Lamb-Feeding Practices

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LAMB-FEEDING PRACTICES

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and
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Introduction

The number of sheep on farms and ranches and the production of market lambs have been declining for some time. An analysis of all the factors that have contributed to this decline is outside the scope of this report. Nevertheless, lamb feeding can be profitable given the proper combination of circumstances. A vital factor in profitable lamb feeding is a requirement that the feeder be knowledgeable with respect to the feeding value of various feedstuffs and the nutrient requirements for fattening lambs. This report has been assembled for the purpose of providing information of this nature in a readily available form for use by lamb feeders as well as other agriculturists.

Some of the information in this report may seem unduly technical. However, with the increased use of processed feedstuffs, synthetic feedstuffs (urea, for example), antibiotics, hormones, and computers to formulate rations, it is necessary for the feeder who wishes to keep up-to-date to become familiar with some of the terminology. For example, much of the new information in trade and technical publications will be using digestible or net energy rather than the older and more commonly used term of TDN (total digestible nutrients). Consequently, a constant effort is required by the feeder who wishes to keep abreast of new information that may help him improve his efficiency of production.

Feedstuff Composition

The cost of feed represents the largest single expense in lamb production. The total feed cost, for both ewe and lamb, will be least when lambs have sufficient finish to be marketed at an early age directly off the ewes. Even so, most of the cost of getting the lamb to market is cost of feed for either the ewe or the lamb. In the case of lambs fed in dry lot, feed may account for 80 to 90% of cash outlay excluding the cost of the lambs.

Two obvious ways to reduce the feed cost per pound of gain are (1) to feed a ration that will produce gain more efficiently and (2) to make savings in the purchase of feedstuffs that may be economically priced. In order to accomplish either of these objectives, it is necessary to have information on the composition of feedstuffs so that their approximate feed value can be estimated. Data shown in Table 1 illustrate the average composition of feedstuffs that are either produced in Oregon or are frequently priced low enough to be used in lamb fattening rations.

The average figures listed in Table 1 may not be accurate in an individual situation, since weather, method of harvesting, varietal differences, fertilization practices, and processing can have some influence on the chemical composition and feed value of grains or forages. However, unless differences in crude protein and fiber are extreme, the feeding value probably will not differ markedly from the averages shown. Milling by-product feeds (such as wheat mill run or hominy feed) and protein concentrates (such as soybean meal or safflower meal) are usually standardized by the processor. Consequently, such feeds are apt to be more uniform than unprocessed grain or roughage.

Energy Values

Listed in Table 1 are four different means of describing the energy value of feedstuffs: net energy, net energy of production, digestible energy, and TDN. These different terms are not given for the purpose of confusing the reader, but because each of them is used by some individuals. The net energy and net energy of production values on the left-hand side of the table are becoming more popular and are expressed in terms of megacalories (abbreviated megcal.) per pound of feed. A megcal. is the same as a therm and is defined as the amount of heat required to raise 1,000 kilograms (2,205 lb.) of water 1° Centigrade. Some writers prefer to express energy values on the basis of energy per 100 pounds of feed; if this were done, the poor-quality alfalfa would have a value of 35-40 as compared to the value of .35-.40 listed in the table. The values listed in the table, for the most part, were suggested by Dr. Spencer Morrison, as published in Feedstuffs (December 24, 1966).

Net energy values are coming into use because many animal nutritionists feel that they more accurately represent the feeding value of a wide range of feedstuffs than other methods do. In the process of determining such values, the feed in question is fed to an animal enclosed in a calorimeter. Such equipment enables the operator to determine how many calories were excreted in urine, feces, gases, and heat given off by the body. With this information, the net energy value can be calculated. Adaptations of this procedure have been used by California researchers in such a manner that the amount of energy deposited in the carcass during a feeding trial can be determined. In either case, it is a time-consuming and expensive procedure. Consequently, net energy values have not been determined on very many feeds nor under very many feeding situations. Most of the values listed in Table 1 are calculated values; however, they represent values which are believed to be reasonably good estimates. For that matter, net energy values are not constants, and this is the reason a range in values is given in Table 1. The energy value declines rapidly when feed intake is increased above maintenance. Temperature also influences the value since more heat is radiated from the body during cold weather than during warm weather, and this item is considered when calculating net energy. In addition, various combinations of feeds may give net energy values that are different than would be expected from results of experiments in which the feeds were fed singly.

