamb performance. In these studies, wether lambs have gained approximately 10 percent faster than ewe lambs. Initial weight, however, has not been a significant factor in determining average daily gains (table 16). As expected, the larger lambs will eat more feed, but their maintenance requirements are also greater. Healthy lambs weighing 65 pounds will gain as rapidly as 75- to 85-pound healthy lambs. However, if the 65-pound lamb is stunted and full of parasites, performance will be disappointing.

Table 14. Effect of pelleting costs and relative grain and hay prices on the cost of producing 100 pounds lamb

Pelleting cost/ton	800 pounds conventional 50:50	800 pounds pelleted 75:25	Added cost/100 pounds gain	Necessary feed saving/100 pounds gain	
				pounds	percent
			When hay costs $15/ton and corn 75¢/bushel		
$ 0	$ 8.00	$ 7.20			
2	8.00	8.00			
4	8.00	8.80	$ 0.80	88.8	11.0
6	8.00	9.60	1.60	177.8	22.2
8	8.00	10.40	2.40	266.7	33.3
10	8.00	11.20	3.20	355.6	44.4
			When hay costs $15/ton and corn $1/bushel		
0	10.16	8.08			
2	10.16	8.88			
4	10.16	9.68			
6	10.16	10.48	.32	31.6	3.9
8	10.16	11.28	1.12	110.9	13.9
10	10.16	12.08	1.92	190.1	23.8
			When hay costs $15/ton and corn $1.25/bushel		
0	11.92	8.96			
2	11.92	9.70			
4	11.92	10.50			
6	11.92	11.30			
8	11.92	12.10	.18	16.1	2.0
10	11.92	12.90	.98	87.5	10.9
			When hay costs $20/ ton and corn 75¢/bushel		
0	9.36	8.72			
2	9.36	9.50	.14	12.8	1.6
4	9.36	10.30	.94	86.2	10.8
6	9.36	11.10	1.74	159.6	20.0
8	9.36	11.90	2.54	233.0	29.1
10	9.36	12.70	3.34	306.4	38.3
0	11.12	9.60			
			When hay costs $20/ton and corn $1/bushel		
2	11.12	10.40			
4	11.12	11.20	.08	6.7	.8
6	11.12	11.00	.88	73.3	9.2
8	11.12	12.80	1.68	140.0	17.5
10	11.12	13.60	2.48	206.7	25.8
			When hay costs $20/ton and corn $1.25/bushel		
0	12.96	10.48			
2	12.96	11.28			
4	12.96	12.08			
6	12.96	12.88			
8	12.96	13.68	.72	55.0	6.9
10	12.96	14.48	1.52	116.0	14.5

In 1954 through 1956 studies, white-faced western lambs, (usually of Columbia, Corriedale, and Rambouillet breeding) did not gain faster or more efficiently than native black-faced lambs (table 16). Thus, merely designating a lamb a "western" does not make it superior to a good native lamb. However, western lambs coming from certain areas may be far superior to western lambs coming from other areas. Idaho and mountain lambs have performed especially well. The feeder should give attention to the health of the lambs and select lambs with relatively heavy bone, long bodies and large frames rather than merely of western or native origin.

Table 15. Effect of anthelmintics on the performance of lambs

Treatment	Number of lambs	Average daily gain—pounds
	Feed lot lambs—1962	
Control	72	.57
Thiabendazole	72	.57
	1968	
Control	53	.44
Phenothiazine	42	.44
Thiabendazole		
Drench	42	.44
Fed	42	.48
Toxiton[1]	12	.43

[1] Proprietary compound.

Table 16. Effect of initial weight and source of lamb on feedlot performance

Variable		Number of lambs	Average daily gain—pounds	Feed intake		Feed per 100 pounds gain—pounds	
				Corn	Hay	Corn	Hay
Source of lambs	Initial weight, pounds						
			1951				
Western	65	30	.38	1.31	1.68	350	450
Western	75	30	.40	1.46	1.73	366	434
Western	85	30	.36	1.36	1.91	384	540
Western	65	30	.37	.95	2.2	256	591
Western	75	30	.42	.95	2.4	226	570
Western	85	30	.38	.95	2.5	244	673
			1955				
Native	60	15	.39	...	...	...	...
Native	72	15	.30	...	...	...	...
			1954				
Western		30	.36	1.55	1.57	429	434
Native		30	.35	1.58	1.58	454	455
			1955				
Western		30	.45	1.69	1.53	371	336
Native		30	.42	1.66	1.48	394	351
			1956				
Western		30	.32	1.27	1.41	400	445
Native		30	.36	1.28	1.43	380	394

Growth Promotants

Antibiotics and hormones, or chemicals with hormone-like properties such as diethylstilbestrol (DES), are the major growth promotants that have made a contribution to improved feedlot performance and have stood the test of time. This station has conducted lamb feeding experiments involving various hormone-like substances almost continuously since 1951. Initially, DES was administered as an implant at a level of 12 milligrams per lamb. These implants increased average daily gain from 25 to 45 percent (table 17), increased feed consumption slightly, and improved feed efficiency 20 to 25 percent. Unfortunately, these levels of DES caused a constriction of the urinary tract and enlargement of the cowpers gland, resulting in blockage of the urinary tract, which was often accompanied by prolapse of the rectum. This condition occurred under feedlot stress (large numbers of lambs, poor environment, etc.). Since that time, Minnesota research contributed significantly to information which made possible the reduction of the dose level of the DES implant from 12 milligrams to 3 milligrams of DES

per lamb. In addition to work with DES, the implant "Synovex" (a combination of estradiol and progesterone), testosterone, and combinations of estrodiol and testosterone, were explored. All of these products increased average daily gain and feed efficiency but were either more costly or did not stimulate as much gain as DES implants. The material presented in tables 17 and 18 includes part of the data gathered and illustrate the following points:

First, three milligram implants result in as great an increase in lamb performance as 6 or 12 milligrams;

second, implants result in a greater increase in lamb gain than when DES is fed;

third, wether lambs respond to DES to a greater degree than do ewe lambs. When DES is fed to ewe lambs they often will gain slower than comparable lambs fed control rations;

fourth, while the greatest response from DES is obtained when lambs are fed finishing rations, a response is also obtained when lambs are fed rations containing high levels of silage and when they are pastured on rape or alfalfa;

fifth, DES is more effective in lambs that are at least 10 weeks old than in younger lambs; and

sixth, DES incorporated into the protein supplement or by mixing it with the salt results in comparable consumption.

Table 17. Effect of hormones and hormone-like compounds on growing finishing lambs

	1956—DES implant levels, drylot					
DES, milligrams[1]	0	2	3	4	5	6
Average daily gain, pounds						
Wethers	.36	.42	.43	.39	.47	.44
Increase, percent[2]		16.7	19.4	10.8	30.6	22.2
Ewes	.37	.54	.54	.59	.56	.47
Increase, percent[2]		45.9	45.9	59.4	51.4	27.0

	1957—Method of feeding DES					
Method	Control		In soybean meal		In salt	
Sex	Wethers	Ewes	Wethers	Ewes	Wethers	Ewes
DES/lamb/day, milligrams	0	0	2	2	1.5	1.5
Average daily gain, pounds	.41	.35	.48	.31	.44	.38
Increase, percent[2]			15	−13	8	6

	1957—Trial 2, wethers only					
DES/lamb/day, milligrams	0	..	2	..	2.29	..
Average daily gain, pounds	.54	..	.59	..	.58	..
Increase, percent[2]			10		8.	

	1957—Response to DES and synovex implants					
	Rape pasture			Alfalfa pasture		
Treatment	Control	3 mg DES	Synovex	Control	3 mg DES	Synovex
Average daily gain, pounds						
Wethers	.40	.55	.57	.25	.35	.34
Increase, percent[2]		28.0	31.0		29.0	27.0
Ewes	.41	.48		.27	.24	
Increase, percent[2]		16.0			−8.0	

	1958—Effect on accessory sex glands					
	Rape pasture			Drylot—full fed		
Average daily gain, pounds[3]	.41	.57	.50	.43	.55	.49
Increase, percent[2]		38.4	21.4		27.4	12.2
Accessory sex glands[4]						
Cowpers	a	c	d	a	c	c
Prostate	a	c	c	a	c	c

[1] DES is diethylstilbestrol.

[2] Increase over control (zero level).

[3] Gain data are average for ewes and wethers.

[4] Coded values: normal, a; moderate enlargement, b; very large, c; and extreme enlargement, d.

Table 18. Effect of hormone and hormone-like compounds on lambs, estradiol-testosterone implants

	Cornfield gleaning		Drylot	
	Control	Treated↓	Control	Treated↓
Average daily gain, pounds				
Wethers	.35	.44	.44	.51
Increase, percent		25.7		15.9
Ewes	.30	.37		
Increase, percent		23.3		

Effect of age on response to DES[1] implants (3 milligrams)

Average daily gain, pounds				
1958—Suckling lambs, 3 weeks				
Control	.63			
DES	.66			
1968—Wean lambs various ages				
Age, weeks	8	9	12	14
Hampshire				
Control	.42		.37	
DES	.44		.51**	
Crossbreds				
Control	.42	.37	.35	
DES	.44	.44*	.46**	
Columbia				
Control				.62
DES				.68**

[1] DES is diethylstilbestrol.

* $P < .05$.

** $P < .01$.

↓ 3 milligrams estradiol and 36 milligrams testosterone.

Under feedlot conditions of these experiments in which care, management, rations, and shelter are above average, little difficulty was experienced with urinary blockage and prolapse. However, an examination of the urinary tract of wether and ewe lambs implanted with DES indicates that levels as low as 3 milligrams do have an effect on these organs and it is entirely possible, if further stress were applied, to have urinary blockage occur. After over 20 years of research with DES at various experiment stations, DES is still not used widely by lamb feeders due to these adverse side effects. The new 3 milligram implants stimulate weight gain sufficiently so that more lamb feeders should be using them. This study suggests feeders experiment with DES on a portion of their lambs to determine whether the feedlot environment and implant are compatible.

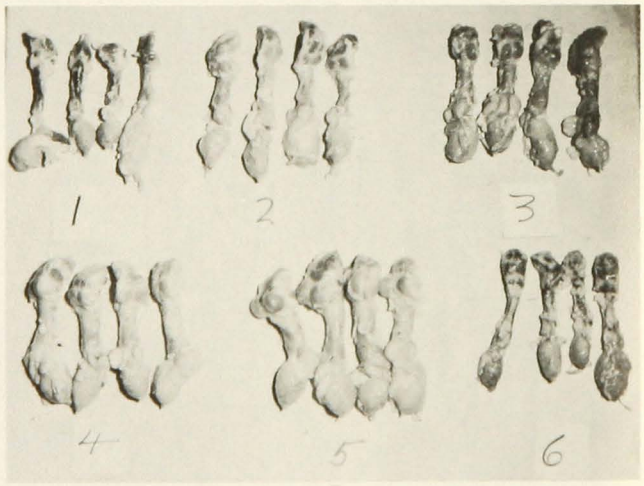

Figure 4. The adverse effect of diethylstilbestrol (DES) on the accessory sex glands of male lambs has hampered the widespread adaptation of this growth stimulent. Number 1 shows accessory glands from untreated lambs; 2, 3, 4, and 5 are from lambs implanted with 2, 3, 4, and 6 milligrams of DES. Number 6 received a non estrogenic material that had no effect. All levels of DES affected these glands. The prostate is enlarged and the cowpers gland (the nob-like protrudence very evident in number 5) emits a clear, viscous fluid partially blocking the urinary tract. Mortality may range from 0 to 20 percent.

Feed Additives for Lambs

A variety of feed additives were incorporated in lamb rations, attempting to improve rate of gain and feed conversion efficiency of lambs. These studies included various antibiotics, enzymes, and tran-

quilizers. Table 19 summarizes a portion of these data. The antibiotics, chlortetracycline, and oxytetracycline are broad spectrum antibiotics and when employed in commercial lamb feedlots where considerable stress (disease and environment) exists, produce increases in weight gain and feed efficiency. In Station tests, response to antibiotics has not been as great as with DES. Usually, feeding lambs 20 to 40 milligrams daily of an antibiotic increased rate of gain slightly and had little effect on feed intake.

Trials conducted during 1969 and 1970 in which 75 milligrams of antibiotic were fed daily, resulted in about 8 to 10 percent increased in rate of gain. Under controlled conditions, in which disease has been a minimum factor, antibiotics have not provided any advantage for starting lambs on feed, minimizing shipping fever, or reducing significantly problems associated with respiratory disorders. However, under typical feedlot stress, antibiotics would likely provide protection from some of these stresses.

The addition of enzymes to increase the utilization of feed stuffs has not met with any success in these studies (table 19).

Tranquilizers administered either in the feed or as implants have had little effect on average daily gain or feed intake and sometimes have shown a depression in weight gain (table 20).

Monosodium glutamate (MSG) has been used for accenting natural flavors in the human diet. To determine its effect on feed intake by lambs, an experiment was conducted in which lambs were fed basal corn diet or a choice of either ground corn or ground corn plus .25 percent sodium glutamate (table 21).

MSG did not significantly affect total feed intake, but the lambs did show a preference for cracked corn containing MSG in two of three comparisons.

Silage for Lambs

Table 22 reports data from six trials involving various types of silage. When either oat or corn silage is properly supplemented with calcium and adequate protein, daily gain and feed conversion efficiency are very similar. The decision to use either oat silage or corn silage should be based on factors other than feeding value.

The weight gain of lambs fed either corn silage or oat silage is usually improved by the addition of a small amount of alfalfa hay (1946, 1952, and 1956 trials, table 22). Obviously, the response obtained with various types of silage depends on the quality of the silage. In some of the trials, the lambs grew at a slower rate when corn silage was fed. This was usually due to poor quality silage—silage that was too dry or silage that contained very little grain.