Table 1. Composition of Feedstuffs

Feedstuffs	Net energy*	Net energy of production*	Digestible energy*	TDN	Crude protein	Digestible protein	Protein digestibility	Crude fiber	Ca	P	Relative feed value**
Roughages				%	%	%	%	%	%	%	
Alfalfa, poor quality		.20	.96	48	13.5	9.3	68	34	1.07	.20	
Alfalfa, good quality	.35-.40	.24	1.00	51	15.2	10.6	70	28	1.20	.20	55-60
Alfalfa, leafy		.27	1.08	53	16.5	12.0	73	25	1.10	.29	
Dehy. alfalfa, 20% protein	.47-.51	.30	1.14	57	20.6	15.4	75	20	1.60	.23	
Grass hay, mixed	.32-.36	.21	.90	45	7.0	3.8	55	32	.40	.30	
Barley straw	.22-.24	.14	0.82	41	3.6	0.6	17	37	0.30	.08	
Wheat straw	.10-.16	.10	0.81	40	3.8	0.5	15	37	0.15	.07	
Proteins											
Cottonseed meal, expeller	.68-.76	.50	1.46	73	41.4	33.5	81	11	.18	1.15	88
Cottonseed meal, solvent	.63-.72	.46	1.32	66	41.6	34.5	83	11	.15	1.10	85
Linseed meal, solvent	.66-.74	.50	1.48	74	35.1	30.9	88	9	.40	.83	
Peas, cull	.74-.78	.53	1.58	79	25.0	20.5	82	6	.17	.32	100
Safflower, solvent (hulls)	.39-.43	.25	1.02	51	21.5	17.2	80	33	.50	.74	64-65
Soybean meal, expeller	.78-.82	.55	1.48	74	43.8	39.4	90	6	.27	.63	
Urea					262.0	153.0	70				
Concentrates											
Barley	.70-.78	.50	1.52	76	9.5	7.5	79	6	.06	.33	87
Barley, light wt.		.43	1.36	69	11.0	8.4	76	8			84
Beet pulp, mol. dried	.66-.70	.47	1.42	71	9.1	6.0	66	16	.56	.08	86-92
Corn, No. 2 dent	.75-.80	.55	1.60	79	8.9	6.9	77	2	.02	.31	100
Fat	1.55-1.60	1.20	3.88	194							165-175
Hominy feed, 5% fat	.78-.80	.60	1.66	83	11.1	7.1	64	6	.03	.54	99-100
Milo, southwest	.58-.65	.42	1.42	70	9.0	5.1	57	2	.03	.28	90-95
Molasses, cane	.50-.56	.38	1.08	54	3.0	1.5	50	0	.66	.08	80-90
Oats, white	.65-.73	.45	1.46	74	9.0	7.0	78	11	.09	.33	80
Wheat	.63-.67	.55	1.30	65	9.9	8.3	84	3	.04	.30	80-85
Wheat mill run	.62-.69	.43	1.28	64	15.8	12.3	78	8	.11	1.09	82
Screenings											
Alfalfa seed screenings	.68-.72	.49	1.46	73	25.0	18.8	75	11	.21	.64	95-100
Light ryegrass screenings	.28-.32	.19	.87	43	8.0	3.6	45	22			50-55
Heavy ryegrass screenings	.43-.46	.34	1.15	58	11.8	8.0	68	12	.21	.13	70-75
Wheat flour screenings	.54-.58	.42	1.28	64	9.0	6.8	75	16	.14	.68	82
Minerals											
Dicalcium phosphate									27.0	20.0	
Monocalcium phosphate									21.0	20.0	
Limestone									35.0		

* Energy values expressed as megcal./lb. feed.
**Relative to corn.

The net energy of production values are primarily those suggested by Dr. Glenn Lofgreen and co-workers from the California Agricultural Experiment Station. In determining some of these values, the feedstuff in question was fed at a rate that would provide for maintenance, but little or no gain to some animals. Other animals were fed additional amounts to allow a reasonable rate of gain. As a result, the value of the feed could be expressed when used only for maintenance and when used for maintenance and production. Whether these values are any more useful than those in the first column remains to be seen. They do serve to emphasize that the feed value of all feedstuffs that supply energy declines drastically when used to produce gain as compared to feeding at maintenance.

Comparable digestible energy values are given in column 3 (Table 1) and TDN values in column 4, since many readers may prefer to use one of these values rather than net energy. Digestible energy is quite similar to TDN, although the values are expressed as megcal. rather than in the typical percentage TDN values. Digestible energy is believed to be a somewhat more accurate measure of feed value than TDN and would be preferred when the data are available; however, many of the digestible energy values in Table 1 were calculated from older TDN values.

It should be pointed out that any of the methods of evaluating the energy value of feedstuffs is subject to error. Feed processing may alter the value, as may fertilization or cultural and harvesting practices. A number of the values listed have been determined with hogs or cattle and then applied to sheep, sometimes with questionable results. It is an expensive and tedious business to collect such data; consequently, newer and more appropriate values are slow to appear in the literature.

Protein Values

The crude protein and digestible protein values listed in Table 1 are estimates of average values that might be expected for these feedstuffs. The value of crude protein can be readily determined by a relatively simple chemical analysis in the laboratory, whereas it is necessary to conduct a digestion trial with animals in order to determine digestible protein. When the data are available, use of digestible protein values will result in more efficient protein utilization since a big variable in the utilization of the protein (the amount of digestion) will have been accounted for. However, from a practical point of view, it is more convenient to depend upon crude protein values since they can be readily obtained. The digestibility of protein in roughages is apt to be much more variable than that in concentrates, since the quality of roughage is usually more variable. The percentage of protein digested is usually inversely related to the amount of crude fiber present.

Other Composition Data

Values shown under the crude fiber column are included because the amount of crude fiber gives a good indication of the bulkiness or density of the feed. The amount of fiber is inversely related to the energy values, although the relationship is not very high if all feeds are included. In the case of roughage, however, the amount of fiber is indicative of the value of the hay. The three listings for alfalfa hay (25, 28, and 34% fiber) would correspond to extra leafy, number 1, and number 2 hay, respectively.

Data in Table 1 show average composition of feedstuffs for calcium and phosphorus, since these two elements are the two most apt to be deficient. Both of these elements can be supplied in natural form from feedstuffs or by any of a number of supplements available commercially. Trace elements that are sometimes deficient include cobalt, copper, iodine, iron, and selenium. With the exception of selenium, it is recommended that these elements be supplied by including a trace-mineralized salt in mixed rations at a level of 1% and/or by making it available for free-choice consumption. At the present time, selenium (required for the prevention of white muscle disease) cannot be legally added to feed because of restrictions by the Food and Drug Administration. If deficiencies have been a problem in your area, selenium can be supplied by providing feedstuffs, such as linseed oil meal, that normally contain adequate amounts or by administering injections of selenium with a syringe.

Data are not given for plant carotenes (precursors of vitamin A) since appreciable amounts of carotenes are found only in forages, and the amount present cannot be predicted with any reliability. Bright, green hay usually will have adequate amounts. However, lambs are seldom troubled with vitamin A deficiencies; if there is a deficiency, synthetic vitamin A can be added in dry form at a very minimal cost.

Relative Value of Feeds

The feeder may wish to substitute one feedstuff for another when prices change throughout the year or from year to year. Unfortunately, there is no simple and accurate way of determining the economic value of any single feed. This is so even if we assume that the values given in Table 1 for energy, digestible protein, calcium, and phosphorus are quite accurate under all situations. The value of any feedstuff is dependent upon the nutrients it provides, the purpose for which it is used or how well it supplies nutrients for a specific purpose, the nutrient requirements of the animal, the value of maximum growth rates, and, of course, the price of alternate sources of nutrients.