Table 19. Effect of various feed additives on lamb performance

Treatments	Average daily gain, pounds	Concentrate consumed, daily pounds
Antibiotics		
1959		
Corn and hay ration fed with:		
Control	.39	1.60
Kanamycin	.45	1.60
Oleadomycin	.46	1.57
1955		
Control	.44	1.52
Aureomycin, 21 milligrams/day	.46	1.52
Aureomycin, 21 milligrams plus 2 milligrams DES/day[1]	.47	1.53
DES, 2 milligrams/day	.44	1.51
Control	.59	1.43
Aureomycin, 40 milligrams/day	.61	1.45
Control	.59	1.57
Aureomycin, 40 milligrams/day	.60	1.58
Enzymes		
1959		
Corn and hay rations fed with:		
Control	.39	1.60
Agrozyme, .68 gram/lamb/day	.37	1.56
Agrozyme, .68 gram/lamb/day	.38	1.53

[1] DES is diethylstilbestrol.

Table 20. Effect of various feed additives on lamb performance

Treatment	Average daily gain, pounds	Corn/day, pounds
Tranquilizers		
1957		
Corn and hay rations		
Control	.63	2.09
44.4 milligrams Chloropromozine	.64	2.09
11.1 milligrams Chloropromozine	.65	2.10
4.4 milligrams Trifluoperazine	.60	2.03
1958		
Control	.63	2.06
22 milligrams Chloropromozine	.62	2.07
90 milligrams Chloropromozine	.60	2.07
1958		
Alfalfa—Corn		
Control	.52	1.75
3 milligrams Hydroxyzine	.54	1.74
Oat silage—Corn		
Control	.45	1.65
6 milligrams Hydroxyzine	.48	1.65
Corn silage—Corn		
Control	.52	1.66
6 milligrams Hydroxyzine	.46	1.67
1958		
Pelleted rations		
Control	.43	3.39
3.3 milligrams Hydroxyline	.41	3.33
3.0 milligrams Hydroxyline plus 2.3 milligrams DES[1]	.38	3.00
1959		
Control	.44	...
5 milligrams Implant of Triflupromazine	.37	...

[1] DES is diethylstilbestrol.

Table 21. Effect of monosodium glutamate (MSG) on concentrate consumption by lambs

Treatment[1]	Corn[2]	Corn[2] with or without MSG
Number of lambs	6	6
Initial weight, pounds	54.0	53.0
Average daily gain, pounds	.49	.40
Average daily feed consumed, pounds		
Corn	1.59	.49
Corn plus MSG	...	1.03
Alfalfa hay	.61	.54
Percent MSG-corn consumed of total corn		72

[1] All lambs self-fed for 42 days.
[2] Level of monosodium glutamate (MSG), .25 percent. Lambs had choice of corn with no MSG added or .25 percent added. Treatments replicated three times.

Table 22. Results of trials involving silage for lambs

1958

Treatments	Alfalfa hay, corn, soybean meal	Oat silage, corn, soybean meal	Corn silage, corn, soybean meal
Average daily gain, pounds	.53	.46	.49
Daily ration, pounds			
Hay	1.65	.50	.50
Oat silage	...	2.14	...
Corn silage	...	...	2.12
Shelled corn	1.65	1.43	1.41
Soybean meal	.10	.20	.20

1956

				Alfalfa hay	
Treatments	Alfalfa hay, corn, soybean meal	Oat silage, corn, soybean meal	Corn silage, corn, soybean meal	Oat silage, corn, soybean meal	Corn silage, corn, soybean meal
Average daily gain, pounds	.30	.22	.21	.27	.27
Daily ration, pounds					
Alfalfa hay	1.42	...	...	.50	.50
Oat silage	...	2.70	...	2.14	...
Corn silage	...	...	2.69	...	2.07
Shelled corn	1.20	1.05	.99	1.07	1.06
Soybean meal	.10	.30	.30	.20	.20

1955

Treatments	Alfalfa hay, corn, soybean meal	Corn silage, corn, soybean meal
Average daily gain, pounds	.36	.36
Daily ration, pounds		
Corn	1.45	1.38
Hay	1.57	...
Corn silage	...	2.26
Soybean meal	.10	.30

1953

Treatments	Corn, alfalfa hay	Corn, corn silage, soybean meal	Corn silage, limited corn, soybean meal	Corn, silage, alfalfa hay, corn last 28 days	Corn silage, soybean meal, corn last 28 days
		1st 49 days			
Average daily gain, pounds	.34	.40	.37	.18	.28
Daily ration, pounds					
Corn	1.39	1.39	.73	...	...
Corn silage	...	2.82	4.74	4.13	5.95
Hay	1.61	...	...	1.00	...
Soybean meal	...	.30	.30	...	.30
		Entire 77 days			
Average daily gain, pounds	.33	.34	.35	.24	.29
Corn	1.52	1.45	1.01	1.31	1.32
Corn silage	...	2.49	3.79	3.24	4.64
Hay	1.40	...	...	.84	...
Soybean meal	...	.30	.30	.19	.30

Table 22. Results of trials involving silage for lambs (continued)

Treatment	Corn alfalfa hay	Corn alfalfa silage	Corn, alfalfa silage, alfalfa hay	Corn, corn silage	Corn, corn silage alfalfa hay, soybean meal
Average daily gain, pounds	.34	.31	.32	.22	.31
Daily ration, pounds					
Corn	1.46	1.66	1.57	1.25	1.36
Corn silage	...	...	...	3.05	2.69
Alfalfa silage	...	3.40	2.87	...	...
Hay	2.65	...	.50	...	.50
Soybean meal	...	. .	...	.30	.20

1946

Treatment	Corn, alfalfa hay	Corn, alfalfa hay, linseed meal	Corn, corn silage, linseed meal	Corn, corn silage, alfalfa hay, linseed meal
Average daily gain, pounds	.40	.42	.39	.44
Daily ration, pounds				
Corn	1.70	1.42	1.40	1.41
Corn silage	...	...	2.77	1.49
Hay	1.66	1.68	...	.85
Linseed meal	...	.30	.30	.30

The 1953 trial involved studies with corn silage in which the lambs were fullfed either a typical fattening ration containing corn silage or were fed nothing but corn silage for a portion of the feeding period and then put on fullfeed during the last portion of the feeding period. There was considerable variation in this trial, but it was concluded that good corn silage can constitute a major portion or all of the forage involved in a lamb finishing ration. If anything stands out clearly, it is that a small amount of alfalfa hay added to a non-legume silage benefits the lambs. Conversely, addition of alfalfa hay to an alfalfa silage, as was fed in the 1952 trial, increases gain very little.

One of the problems with feeding silage is getting lambs to consume a full feed of corn. Normally, it is necessary to limit the silage to about 2.5 pounds per lamb daily.

An all-in-one silage ration based on adding grain, minerals, and a protein supplement to the chopped corn plant at the time it is ensiled, appears to offer several advantages. It would encourage a lamb feeder to mechanize his feeding operation (silo unloader, unloading wagon or auger feeding arrangement) to reduce labor required to feed a large number of lambs.

Rations of this type were experimentally fed in 1965. Two sources of nitrogen were used. One all-in-one ration consisted of approximately 71 percent corn silage, 24 percent shelled corn, and 5 percent soybean meal. The other consisted of 70 percent corn silage, 29 percent shelled corn, and 1 percent urea; it contained about 55 percent dry matter. The basal corn silage contained about 45 percent dry matter.