Some examples of how the relative price of various feedstuffs may vary are shown in Tables 2 and 3. In these examples, the rations are formulated to contain 8.5% digestible protein and 0.40 or 0.44 megcal. of net energy of production. In the examples the energy value, digestible protein, calcium, phosphorus, amount of crude fiber, and cost of each feedstuff are used in formulation. In some cases, various feeds have been excluded, thus forcing in other ingredients.

For the prices used in Table 2, ration No. 5 meets the protein and energy requirements at the lowest cost, $48.41 per ton. That this ration is close to being optimum under the given prices can be seen by examining the imputed values for the feeds which are not contained in ration No. 5. For example, rolled barley has an imputed value of $56.95 per ton. However, since its assumed cost was $63, it would not pay in this case to try to use it in ration No. 5 to replace rolled wheat. Similarly, pelleted alfalfa would be worth only $35.07 per ton. However, ration No. 5 could be improved slightly, since molasses has an imputed value of $42.40 per ton and its assumed price is only $39.

Table 2. Various Combinations of Ingredients Which Supply Exactly 0.40 Units of Net Energy of Production Per Pound of Ration and 8.5 Percent Digestible Protein

	Percent ingredient and imputed values								
Ration number	Rolled barley	Pelleted alfalfa	Corn	Rolled wheat	Molasses	Barley straw	Cottonseed meal	Urea	Ration cost/ton
1	60.1	37.3	$63.98*	$68.35*	2.6	$21.61*	$133.16*	$549.21*	$59.39
2	62.8	$40.66*	$67.07*	$68.81*	$44.60*	26.6	10.6	$219.84*	$54.21
3	$72.14*	$40.82*	52.6	$79.27*	$51.80*	33.5	13.9	$157.20*	$59.96
4	72.8	$36.85*	$67.90*	$68.88*	$46.38*	25.8	$ 74.96*	1.4	$52.77
5	$56.95*	$35.07*	$61.04*	63.9	$42.40*	34.6	$ 69.26*	1.5	$48.41
6	$57.27*	37.0	$57.08*	54.4	$33.36*	8.6	$137.29*	$617.60*	$55.80
7	51.4	27.9	$64.45*	$65.13*	20.0	$47.25*	$ 72.78*	0.7	$56.40
8	57.2	8.1	$63.95*	$68.56*	20.0	13.2	$136.95*	1.5	$52.81
9	$57.27*	9.0	$57.08*	50.0	20.0	19.5	$137.29*	1.5	$49.53
10	$74.71*	18.5	47.7	$81.95*	20.0	12.3	$136.25*	1.5	$59.52

* These figures represent the imputed values of feeds not in the ration, based upon the nutritive contribution and prices of feeds making up the ration. For example, in Ration No. 1 the imputed values are based upon feeding values and costs of rolled barley, pelleted alfalfa, and molasses. Costs of ingredients per ton which made up the rations were as follows: rolled barley, $63; pelleted alfalfa, $55; corn, $78; rolled wheat, $62; molasses, $39; barley straw, $20; cottonseed meal, $88; and urea, $125.

Table 3. Various Combinations of Ingredients Which Supply Exactly 0.44 Units of Net Energy of Production Per Pound of Ration and 8.5 Percent Digestible Protein*

Ration number	Rolled barley	Pelleted alfalfa	Corn	Rolled wheat	Molasses	Barley straw	Cottonseed meal	Urea	Ration cost/ton
	Percentage of ingredients								
1*	---	----	--	---	---	---	---	--	---
2	76.4					15.8	7.8		$58.16
3			63.9			24.2	11.9		$65.15
4	83.7					15.2		1.1	$57.15
5				73.6		25.3		1.1	$52.07
6		27.8		66.4		5.8			$57.62
7	67.0	12.0			20.0			1.0	$57.86
8*	---	----	--	---	---	---	---	--	---
9*	---	----	--	---	---	---	---	--	---
10		11.6	59.1		20.0	7.8		1.5	$63.71

* Ration ingredients and imputed values of feeds are the same as for Table 2, except for Rations 1, 8, and 9. The specifications used for Rations 1, 8, and 9 cannot be met exactly by using only the ingredients of Rations 1, 8 and 9 of Table 2. Costs of ingredients per ton were the following: rolled barley, $63; pelleted alfalfa, $55; corn, $78; rolled wheat, $62; molasses, $39; barley straw, $20; cottonseed meal, $88; and urea, $125.

The optimum ration, considering all possible rations, would be 20% molasses, 50.2% rolled wheat, 2.6% cottonseed meal, 25.7% straw, and 1.5% urea. This ration was not listed in Table 2. The cost of this ration would be approximately $48.23 per ton, which is about 18 cents per ton less than for ration No. 5.

It should be noted that the imputed values of the feeds given in Tables 2 and 3 are correct only for the assumed prices given in the footnotes to the tables. If these prices were changed, then the imputed values in Tables 2 and 3 would also change. However, it is possible to state the imputed values of the feeds in a more general form which would hold under any price condition. For ration No. 5, it is possible to write the imputed value of the various feeds in terms of the prices of wheat, straw, and urea, the ingredients of ration No. 5. For example, the imputed value of rolled barley could be written as follows:

$$\text{Value of barley} = 0.1211\, P_s + 0.8783\, P_w + .00064\, P_u.$$

In the above equation, P_s denotes the price of barley straw, P_w denotes the price of rolled wheat, and P_u the price of urea. For the prices given in the footnote to Table 2, this equation gives the same imputed value for rolled barley as that given in Table 2, except for rounding error. The advantage of the above equation is that it also could be used for any prices of wheat, straw, and urea. In a similar manner, an equation could be written for the imputed value of pelleted alfalfa, corn, molasses, and cottonseed meal in terms of the prices of straw, wheat, and urea. Furthermore, the same procedure could be followed for all the other rations listed in Table 2. Due to the large number of possible equations, these are not presented in this report.

Seven rations which had the same ingredients as the rations of Table 2 are presented in Table 3. The only difference is that the rations of Table 3 have a higher energy content. As a result, the rations in Table 3 contain a larger percentage of barley, corn, or wheat. Consequently, these rations cost more than their counterparts in Table 2. Rations 1, 8, and 9 in Table 3 are left blank because it is not possible to meet the high energy requirement with those ingredients.

From a practical point of view, the relative value can be calculated by determining the cost per pound of TDN or per megcal. of energy for feedstuffs of interest. Table 1, last column on the right, shows some relative values where corn is rated at 100. These values were suggested by Dr. Morrison and represent a composite of research results. OSU data, obtained in a recent lamb-fattening trial, indicate that where corn is given a relative value of 100, barley is worth 84%, milo 82%, and wheat 75% when valued on the basis of conversion of feed to weight gain. This data is from only one trial and may or may not hold up in future work.

Finishing Lambs in Dry Lot

A considerable percentage of lambs are fed in the dry lot after weaning because of lack of sufficient finish or adequate size to meet market standards.

Many of these are from range bands or may be late or "poor-doing" lambs from farm flocks. Nutrient requirements for feedlot lambs are not very restrictive. However, a nutritionally adequate and well-prepared ration may be expected to result in more rapid gain, greater feed conversion, or lower cost of gain than a ration which is lacking in nutrients or is poorly prepared.

For a maximum rate of gain and feed conversion, our research data indicate that pelleted rations should contain 14 to 15% crude protein and an energy concentration that would correspond to about 0.60 megcal. of net energy, 0.40 megcal. of net energy of production, or 60 to 65% TDN. This is not to say that lambs may not do well on less protein and either more or less energy. As a matter of fact, lambs will gain rather well on alfalfa pellets alone. However, the concentrations specified will result in a good feed conversion as well as a rapid rate of gain.

Calcium and phosphorus are the other two nutrients that are routinely checked when formulating rations. Amounts on the order of 0.5 to 0.6% Ca and 0.4 to 0.5% P are generally used, although somewhat less may be satisfactory.

Other information relating to feed processing (pelleting and grinding) will be discussed in succeeding sections of this report.

Least-cost Ration Formulation

Least-cost formulation, also called linear programming, is a relatively new procedure that has come into use along with the availability of electronic computers. What the computer does, in effect, is to solve a group of simultaneous equations while considering the nutrients required in the ration, the nutrients supplied by each available feedstuff, and the cost of each feedstuff. The end result will be a formula that meets the ration specifications with a minimum ingredient cost. There are some nutritional disadvantages associated with this procedure, but they are not the fault of the computer.

One of the biggest problems in least-cost formulation is the fact that chemical analysis of nutrients in a feedstuff does not provide infallible information on the availability of the nutrients to the animal. Secondly, means of measuring taste, palatability, and preference for certain textures are inadequate. Thirdly, a feedstuff may have one value when fed in combination A, but a different value when fed in combination B. These problems exist when formulating rations by any means, but they may become more important when using complex formulas about which no previous information is available.

For experiments in which linear programming procedures have been used to formulate rations, ration specifications that have been used at Oregon State University are described below:

Protein--Crude or digestible protein can be used; available data indicate that digestible protein is preferable. However, from a practical point of view, crude protein is much easier to obtain.

Crude protein--Exact amounts are specified, although in feedlot use a minimum amount might be preferable.

Energy--TDN, digestible energy, or net energy can be used. In lower energy rations, use of net energy as compared to digestible energy or TDN may result in better feed conversion. Exact amounts are specified, but minimum amounts might be satisfactory.

Crude fiber--Usually only a minimum amount is specified. Nine to ten percent is the amount usually called for, although most rations will be considerably above this level. As mentioned previously, ration density might be preferable if the required data were available.

Minerals:

Calcium--Usually exact amounts are specified. We have been using levels of 0.6%, although this is somewhat higher than most nutritionists call for. However, we have had no trouble with urinary calculi.

Phosphorus--Usually exact amounts; 0.4% is used routinely.

Salt--1.0% routinely used.

Trace minerals--Supplied routinely in trace mineralized salt.

Individual feedstuffs:

Alfalfa hay--Usually included at a minimum level of 5% because of the beneficial effect on digestion.

Molasses--A minimum amount of 5% is used because of the palatability factor. Maximum amounts are restricted to 15% because of handling problems.

Other feedstuffs--On occasion, restrictions may need to be placed on material such as some of the by-product feeds used, or on urea because of its potential toxicity when used in large amounts.

Linear programming has been used in a number of experiments with lambs at the Umatilla Experiment Station. Objectives in different experiments have included such items as study of optimum protein and/or energy levels, and the evaluation of various by-product feedstuffs for fattening lambs. Results of experiments on protein or energy requirements are discussed below.

Protein and Energy Experiments

Data from one of the trials are shown in Table 4. In this experiment, rations were formulated to contain 10 or 14% crude protein and different energy levels (net energy of production). Statistical analysis of the results of this trial show that lambs receiving the rations containing 14% crude protein gained at a significantly higher rate than those receiving 10% crude protein. An increase in energy likewise resulted in somewhat more gain, although with

Table 4. Ration Composition and Lamb Performance, Trial 2

Item	Ration No. 1	2	3	4	Control
Crude protein, %	10	10	14	14	12
Estimated net energy of production, megcal./lb.	.294	.324	.327	.352	.285
Ration ingredients, lb/T					
Rolled barley					400
Beet pulp					200
Milo, gr.	850	1123	290	595	
Peas, gr.			547	479	
Molasses, 3% P	139	128	125	113	
Alfalfa, 2nd grade	676	478	881	787	1378
Barley straw	305	235	135		
Limestone	8	14		4	
Salt	20	20	20	20	20
Antibiotic premix	1.5	1.5	1.5	1.5	2
Cost per ton, $	45.47	48.43	45.36	48.21	42.65
Lamb performance*					
Daily gain, lb.	.370[a]	.425[a]	.448[b]	.483[b]	.397
Dressing percentage	49.9[ac]	51.0[ad]	50.2[bc]	51.2[bd]	50.2
Carcass grade	4.15	4.10	4.20	4.10	4.15
Feed conversion	10.42[ac]	8.90[ad]	9.0[bc]	7.26[bd]	10.14
Cost of gain, ¢/lb.	23.69[ac]	21.55[ad]	20.41[bc]	17.51[bd]	21.62

* Different superscripts indicate statistically different treatment effects. Carcass grade 5:prime, 4:choice.

less statistical certainty. Feed conversion, dressing percentage, and cost of gain followed the same pattern; that is, with an increase in either protein or energy, there was an effect on the particular item evaluated--dressing percentage was increased, feed conversion was improved, and cost was reduced.