Table 23 presents the results of this experiment. The principle of an all-in-one ration is sound. However, with finishing rations high in silage, it is often difficult to get lambs to consume sufficient amounts of energy for optimum gain. In neither ration, shelled corn added at time of feeding or at time of ensiling, was the intake of shelled corn adequate for satisfactory daily gain (.40 to .60 pound per day). The difference in daily gain (control lambs .30 pound versus .23 pound daily for lambs fed all-in-one silage) is due largely to the lower intake of dry matter and particularly less shelled corn when lambs were fed the all-in-one ration.

The data suggest the following points:

- Adding shelled corn and protein supplement to silage at ensiling time will usually reduce the moisture content of the ration. To assure a good pack (to minimize spoilage) aim for about 50 percent moisture.

- Growing-finishing lambs (75 to 85 pounds) will consume 2.5 to 3.5 pounds of silage. Therefore,

Table 23. Response of lambs fed corn silage and corn or an all-in-one silage ration (fed 42 days, 1965)

Treatment	Silage, shelled corn, soybean meal supplement, and hay	All-in-one silage	Silage with soybean meal	Silage with urea
Number of lambs	48	48	48	48
Initial weight, pounds	76.0	74.2	75.2	75.0
Average daily gain, pounds	.30	.23	.28	.25
Daily feed, pounds				
Silage (dry matter basis)	1.06	1.22	1.41	1.36
Shelled corn	.85	.42		
Protein supplement	.18	.09		
Alfalfa—brome hay	.49	.49	.49	.49
Total	2.58	2.22		
Feed per pound gain, pounds	8.60	9.60		

[1] Components of the all-in-one silage are given on page 22. Thus the total intake of all-in-one silage dry matter would total 1.72 pounds. This has not been done for the columns headed soybean meal or urea since those values include soybean meal or urea fed conventionally and in an all-in-one ration.

if lambs are to consume 1.25 to 1.75 pounds of shelled corn equivalent, 40 to 50 percent, by weight, shelled corn or other suitable grains need to be added to the silage.

- Either a preformed protein or urea may serve as the source of nitrogen. In these studies soybean meal resulted in superior weight gains but not as economic gains as with urea.

Nitrogen Sources for Lambs

Since lambs are ruminants, they can utilize sources of non-protein nitrogen. However, in typical commercial lamb feedlots the feeding period is of relatively short duration (60 to 100 days). Apparently the lambs and/or micro-organisms in the rumen require an adjustment period to a source of non-protein nitrogen. Usually slower gains occur during the first three to four weeks when non-protein sources of nitrogen are fed to lambs. This point is apparent in figure 5.

Trials represented by table 24 involved the use of a molasses, alcohol, and urea mixture and hydrolyzed feathers as well as dicyanamide and urea. In these studies, lambs fed finishing rations consisting of shelled corn, hay, molasses, and soybean meal made significantly greater gains than rations consisting of shelled corn, hay, and molasses-urea mix. Furthermore, the addition of molasses per se did not increase weight gains and often resulted in a lower consumption of energy feeds.

Hydrolyzed feather meal contains about 85 percent protein and is frequently used at low levels in poultry diets. When properly hydrolyzed, it proved to be a relatively palatable protein supplement and when fed at a level to provide the same amount of protein as soybean meal, resulted in quite comparable weight gains. For example, in the 1955 trial, lambs were fed non-legume hay, corn, and a level of soybean meal to provide a ration somewhat lacking in protein. This ration was compared with a ration consisting of the same amount of soybean meal plus an equal amount of feather meal. The average daily gains of the lambs fed the soybean meal and feather mixture were significantly greater than the low level of soybean meal and in fact were as great as when the lambs were fed .3 pound of soybean meal (table 24). In another 1955 trial, the same response was shown; namely, that feather meal resulted in gains very similar to those of soybean meal.

Dicyanamide, a rich source of nitrogen, is very bitter. A supplement containing only 2½ percent dicyanamide made it difficult to get lambs to eat their rations and consequently there were much lower rates of gain.

Urea was compared with soybean meal as a source of nitrogen in 1964 and 1965 trials (table 25). Feeding urea resulted in significantly slower gain during the first 28 days. (See figure 5.) However, over the entire feeding period, lambs fed urea gained as rapidly as lambs supplemented with soybean meal. This was true whether urea was fed with corn silage, with long hay, or in pelleted rations. Since the cost of the supplement containing urea was appreciably less than soybean meal, the net

Figure 5. Cumulative average daily gains by periods for major treatments (summary of 1965 and 1966 data)