It was anticipated that rations having 10% crude protein would not result in maximum performance, since some published data indicate that 11 to 12% is more nearly the optimum level. The optimum level of either protein or energy is, of course, a function of feed cost and animal performance. Consequently, a given energy and protein level may result in maximum performance, but not necessarily in the lowest cost of gain. The cost of gain of lambs on different rations will tend to vary as relative feed prices change throughout the year.

Results of two other trials involving different levels of protein are shown in Table 5. These trials were carried out during the winter, and the lambs did not do particularly well insofar as cost of gain is concerned. However, the data indicate that daily gains and feed conversion were both improved by increasing levels of crude protein in the ration, confirming results obtained in the previous experiment.

Data are shown in Table 6 from another experiment in which different energy and protein levels were used. The rations used in this experiment are quite different from those in the previous experiments, yet the results indicate that feed conversion was improved, and cost of gain was reduced by increasing the amount of protein in the diet to levels considerably higher than commonly believed necessary. In this case, daily gain was increased more by addition of protein to the rations with the lower energy values (rations 1 and 2). On the higher energy rations (rations 3 and 4), only a slight improvement was noted by increasing the protein from 15.2% to 18.4%--although feed conversion and cost were improved. Data from this experiment show that addition of protein results in a greater improvement in "lower" energy rations than in "higher" energy rations, a situation which is similar to the response obtained in experiments with fattening calves. Although this experiment does not prove the following point, it is probable that around 17 to 18% protein should support maximum gain, at least on rations of this nature and with relatively large lambs (70 to 80 lbs.) when fed for about 60 days.

By-product Feedstuffs

Frequently, by-product materials are available to the feeder at reasonable prices. Available products depend upon the agriculture or industry in a particular area. Several rations in Tables 5 and 6 used alfalfa seed screenings, cull peas, and wheat flour screenings. Other products that are suitable for sheep would include grass seed or grain seed screenings; peavine, mint, or other silages; bruised or cull fruit or cannery waste. If such "waste" material is used, care should be exercised not to feed products that are contaminated with pesticides which may be retained in the fat or lean tissue. For example, the use of DDT on legume seed crops is currently of concern to the Food and Drug Administration. Feeding contaminated material to animals could make carcasses subject to condemnation.

Table 5. Ration Composition and Lamb Performance, Trials 3 and 4

Item	Ration No. 1	2	3	4
Crude protein,* %	11.9	13.6	15.1	16.7
Estimated net energy of production, megcal./lb.	.387	.384	.380	.392
Ration ingredients, lb./T				
Alfalfa screenings	222	474	470	203
Barley	428			
Beet pulp	650	650	650	322
Corn	160			
Cull peas			75	623
Molasses	132	110	100	100
Barley straw	336	374	182	104
Alfalfa hay, top grade	200	200	502	627
Limestone	11	10		
Salt	20	20	20	20
Lamb performance				
Cost, $/T, No. 3	46.72	45.38	45.51	48.83
No. 4	49.69	50.12	50.84	51.84
Daily gain, lb.	.392	.416	.416	.456
Dressing percentage	48.0	47.8	47.9	48.9
Grade	3.88	3.95	3.95	4.02
Feed conversion	10.14	9.95	10.02	8.99
Cost of gain, ¢/lb.	24.53	23.89	24.35	22.61

* Analytical average of both trials.

Table 6. Ration Composition and Lamb Performance, Trial 9

Item	Ration No. 1	2	3	4	Control
Crude protein, %	14.5	17.0	15.2	18.4	13.6
Estimated net energy of production, megcal./lb.	.340	.340	.418	.420	.399
Ration ingredients, lb./T					
Alfalfa hay, top grade	529	726	200	200	652
Wheat straw	300	162	76	118	
Alfalfa seed screenings	400	400	400	400	300
Cull peas	191	165	250	653	
Urea		24		8	
Barley					448
Beet pulp			443		330
Molasses	153	100	200	185	50
Wheat flour screenings	400	400	400	400	200
Dicalcium phosphate	3	3	4		
Limestone	4		7	16	
Salt	20	20	20	20	20
Lamb performance					
Feed cost, $/T	35.78	36.88	39.78	38.80	42.20
Daily gain, lb.	.375	.445	.400	.410	.360
Feed conversion, lb.	12.05	9.76	10.24	9.82	10.84
Cost of gain, ¢/lb.	21.56	18.01	20.38	19.16	22.90
Dressing percentage*	48.2	48.9	49.4	49.0	48.1

* Cold-weight basis.

Three of the available by-product feeds--alfalfa seed screenings, wheat flour screenings, and screenings from annual ryegrass--have been evaluated in sheep experiments at Oregon State University. Cull peas, however, have been used extensively in both sheep and cattle rations with excellent results. Results of these experiments are presented below.

Alfalfa seed screenings. This product, when not contaminated with DDT or other pesticides, can be a very useful feed. Its protein content will be relatively high, usually something on the order of 22 to 26%. Its energy value also should be relatively high in view of its composition. In addition, it is a relatively good source of phosphorus. Results of an experiment with alfalfa seed screenings are shown in Table 7. In this case the screenings were fed at levels of 10 to 40% of the total ration.

Results of this experiment show that the lambs performed well on rations containing alfalfa screenings. The improved feed conversion observed at the 30 to 40% levels is indicative that the calculated energy value of the screenings may be too low, although this is only a guess in view of the marked differences in ration composition. At any rate, the data point out that alfalfa screenings can be utilized very well by lambs. No adverse effects were noted from feeding high levels of this product.

Wheat flour screenings. Another by-product feed that has been evaluated is wheat flour screenings. This product resembles wheat mill run, although it contains less protein and more fiber. This feedstuff is not commonly available (particularly in small lots), since the supply is not very great and wheat flour screenings are frequently used in standardizing other milling by-product feeds more commonly found on the market.