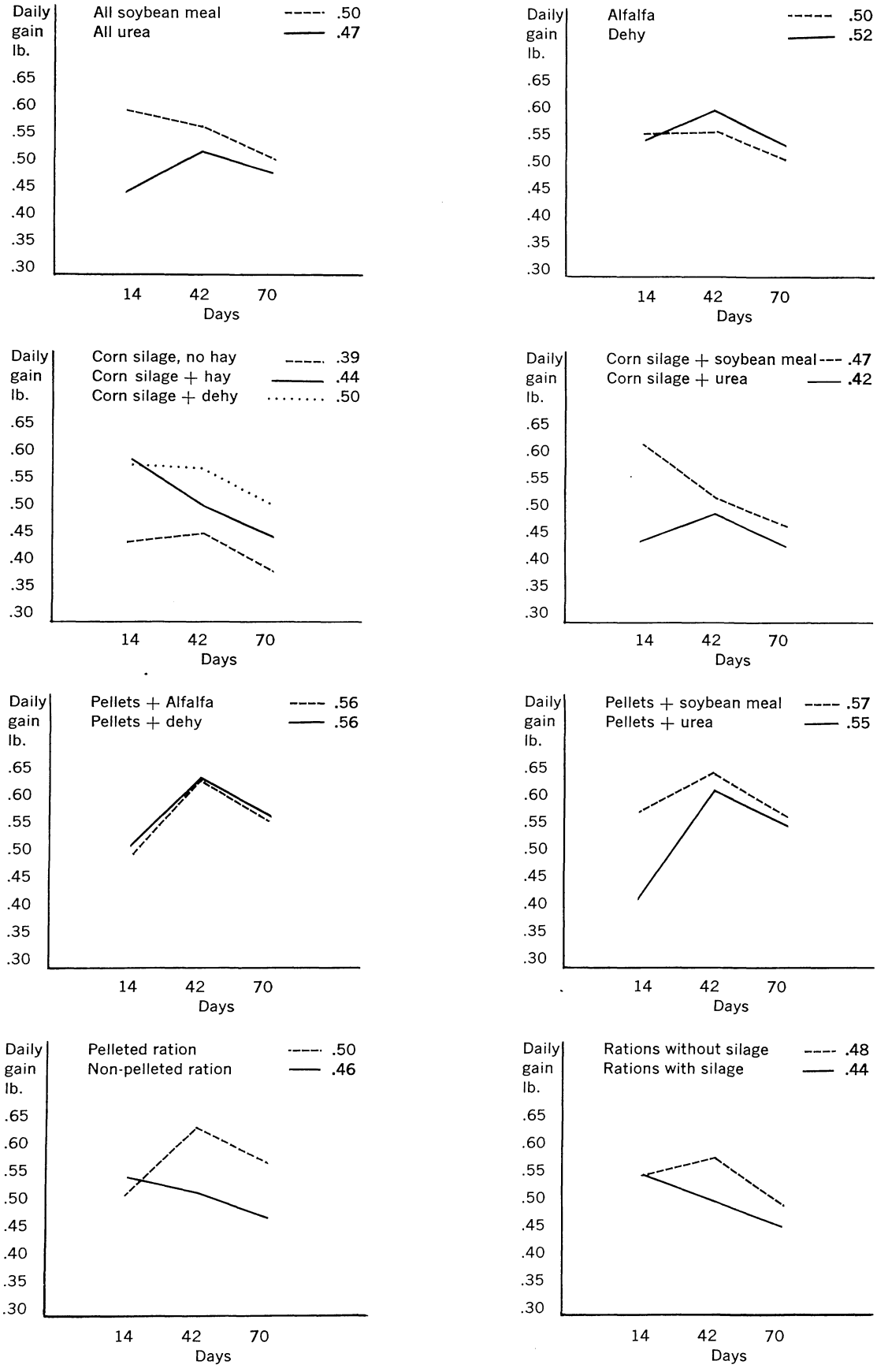

Table 24. Effect of various nitrogen sources as protein substitutes for lambs

Molasses-urea, 1959

Treatments[1]	Brome hay		Alfalfa hay		
	Soybean meal	Molasses-urea	Soybean meal	Molasses	Molasses-urea
Average daily gain, pounds	.51*	.44	.52*	.43	.40
Daily ration, pounds					
Corn	1.40	1.62	1.65	1.51	1.59
Hay	1.10	1.10	1.65	1.27	1.31
Molasses	1.14	...	...	.48	...
Molasses-urea	...	.81	...	...	.35
Soybean meal	.30	...	.10	.10	...

[1] Corn and hay were full fed in all comparisons. Molasses and molasses-urea were full fed with brome hay, but limited fed with alfalfa hay rations. Molasses-urea contained 30 percent protein equivalent.
* Significantly greater ($P < .05$).

Feather meal, 1956

Treatments	Alfalfa hay		Prairie hay	
	Soybean meal	Feather meal	Soybean meal	Feather meal
Average daily gain, pounds	.30	.27	.20	.21
Percent protein in supplement	44.0	44.4	44.0	44.4

Brome hay, 1955

	Soybean meal .1 pound daily	Feather meal .1 pound, Soybean meal .1 pound daily	Soybean meal .3 pound daily
Average daily gain, pounds	.38	.47*	.46*

Brome hay, 1955

	Soybean meal	Soybean meal, feather meal 1:1	Soybean meal	Soybean meal, feather meal 1:1
Average daily gain, pounds	.42	.44	.42	.43

Dicyanamide, 1955

Corn silage

Treatment		Dicyanamide
Average daily gain, pounds	.36*	.28

* Significantly greater ($P < .05$).

profit per lamb usually favored lambs fed urea rations. This will not always be true and depends primarily on the difference in rate of gain obtained and the margin existing for the gains put on. With short (40 to 60 days) feeding periods, urea may reduce gains enough during the adjustment period to negate its price advantage.

High protein seeds, such as soybeans or flaxseed, have been successfullly used as sources of proteins for ruminants. Their high oil content reduces the percent of protein appreciably: soybean meal contains 44 to 50 percent protein whereas whole soybeans contain only 37 percent protein. Furthermore a high fat content in the ration (above 8-10 percent) usually reduces feed intake and rate of gain.

Table 26 presents data from three experiments involving feeding lambs grain rations that contained the following: 1) all soybeans, 2) half soybeans, 3) one-quarter soybeans, and 4) one-quarter flaxseed.

Lambs fed the high oil grains usually had lower feed consumption and rates of gain than those fed

Table 25. Urea or soybean meal and alfalfa hay or dehydrated alfalfa (dehy) as components of lamb finishing rations (fed 81 days)

Ration	Number of lambs	Average daily gain, pounds	Feed per pound gain, pounds	Net profit per lamb
Soybean meal	72	.460	8.94	$2.02
Urea	72	.461	9.30	2.34
Alfalfa hay	48	.470	9.24	2.24
Dehydrated alfalfa (dehy)	48	.473	9.05	1.89
Corn silage, no alfalfa	24	.409	12.7	2.02
Corn silage + alfalfa	24	.439	11.0	2.49
Corn silage + dehy	24	.467	10.9	2.51
Corn silage + soybean meal	36	.446	11.4	2.34
Corn silage + urea	36	.430	11.7	2.34
Pellets with alfalfa	24	.500	7.2	1.97
Pellets with dehy	24	.496	7.0	1.27
Pellets with soybean meal	24	.482	7.1	1.38
Pellets with urea	24	.496	7.3	1.87

Table 26. The effect of feeding high-oil seeds to fattening lambs

	I[1]			II[2]			III[3]			
Trial lot	1	2	3	1	2	3	1	2	3	4
Number of lambs	10	10	10	10	10	10	12	12	12	12
Number of days fed	49	49	49	77	77	77	84	84	84	84
Average initial weight, pounds	88.1	84.7	87.4	74.6	71.3	69.4	68.6	68.6	68.6	68.5
Average gain, pounds	17.3	6.0	2.9	31.3	27.7	29.7	45.1	42.7	36.1	44.3
Average daily gain, pounds	0.35	0.12[4]	0.06[4]	0.41	0.36	0.38	0.54	0.51	0.43[4]	0.53
Calculated fat content of grain rations, percent	3.9	10.9	18.0	3.9	10.9	7.4	3.9	11.9	10.9	7.4
Average daily feed consumption										
Grain, pounds	1.78	1.39	1.18	1.64	1.44	1.63	1.65	1.75	1.51	1.74
Brome hay, pounds	1.47	1.30	1.24	1.15	1.15	1.19	1.68	1.63	1.67	1.71
Soybean meal, pounds	.20	...	...	.10	...	...	.10	...	...	...
Feed per 100 pounds gain, pounds										
Grain	505	1133	2000	404	400	425	307	344	351	330
Hay	417	1062	2100	283	319	309	313	321	388	324
Protein supplement	57	...	...	24	...	...	19	...	...	...
Carcass grade[5]	6.3	5.9	5.8	6.3	5.8	5.5	6.5	6.7	5.4	6.4
Yield	54.8	52.1	51.5	52.3	51.1	54.1	54.1	54.2	53.0	54.6

[1] Trial I: Lot 1, control; Lot 2, ½ corn, ½ soybeans; Lot 3, soybeans.

[2] Trial II: Lot 1, control; Lot 2, ½ corn, ½ soybeans; Lot 3, ¾ corn, ¼ soybeans.

[3] Trial III: Lot 1, control; Lot 2, ¾ corn, ¼ flaxseed; Lot 3, ½ corn, ½ soybeans; Lot 4, ¾ corn, ¼ soybeans.

[4] Significant difference at the 1.0% level of probability.

[5] Carcass grade code: Low choice, 7; High good, 6; Average good, 5.

soybean meal. In these experiments the whole seed was intended to serve as a source of protein as well as energy. However, if either grain is added at levels to provide only protein, (14 to 20 percent) comparable gains will occur.