Results of an experiment with wheat flour screenings are shown in Table 8. In this experiment, as with the alfalfa seed screenings, wheat flour screenings were incorporated into the rations at levels of 10 to 40% of the total ration. Their cost was only $24 per ton, a price which included the cost of mixing. As shown in the table, inclusion of these screenings reduced the cost of the rations appreciably. The lambs gained very well on all rations containing wheat flour screenings and the No. 4 ration with 40% screenings produced gain at a very reasonable cost of 15.26 cents per pound.

Grass seed screenings. Because of the large grass seed industry in Oregon, a considerable amount of screenings is available for use in one way or another. Some screenings may not be safe to use due to the presence of toxic factors, but this does not appear to be the case with screenings from annual ryegrass (*Lolium multiflorum*). An appreciable quantity has been fed in a number of different experiments without any undesirable effects.

Evaluation of ryegrass screenings (abbreviated RGS) has been done primarily by means of digestion trials rather than with fattening trials as with the other by-product feeds discussed above. Consequently, the data obtained provide a more thorough means of evaluating the nutrient composition of RGS. With such a feedstuff, it must be borne in mind that composition is rather variable from lot to lot and that feeding value will also be variable. To get some idea as

Table 7. Ration Composition and Lamb Performance, Trial 6

Item	Ration No. 1	2	3	4	Control
Crude protein, %	15.3	14.9	14.8	16.4	12.4
Estimated net energy of production, megcal./lb.	.380	.376	.379	.374	.285
Ration ingredients, lb./T					
Alfalfa seed screenings	200	400	600	800	
Barley, ground	214	121	36		400
Beet pulp	408	541	650	388	200
Cull peas	318	138			
Molasses	100	100	100	100	
Wheat mill run	37				
Alfalfa, 2nd grade	701	627	434	658	1378
Wheat straw		51	154	32	
Limestone			4		
Salt, trace mineralized	20	20	20	20	20
Antibiotic premix	2	2	2	2	2
Feed cost, $/T	43.23	44.71	44.86	46.39	41.20
Lamb performance					
Daily gain, lb.	.490	.471	.526	.543	.509
Dressing percentage	48.5	50.0	49.1	48.3	49.3
Carcass grade	4.15	4.15	4.20	4.20	4.15
Feed conversion	9.26	9.20	8.68	8.67	10.06
Cost of gain, ¢/lb.	19.74	20.21	19.12	19.71	20.56

Table 8. Ration Composition and Lamb Performance, Trial 7

Item	Ration No.				
	1	2	3	4	Control
Crude protein, %	12.6	13.6	13.6	12.9	12.9
Estimated net energy of production, megcal./lb.	.368	.371	.373	.376	.285
Feed ingredients, lb/T					
Wheat flour screenings	200	400	600	800	
Alfalfa seed screenings	496	545	593	642	
Barley					400
Beet pulp	516	344	172		200
Molasses	100	100	100	100	
Alfalfa hay, 2nd grade	625	486	347	208	1378
Wheat straw	41	97	154	210	
Limestone		6	12	18	
Salt, trace mineralized	20	20	20	20	20
Antibiotic premix	2	2	2	2	2
Feed cost, $/T	41.37	39.16	36.76	34.36	42.65
Lamb performance					
Daily gain, lb.	.515	.480	.543	.545	.463
Dressing percentage	49.5	49.3	49.6	49.1	48.2
Carcass grade	4.10	4.10	4.0	4.10	4.10
Feed conversion	9.28	9.74	9.67	8.89	10.93
Cost of gain, ¢/lb.	18.98	18.91	17.69	15.26	23.11

to variability, samples were obtained from a number of seed-processing plants in the Willamette Valley. For these samples, crude protein varied from 7.8 to 12.0%, with most samples containing about 8 to 9%. Crude fiber varied from 8.0 to 24.8%, with the bulk of the samples containing 20 to 22%. Samples ranged from 4.1 to 10.5% ash, with no particular trend. Dry-matter digestibility was estimated in a laboratory procedure and ranged from 48 to 66%. By way of comparison, a good grade of alfalfa hay would have a dry-matter digestibility of about 55 to 58%.

In order to evaluate RGS, two digestion trials were conducted. The composition of the feeds used and results of the trials are shown in Tables 9, 10, 11, and 12. In the first trial, a rather high quality batch of RGS was fed at levels of one-fourth or one-half of the ration in combination with an alfalfa pellet, or in two mixed rations. In this case (Table 10), the RGS made a particularly good combination with alfalfa hay. The combination of RGS and ration No. 2 was somewhat better than RGS and ration No. 3. The chief difference between these rations was that No. 2 contained 20% alfalfa and No. 3 only 5% alfalfa, with the bulk of the remainder made up of barley and wheat mill run. The data also show that RGS was digested to a greater extent when present as only one-fourth of the ration as compared to digestion when RGS made up one-half of the ration.

In the second experiment, two different batches of screenings were obtained and fed alone and in combination with alfalfa pellets, corn silage, and a mixed steer ration (No. 7). Results show that the heavy screenings were digested much more completely than the light RGS. The heavy screenings, particularly, made a good combination with alfalfa, as indicated by the digestion coefficients for the mixtures or by the calculated coefficients for the RGS (in the C columns). The heavy RGS also combined very well with the mixed steer ration and the corn silage, as indicated by coefficients for organic matter, protein, and energy.

Digestibility of the RGS also was evaluated with an artificial-rumen procedure in the laboratory. In this work, results indicated that maximum digestibility of heavy RGS and alfalfa was reached at a level of 70% RGS; with light RGS, digestibility was at a maximum with 30% screenings and declined with further additions. With RGS and ration No. 7, there was a gradual decrease in digestibility as heavy RGS were increased from 30 to 70%, but the decline was not marked until 80% RGS were added. With the light RGS there was a gradual decrease in digestibility as screenings were increased from 20 to 80%. With the corn silage there was a gradual increase in digestibility as the heavy RGS were increased; with light RGS, the level of digestibility remained about constant throughout.