The addition of 10 percent animal tallow to soybean meal provides an excellent source of energy, and at that level (about the maximum that can be incorporated) does not affect feed intake. In three of four experiments, rate of gain and feed efficiency were improved (table 27).

Table 27. The effect of feeding tallow-soybean oil meal supplements to fattening lambs

Trial lot treatment[1]	I		II		III		IV	
	1 Soybean meal	2 Tallow	1 Soybean meal	2 Tallow	1 Soybean meal	2 Tallow	1 Soybean meal	2 Tallow
Number of lambs	10	10	10	10	15	15	15	15
Number of days fed	49	49	98	98	84	84	56	56
Average initial weight, pounds	86.2	87.2	66.0	66.1	57.7	57.2	73.3	72.5
Average gain, pounds	15.5	14.2	40.4	42.6	33.2	35.1	22.5	25.3
Average daily gain, pounds	0.32	0.29	0.41	0.45	0.40	0.42	0.40	0.45
Average daily feed consumption								
Grain, pounds	1.76	1.67	1.56	1.53	1.50	1.50	1.39	1.41
Brome hay, pounds	1.39	1.38	1.16	1.17	1.27	1.19	1.19	1.15
Protein supplement, pounds	0.30	0.30	0.30	0.30	0.31	0.31	0.25	0.25
Feed per 100 pounds gain, pounds								
Grain	556	573	378	353	379	358	349	311
Hay	440	471	282	268	323	286	298	255
Protein supplement	95	103	73	69	80	76	64	56
Carcass grade[2]	5.9	6.4	6.2	5.9	6.9	6.5	...	...
Yield	53.4	53.9	50.1	49.4	52.0	49.1	...	...

[1] In each trial, Lot 1 was the control and Lot 2 the experimental which had 10 percent tallow added to the soybean meal.
[2]Carcass grade code: Low choice, 7; High good, 6; Average good, 5.

Beet Pulp

Dried beet pulp with or without molasses, fed either pelleted or unpelleted, has long been popular with lamb feeders. Table 28 presents a summary of two trials involving beet pulp. The addition to the concentrate of 15 to 35 percent beet pulp, containing either 25 percent added molasses or no molasses, usually resulted in gains comparable to gains with shelled corn as the sole concentrate. In one trial, lambs fed shelled corn as a concentrate, performed slightly better than lambs fed rations containing beet pulp. In the second trial, lambs fed equal parts of shelled corn and beet pulp gained somewhat faster. Beet pulp proved to be somewhat laxative and increased the problem of keeping pens dry. While lambs perform well with beet pulp, they prefer shelled corn to pelleted beet pulp. When fed with good quality hay, beet pulp usuallly reduces the corn and hay intake.

Ration Comparisons of 30 Years

The data in table 29 provide a comparison of typical rations fed during the 1920's and 1930's with those fed during the 1960's. These comparisons, all made within one replicated trial, involved specific variables characteristic of the era and offer good proof that advances have been made in lamb feeding. The results of these various comparisons may be summarized as follows:

- Prairie or non-legume hay, shelled corn, and salt—while the best available in the 1920's is a very inefficient ration for the 1970's. The addition of ground limestone to this ration improved the weight gains about 14 percent and reduced the cost of the gain about $1.50 a hundred. The addition of soybean meal to the ration increased the weight gain about 26 percent over the original corn-prairie hay and salt ration.

- Since the 1930's, corn, salt, and alfalfa hay has been the standard lamb finishing ration, and it is difficult to improve. For example, alfalfa hay and corn resulted in about 10 percent faster gain than corn, mineral, prairie hay, and soybean meal. The addition of soybean meal to a corn-alfalfa ration improved the weight gains about another 12 percent but not necessarily the returns over feed costs.

- In this series of trials, the addition of antibiotics and antibiotics and oral DES had little influence on weight gain or feed efficiency. Conversely, when lambs were implanted with 3 milligrams of DES and fed corn and alfalfa hay, the weight gains increased about 20 percent.

- Lambs fed pelleted rations gained appreciably faster than lambs fed non-pelleted rations. However, their feed intake increased, as did the cost of the ration, so the per lamb profit did not increase.

Table 28. Response of growing finish lambs to two types of beet pulp pellet fed at various levels (1962-1964)

	I 1962-63			II 1963-64					
								No molasses	
Experiment									
Treatment[1] Percent Corn	100	50	0		85	75	65	75	65
Beet pulp	0	50	100	100	15	25	35	25	35
Number of lambs	24	24	24	24	24	24	24	24	24
Initial weight, pounds	65.3	66.3	65.4	80.4	81.1	81.1	80.7	81.8	81.2
Gain per lamb, pounds	20.2	25.4	22.1	21.3	19.6	21.3	19.4	21.6	19.0
Day fed	64	64	64	69	69	69	69	69	69
Average daily gain, pounds	.32	.40	.35	.31	.28	.31	.28	.31	.28
Average daily feed eaten, pounds									
Corn	1.54	1.10	...	1.87	1.48	1.35	1.18	1.34	1.16
Beet pulp	...	1.05	2.16	...	.27	.45	.64	.45	.63
Alfalfa hay	1.32	1.00	.94	1.09	1.12	1.13	1.13	1.14	1.13
Soybean meal	.10	.10	.10	.10	.10	.10	.10	.10	.10

[1] Lambs were all full fed. The beet pulp contained 25 percent beet molasses in all lots except where noted.

Table 29. Comparison of typical lamb finishing rations of the 1920's with those fed in the 1960's

Ration	Number of lambs	Average daily gain (pounds)	Total feed intake (pounds)	Total feed/pound gain (pounds)	Profit or loss ($)
1920's					
Prairie hay and corn					
Salt	22	30[e1]	2.8	9.2	−1.33
Salt + limestone	22	.34[de]	2.8	8.2	−1.16
Salt, limestone + soybean meal	22	.38[d]	3.0	7.9	−1.30
1960's					
Alfalfa hay and corn					
Salt	22	.42[cd]	3.0	7.2	− .47
Salt, dical + soybean meal	22	.47[c]	3.1	6.5	+ .02
soybean meal + antibiotics	22	.49[c]	3.2	6.4	− .12
Soybean meal, antibiotics + oral stilbestrol	22	.49[c]	3.2	6.6	+ .02
Soybean meal + antibiotics + stilbestrol implant	22	.57[b]	3.2	5.7	+1.00
Pelleted rations					
Basal	22	.59[b]	4.0	6.8	− .23
Basal + antibiotics	22	.57[b]	3.8	6.7	− .16
Basal, antibiotics, + oral stilbestrol	22	.56[b]	3.8	6.8	− .28
Basal, antibiotics + stilbestrol implant	21	.73[a]	4.3	5.9	+1.01

All lambs were full-fed and self-fed pelleted rations.
[1] Values in this column with different superscript letters are significantly different from one another ($P < .05$).

Heat processed flaked corn—Stockmen are constantly altering the type of ration fed and processing it in various ways, trying to increase the amount of nutrients livestock can obtain from a given amount of feed. In some areas, cattlemen have had considerable success with cooking and flaking, popping or rolling, corn, milo, and barley. In these studies, neither cooking and flaking nor steaming and rolling grains has contributed substantially to rate of gain or feed efficiency.

The results of three separate trials involving the feeding of cooked and flaked corn to growing-finishing lambs are presented in tables 30 and 31. Cooked-flaked grain reduced the lamb feed intake consider-

ably (table 30). The second and third trial limited the amount of shelled corn fed daily to the amount of flaked corn the lambs consumed. Lambs were usually fussier about eating the flaked corn: in the third trial it took about a month before they readily consumed it. Weight gains were not significantly affected but tended to favor the shelled corn. Conversely, lambs fed flaked corn were slightly more efficient. However, the increase in the lambs' performance is not sufficient to warrant the $2 to $4 per ton cooking and flaking cost.

Steamed-rolled grain did not increase weight gains of growing-finishing lambs (table 32). Lambs fed cold-rolled barley tended to eat less grain than lambs fed the other types of barley. However, neither steamed nor cold-rolled barley was superior as a lamb feed to whole barley. Lambs fed shelled corn gained approximately 21 to 23 percent faster and produced a pound of gain more efficiently than lambs fed various types of barley. In general, barley, as a lamb-finishing grain, is worth 80 to 85 percent as much as shelled corn (table 32).

Table 30. Effect of heat-treated flaked corn on growth and feed utilization of lambs

Treatment[1]	Shelled corn	Flaked corn
Number of lambs	12	12
Initial average weight, pounds	60.3	62.2
Final average weight, pounds	71.0	70.7
Total gain/lamb, pounds	10.7	8.5
Days fed	41	41
Average daily gain, pounds	0.26**	0.21
Average daily feed consumption, pounds		
Corn	1.41	1.19
Hay	1.19	1.21
Feed/100 pound gain, pounds		
Corn	555.8	591.8
Hay	474.8	602.1

[1] All lambs were self-fed corn. Hay was fed in equal but limited amounts twice daily. Six replications per treatment are represented in the summary.

** $P < .01$.

Table 31. Effect of heat-treated flaked corn on growth and feed utilization of lambs

	Experiment 2		Experiment 3	
Treatment[1]	Shelled corn	Flaked corn	Shelled corn	Flaked corn
Number of lambs	12	12	27	27
Initial weight, pounds	112.9	112.8	71.4	73.5
Days fed	40	40	56	56
Average daily gain, pounds	.40	.39	.53	.53
Daily feed, pounds				
Grain	1.37	1.32	1.72	1.66
Hay	1.76	1.59	1.45	1.34
Soybean meal	.20	.20	.10	.10
TDN per pound gain, pounds[2]	5.37	5.20	4.16	3.94

[1] All lambs were hand-fed twice daily. Corn intake was equalized in experiment 2 and hay was limited to encourage consumption of the flaked corn in experiment 3.

[2] Total digestible nutrients (TDN) were calculated on the following basis: corn, 80 percent; alfalfa-brome grass hay, 50 percent; and soybean meal, 78 percent.

Finishing Lambs on Pastures

Of all the schemes employed in finishing lambs at the Minnesota Experiment Station, the system of pasturing western or native feeder lambs on rape pasture has been the most economical and satisfactory. Lambs fed on rape pasture and supplemented with water and trace mineralized salt, gained as rapidly as lambs full-fed shelled corn, alfalfa hay, and protein supplement in drylot (table 33). Rape pasture normally provides a parasite-free forage. While the lambs do not initially eat it readily, they become accustomed to it in about 10 days and eat sufficient quantities to result in very rapid gains. Rape pasture does have the following drawbacks: first, the lambs may not carry sufficient finish to sell directly off rape pasture; and second, fall weather in the Upper Midwest is often uncertain so that occasionally the pasture feeding program is curtailed before the lambs have reached market weight.

Table 32. Comparison of shelled corn, steam rolled barley, cold rolled barley and whole barley for fattening lambs

Treatment	Shelled corn	Steam rolled barley	Cold rolled barley	Whole barley
Number of trials	2	2	1	1
Number of lots fed	4	4	2	2
Number of lambs	53	52	27	26
Average initial weight, pounds	68.2	68.6	70.6	66.0
Average daily gain, pounds	.48**	.37	.38	.37
Gain index, percent	100	77	79	77
Average number days fed	46	46	39	53
Average daily concentrate consumed, pounds	1.74	1.58	1.40	1.68
Average concentrate per pound, gain, pounds	3.63	4.27	4.42	3.80

** $P < .01$

With a vigorous stand of rape, 6 to 8 lambs per acre can be grazed for approximately 60 days with an expected gain per acre of about 225 to 250 pounds. Grazing can begin from September 1 to 15, depending on the removal date of the companion crop. Bloat, while a common concern of lamb feeders when pasturing rape, has not been a serious problem in any of these studies.

Alfalfa. Pastured during September and October, alfalfa proved to be a very unsatisfactory feed for finishing lambs. During September, lambs gained about half as fast as lambs grazing rape pasture; during October they made virtuallly no gain. Grazing alfalfa in September normally reduces the vigor of the plant and results in a high proportion of winter kill.

Cornfield gleanings. In Minnesota, grazing lambs in cornfields in an attempt to produce inexpensive gains without reducing corn yields, appears to be a poor practice. Lamb grazing studies in cornfields have been conducted at the following times: mid-July, September before corn picking, and early October after corn picking.

Attempts were made to answer the following questions:

- Will corn yields be reduced by grazing in cornfields?
- When are the most rapid gains made—pre or postharvesting?
- Should a protein supplement; limited or full feeding of concentrates; hay or a combination of these; be fed to lambs grazing in standing corn?
- Is it possible to get lambs to grade choice?
- Profit-wise, how does it compare with drylot feeding?

Table 33. Finishing lambs on pasture

1959		
Treatment	Full-fed drylot	Rape pasture
Number of lambs	26	59
Average daily gain, pounds	.49	.49

1958			
Treatment	Full-fed drylot	Rape pasture	Alfalfa pasture
Number of lambs	20	37	39
Average daily gain, pounds	.40	.46	.28

Fields were stocked at 4½ lambs per acre; some were fed protein supplement; others, grain, hay, or a combination of the three. Salt and soybean meal in a 1:3 ratio were mixed to regulate the protein intake. Table 34 presents the results of the trial. During the early weeks in the field, the lambs restricted their intake to weeds and the lower leaves of the corn plant. When these suppplies were exhausted, lambs began to knock over the stalks and eat some of the corn ears. Weight gains were very low and averaged from one-third to one-half the rate of gains of lambs full-fed in drylot. In two of the three years, corn yields were reduced by preharvest

grazing. Yields were rather low during those two years and perhaps there was also some corn borer damage resulting in a high proportion of ear drop. In 1961 corn yields averaged 65 to 70 bushels and there was virtually no reduction in corn yield due to preharvest grazing. However, during that year the lambs were self-fed supplemental grain or pellets. Feeding a protein supplement increased average daily gain. A 1:3 ratio mixture of salt to soybean meal limited protein consumption to .10 to .15 pound of soybean meal per lamb daily.