An overall evaluation of the feeding value of RGS would indicate that the heavy end of the screenings is probably worth about as much as a lightweight barley. However, there are probably not very many lots of screenings of this quality. The light RGS fed in Experiment 2 (Table 12) were quite bulky, high in fiber, and rather low in digestibility. Their feeding value would be worth about two-thirds the value of the alfalfa pellets or about one-half of the value of the heavy screenings. Such material would be suitable when included in limited amounts (30% or less) along with other ingredients in a finishing ration but would not be recommended if maximum performance is desired.

Table 9. Composition of Ration Ingredients as Fed

Feedstuff	Dry matter	Organic matter	Crude protein	Cellulose	Gross energy
	%	%	%	%	Kcal/g
Alfalfa pellet	91.9	81.5	12.0	25.9	3.974
Mixed ration No. 2	88.9	82.4	11.8	8.3	3.782
Mixed ration No. 3	88.7	83.1	11.1	8.3	3.767
Ryegrass screenings (RGS)	90.0	85.1	11.8	11.0	3.944

Table 10. Digestion Coefficients Obtained with Experimental Rations

Ration	No. lambs	Digestion coefficients*			
		Organic matter	Crude protein	Cellulose	Energy
		%	%	%	%
Alfalfa	4	57	67	51	56
+ ¼ RGS	2	63(83)	70(80)	51(52)	61(78)
+ ½ RGS	2	65(74)	72(76)	46(34)	64(72)
Ration No. 2	4	75	76	36	73
+ ¼ RGS	2	75(73)	79(85)	29(15)	72(70)
+ ½ RGS	2	72(68)	72(68)	27(21)	68(63)
Ration No. 3	3	75	74	43	72
+ ¼ RGS	2	74(70)	72(66)	38(26)	70(66)
+ ½ RGS	2	68(63)	67(63)	23(9)	64(58)
Average for RGS					
when ¼ of ration		(75)	(77)	(31)	(71)
when ½ of ration		(68)	(69)	(21)	(64)

* Data shown in parentheses are coefficients for RGS calculated by difference.

Table 11. Chemical Composition of Ration Ingredients (dry basis)

Feedstuff	Organic matter	Ash	Crude protein	Cellulose	Nitrogen-free extract
	%	%	%	%	%
Light ryegrass screenings	90.3	9.7	8.0	24.2	54.6
Heavy ryegrass screenings	95.2	4.8	12.0	9.8	70.1
Alfalfa pellet	89.7	10.3	16.2	27.6	43.5
Corn silage	93.3	6.7	11.3	33.2	47.3
Ration No. 7	95.1	4.9	12.9	10.3	69.4

Table 12. Digestion Coefficients from Experiment 2*

Ration	Organic matter		Crude protein			Cellulose			Energy		
	A	B	A	B	C	A	B	C	A	B	C
	%		%			%			%		
Heavy RGS	71		68			25			68		
Light RGS	54		43			52			52		
Alfalfa pellets	61		72			55			60		
+ 40% heavy RGS	65	65	69	71	63	44	49	-4	61	63	64
+ 60% heavy RGS	78	67	80	70	87	58	45	64	77	65	88
+ 40% light RGS	55	58	60	65	23	56	54	57	52	57	40
+ 60% light RGS	51	57	53	60	27	51	53	47	47	55	39
Mixed ration No. 7	79		75			51			76		
+ 40% heavy RGS	76	76	73	72	69	42	41	29	74	73	70
+ 60% heavy RGS	76	74	70	71	66	43	38	34	73	71	71
+ 40% light RGS	64	70	58	66	16	47	52	44	59	66	33
+ 60% light RGS	57	65	48	60	19	41	52	37	51	61	35
Corn silage											
+ 40% heavy RGS	68		61			23			61		
+ 60% heavy RGS	74		68			25			63		
+ 40% light RGS	56		52			24			49		
+ 60% light RGS	51		48			25			51		

* Coefficients under A are the actual digestibilities for the feedstuffs and mixtures shown in the table. Those under B are estimated digestibilities based on calculations when the various feeds were fed alone. Those under C are coefficients for RGS only, calculated by difference.

Feed Additives

As the term is used, feed additives include hormones, tranquilizers, antibiotics, and similar products that may or may not have some growth-promoting value, but do not provide nutrients. In the last four or five years, Food and Drug Administration regulations have been so strict that research with such products has been very limited. However, prior to this time an appreciable amount of research results were published. Some work has been done at both Corvallis and the Umatilla Experiment Station. A brief summary of the value of some of the common additives is presented below.

Antibiotics. Penicillin, oxytetracycline (Terramycin), chlortetracycline (Aureomycin), and oleandomycin are antibiotics that have been used in lamb feeding. In general, results have been best at low levels, usually on the order of 10 to 20 grams per ton (5 to 10 mg./lb). These levels are much lower than would be used for therapeutic doses. When evaluating the results of a large number of experiments in which conditions have frequently been quite different, one comes to the conclusion that sometimes antibiotics have been helpful and at other times they have not resulted in any appreciable growth responses. Most nutritionists feel that antibiotics may be helpful when subclinical disease (not visibly evident) is rather prevalent and that antibiotics frequently result in a reduced incidence of enterotoxemia. Antibiotics are believed to be of value when various forms of stress are applied intentionally or inadvertently. Situations such as a cold and wet environment, heavy parasite infestation, shipping, and change of feed are examples. For these reasons alone, antibiotics could well be worth their cost, depending upon the conditions prevailing in the feedlot. The authors feel that possible benefits are worth the slight cost involved.

Tranquilizers. Several of these products were tested several years ago, and some of the initial reports seemed promising. However, after a number of experiments had been reported from various experiment stations, the results indicated that very little, if any, growth response was likely.

Hormones. Of the hormones that have been used, diethylstilbestrol is the one on which most research has been done. Results with lambs are similar to those with cattle. Implantation of pellets in the ear or supplementation in the feed can be expected to result in an increased rate of gain, usually something on the order of 10 to 15%, with a corresponding improvement in feed conversion. Average results of many trials also indicate that carcass grade is apt to be reduced, but this is not as much a factor with our present grading systems as it was previously. However, hormone implants or oral supplementation have not been used with lambs nearly as often as with beef cattle.

Pelleting and Pelleted Feeds

In the late 1950's and early 1960's, there was a great deal of interest in the use of pelleted feeds, particularly for rations with large amounts of roughage in them. Results of some of the research at Corvallis and Union will be reviewed briefly.