In each of the three years a severe snowstorm occurred on or about November 1 and the lambs had to be removed before they reached a choice grade or weighed enough to warrant marketing. While the cost of producing a pound of gain in the cornfield was slightly lower than drylot feeding in two of the three years, greater return over fed cost per lamb was made each year by drylot feeding (greater weight and higher selling prices).

Another important consideration is that late fall grazing normally precludes fall plowing, and this normally would result in an 8 to 10 percent reduction in yield of the subsequent crop. Finally, lambs grazing in standing corn are impossible to observe, so it necessitates driving them to an open end of the field daily to keep track of them and to be sure nothing is amiss.

Roughage Substitutes

Tables 35 and 36 present the results of trials in which lambs were fed beet toplage, alfalfa haylage, or oyster shells as substitutes for typical alfalfa hay forage. In the trial involving feeding of beet toplage, two levels of toplage were fed with or without hay. Beet toplage proved to be palatable and economical, and had a value of 90 to 95 percent that of alfalfa haylage. The feeding of relatively high levels of alfalfa haylage (1.2 pounds of dry matter per lamb daily) reduced the intake of shelled corn and often lowered weight gain. The addition of beet toplage or alfalfa haylage generally increased the dry matter intake but did not consistently improve average daily gain.

Using either 3 or 6 percent oyster shells in the concentrate ration as a substitute for alfalfa hay, resulted in significantly lower gains, and the lambs exhibited a depraved appetite and chewed on the wood bunk and ate sawdust bedding (table 36). These data on oyster shells suggest that growing-finishing lambs need relatively high proportions of roughage and that oyster shells are not a good substitute.

Table 34. Pasturing lambs in standing cornfields

Treatments	Year	Lots	Average daily gain, pounds: Pre-harvest	Average daily gain, pounds: Post-harvest	Corn yield reduction, bushel/acre
Cornfield					
No supplemental feed	1959	2	.15	.18	9.1
No supplemental[1] feed	1959	2	.30	.48	34.6
Salt-soybean meal 1:3 self-fed	1959	2	.26	.27	10.2
	1960	1	.27	.37	8.5
Salt-corn and soybean meal 1:6 self-fed plus hay	1960	1	.19	.36	7.9
Salt-corn and soybean meal 1:6 self-fed	1960	1	.23	.49	8.5
Corn self-fed[2]	1961	2	.30	.35	0
Pelleted ration self-fed	1961	1	.37	.41	0
Drylot					
Hay, corn and soybean meal hand-fed	1959	4	.48	.48	..
	1960	1	.51	.44	..
	1961	1	.39	.55	..
Pelleted ration self-fed	1961	1	.72	.51	..

[1] Stocking rate was 4.5 lambs per acre in all cornfield lots with this one exception, which was 7.6 lambs per acre.

[2] Averages include data for lambs started on self-fed salt and corn-soybean meal as well as lambs self-fed corn.

Table 35. Beet toplage and alfalfa haylage for lambs (26 lambs per treatment)

Treatment[1]	Initial weight (pounds)	Acreage daily gain (pound)	Daily feed intake (pounds) Concentrate	Haylage	Toplage	Dry matter per pound gain (pounds)
Low toplage, no hay	58.0	.37	2.0	..	1.2	6.5
Low toplage, .5 pound hay	58.5	.48	2.0	..	1.2	5.8
High toplage, no hay	57.3	.46	1.8	..	2.4	6.2
High toplage, .5 pound hay	57.8	.45	1.6	..	2.4	6.6
Low haylage, no hay	57.3	.46	2.2	1.0	..	5.5
Low haylage, .5 pound hay	58.2	.46	1.8	1.0	..	5.7
High haylage, no hay	57.5	.44	1.6	2.0	..	6.0
High haylage, .5 pound hay	58.2	.38	1.3	2.0	..	7.0

[1] All lambs full-fed shelled corn. Protein intake was equalized by adding soybean meal to some lots.

Table 36. Effect of oyster shells in lamb finishing rations

	Trial 1			Trial 2		
Treatment[1]	Corn and hay	Oyster shells 3 percent	Oyster shells 6 percent	Corn and hay	Oyster shells 3 percent	Oyster shells 6 percent
Number of lambs	12	12	12	12	12	12
Intial average weight, pounds	63.6	63.4	62.7	78.8	79.0	78.3
Number of days fed	62	62	62	51	51	51
Average daily gain, pounds	.45[2]	.37	.39	.48[3]	.27	.27
Average daily feed consumption, pounds						
Corn	1.66	1.74	1.89	1.69	1.64	1.64
Hay	1.11	..	..	1.52	.06	.06
Oyster shell	..	.05	.10	..	.05	.10
Soybean meal	.10	.20	.20	.09	.27	.27
Feed/100 pounds gain, pounds						
Corn	368.9	470.3	484.6	352.1	607.4	607.4
Hay	246.7	..	..	316.7	22.2	22.2
Oyster shell	..	13.5	27.7	..	18.2	36.1
Soybean meal	22.2	54.1	51.3	18.8	100.0	100.0

[1] All lambs were full-fed. Oyster shells were spread on top of coarsely ground corn. A very limited amount of hay was fed to lambs receiving shells. All lambs were bedded with wood shavings.

[2] $P < .05$.

[3] $P < .01$.

Figure 6. Lambing off corn is successfully practiced by some feeders. Gleaning corn fields following picking can salvage some missed corn, but weight gains of only .15 to .25 pound per lamb daily, uncertain weather that may curtail gleaning entirely, and fencing problems make it an old fashioned practice that doesn't fit an intensive feeding operation.

Summary

All the studies reported here were done with purchased feeder lambs. However, the results can be applied equally well to the growing and finishing lambs raised in the farm flock.

These studies provide good evidence of the following principles:

- Lamb gains, and often feed requirements per unit of gain largely depend on a maximum intake of a nutritious ration.

- The components of a nutritious ration need not be fixed and may range from corn to beet pulp as concentrate and from alfalfa hay to various silages as forage. There may still be a difference in their nutritive value; various inadequacies of all feeds need corrective supplements to obtain maximum gains. With non-legume forages such as oat silages, corn silage, or non-legume hays, a protein supplement, either as a preformed or a non-protein source of nitrogen, is a must. If the ration proves unacceptable (unpalatable) to the lamb, feed intake of that portion of the ration and possibly the entire ration will be reduced and performance will be disappointing.

- Processing of feeds such as flaking grain, ensiling grain, or pelleting rations do not guarantee a profitable type of ration. Processed grains may increase feed efficiency while reducing intake so that overall performance of the lamb is not as great as with the basal ration. Conversely, the pelleting of rations normally increases feed intake and average daily gain but the cost of pelleting may exceed the advantages in average daily gain and feed efficiency.

- Lambs can convert a variety of low cost and often waste products into salable meat. Grains of very low bushel weight or high moisture content (and consequently low cash market value) and crop residues (beet toplage, grain aftermath, and corn fodder) can be merchandised through lambs at a much higher price than they would bring on the market.

- Few feed additives have added significantly to the performance of growing-finishing lambs. The exceptions appear to be antibiotics, when fed at 30 to 50 milligrams per lamb daily, and the implantation of DES, which has increased weight gains 20 to 40 percent. Its adverse effects continue to be a problem, however. Farm flock owners and commercial lamb feeders should use DES with discretion.