In two trials, pellets containing from 65 to 100% alfalfa were fed to lambs. In pellets containing less than 100% alfalfa, the remainder was made up of 5% molasses and barley. In both cases lambs did very well on all of the rations. Lambs receiving pellets of 100% alfalfa did not gain quite as much as those receiving pellets with grain in them, but they performed well. Their feed conversion was somewhat less, as might be expected, and they graded slightly lower; however, most graded choice on the carcass standards in force several years ago. The results, in general, agreed with those from other experiment stations in that pellets having 60 to 80% roughage usually result in the most rapid gain.

Research with pellets, whether with feeding trials or digestion trials, indicates that pelleting improves roughages much more than it does concentrates. Usually a greater feed intake is obtained. This may be due to a faster passage through the gastrointestinal tract and/or a preference of the lamb for pellets over meals. The digestibility of pelleted hay is frequently depressed, but the greater intake more than balances this. The general rule applies that the lower the quality of the roughage the greater will be the improvement by pelleting. Alfalfa, for example, will be improved less than a poor-quality grass hay or straw.

The influence of pellet size and fineness of grind of the roughage in the pellets also has been investigated. The pellets fed had 60 to 65% roughage, which was a mixture of alfalfa and grass hay. The results of two experiments indicated that lambs gained slightly more when fed one-fourth inch pellets, but that feed conversion was slightly better when lambs were fed one-half inch pellets. In this case, the one-half inch pellets were somewhat harder and the apparent waste was less than with the smaller pellets. Very likely pellet hardness is a more important factor than pellet size.

In case of the pellets made from roughage ground through different size hammer mill screens, gain of the lambs was similar on the different pellets. There was a slight improvement in feed conversion as roughage was ground through finer screens (from ¼ to 3/32 inch). Although no comparison was made, it is probable that pellets having an appreciable quantity of grass hay should be ground finer than pellets made primarily from alfalfa hay. This is because alfalfa hay makes a harder pellet that does not crumble as readily as a pellet made from grass, straw, or similar materials.

As indicated, lambs do very well on pellets containing rather large amounts of roughage. Unfortunately, the cost of grinding and pelleting roughage has been relatively high, with the result that the economy of feeding such pellets is not always favorable. However, pelleting is used quite extensively by most commercial sheep feeders. Most of them are using some roughage, usually something on the order of 20 to 30%.

Creep Feeding and Early Weaning

Creep feeding of suckling lambs is commonly practiced by most sheep producers, with the exception of lambs in range bands. As a general rule, creep feeding will result in a more rapid rate of gain, although the effectiveness of creep feeding will be dependent upon several factors: the quality and availability of hay or pasture; the amount of creep feed consumed; and the amount of milk produced by the ewe, especially where twins or triplets are concerned.

Palatability of rations for lambs is quite an important factor if maximum consumption is to be obtained. Research results vary somewhat but, in general, indicate that lambs prefer pellets to meals. Rolled grains (barley, for example) usually are preferred to whole or cracked grains, with the possible exception of oats. In addition, several feeds seem to be particularly palatable to young lambs. Included in this group are wheat bran or wheat mill run, soybean meal, and sugar or molasses. Consequently, when such feeds are reasonably priced, it would be advisable to include them in a creep ration.

More economical results probably would be obtained by creep feeding lambs from ewes which are poor milk producers and twin lambs from ewes which are producing a relatively good supply of milk, using different rations for the single lambs and the twins. The twin or the single from the poor producer is going to be deficient in both protein and energy; consequently, the ration supplied should be rather high in protein and moderately high in energy. Single lambs from high-producing ewes would require less protein. As a result of these differences, if enough protein is supplied for the twins, you would be overfeeding the single lambs.

Examples of two simple rations that might be used in creep feeding are shown below. It is recommended that these rations be pelleted.

Item	Ration No. 1 (for singles)	Ration No. 2 (for twins)
	%	%
Barley, ground	55	55
Soybean oil meal	15	23
Wheat mill run	25	17
Molasses	5	5

Ration No. 1 will run about 16% crude protein and ration No. 2 about 18%. Recent research on the protein requirements of lambs indicates that 16 to 18% protein should be adequate. Ration No. 2 would be recommended for twins or poor-doing singles until they reach a weight of 70 to 75 pounds, and then they could be switched over to a ration comparable to No. 1. Legume hay of good to excellent quality should be fed in addition to such concentrates, unless lambs have access to high-quality pasture.

During the last few years, there has been a considerable amount of interest in early weaning of lambs. The aim in a program of this kind is to get the lamb off the ewe at a reasonably early age so that the ewe can be rebred. In such a program, it is possible to get three lamb crops in a two-year period. This management practice has been highly recommended in the southeastern states. It is the feeling there that early weaning may be more profitable than normal practices in areas where the quality of pastures is relatively low and internal parasites are a big problem. Research on early weaning in the southeast has frequently included the practice of putting lambs on slatted floors, since this tends to greatly reduce the internal parasite problem.

Published data on performance of early-weaned lambs are somewhat conflicting. Indications are that lambs can be weaned at about 65 days of age or when weighing about 50 pounds and still show reasonably good performance. Lambs weaned at lighter weights or younger ages may be expected to grow rather poorly for a time after weaning unless supplemented with a high-quality ration containing expensive ingredients. Published data indicate that a ration similar to No. 2 should be adequate for lambs of about 50 pounds.

Conclusions based on one year's results at Corvallis are as follows:

1. The weight at which a lamb was weaned appeared to be of more importance than the age of the lamb. Lambs weighing 45 pounds or more when weaned gained more rapidly than lambs of the same age or older weighing less than 45 pounds at weaning.

2. In one group of early-weaned lambs which were fed for 33 days, the average daily gain and feed conversion was 0.81 and 3.7 pounds, respectively. During a comparable period, unweaned lambs having access to creep feed gained at the rate of 0.6 pounds per day. Cost of gain of all early-weaned lambs varied from 10.5 to 15.7 cents per pound, depending upon size of lamb and the kind of ration fed.

Further work on rations and cost of the early-weaning program will be required before it can be recommended.