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Net Energy Requirements And Energy Values Of Feeds for Growing Lambs

T. B. Keith, D. A. Price,
K. R. Frederiksen and D. O. Everson

UNIVERSITY OF IDAHO
College of Agriculture

Summary

Data from records of individual daily feed intake and ADG of 226 lambs were used to evaluate an equation for energy requirement and accuracy of NE values of feeds for growing-finishing lambs.

NE_m (1.23 Mcal/kg) and NE_g (0.70 Mcal/kg) values proved to be most accurate for alfalfa hay containing 24 to 30% fiber when fed to lambs in Idaho's feeding environment.

NE_m and NE_g values of barley, oats, wheat bran, and linseed meal derived for cattle proved to be sufficiently accurate for growing-finishing lambs.

Ratio of observed to computed gains of ram lambs was from 18 to 34% higher than that of ewe lambs. This indicates a sex difference in sheep similar to that observed in cattle. The NE_g (4.0 g) factor is too large for ram lambs but is approximately correct for ewe lambs.

The results of this study clearly demonstrate that NE values of concentrates, NE_m of 1.23 Mcal/kg, and NE_g of 0.70 Mcal/kg for alfalfa hay determined with cattle experiments are accurate for formulating diets for growing lambs.

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University of Idaho — College of Agriculture

Moscow, Idaho — CP 1.5M 10 71

The Authors

Dr. T. B. Keith is professor emeritus, Department of Animal Industries, University of Idaho.

Dr. D. A. Price is director and range nutritionist, U.S. Sheep Experiment Station, Sheep and Fur Animal Research Branch, ARS, USDA, Dubois, Idaho.

K. R. Frederiksen is associate research professor of animal science, University of Idaho, headquartered at the U.S. Sheep Experiment Station, Dubois.

Dr. D. O. Everson is professor and statistician, Idaho Agricultural Experiment Station.

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Garrett, Meyer, and Lofgreen (1959), Lofgreen, Bath, and Young (1962), and Lofgreen and Garrett (1968) derived equations for estimatmating the NE_m (net energy for maintenance) and NE_g (net energy for gain) of growing-finishing cattle. Garrett et al. (1959) derived an equation for NE_{m+g} (net energy for maintenance + gain) of growing-finishing lambs. However, there are no derived NE_m and NE_g values of feeds from actual experimental work with lambs.

Armsby and Fries (1916) and Armsby (1918), after studying the energy requirements of cattle with a calorimeter, devised a table of NE values of feeds for cattle and sheep from a table of total digestible organic matter. Fraps (1931) determined productive energy values of feeds used in various experiment station studies with sheep. Morrison (1949) and Morrison (1969) derived ENE_{m+g} (estimated net energy values) for ruminants from related data (TDN and NE values). Since NE in tables prepared by Armsby, Fraps, and Morrison do not present an accurate method for determining the NE requirements of animals and do not separate NE_m and NE_g values of feeds, they are not well adapted for estimating the nutritive value of diets for sheep.

The purpose of this study was to evaluate an equation for estimating energy requirements of growing lambs and to determine whether the NE values of feeds derived for cattle could be adapted to formulation of diets for sheep.

Experimental Procedure

Data used in this study are from two sources. The first source included 186 white-face lambs (95 rams and 91 ewes) fed for 84 days at the U.S. Sheep Experiment Station, Dubois, Idaho. Average age at beginning of each feeding period was 270 days. They were fed a pelleted diet of 87.5% alfalfa hay and 12.5% oats during January, February, and March of 1957, 1958, 1959, and 1960. These lambs were self-fed in individual stalls.

Table 1. Proximate analysis and energy values of the diet for ram and ewe lambs in Dubois trials, 1957-1960.

Year	Dry matter	Crude protein	Digestible protein	Ether extract	Crude fiber	Nitrogen-free extract	Ash	Gross energy	Digestible energy
	%	%	%	%	%	%	%	kcal/g	kcal/g
1957	94.3	14.7	......	2.4	29.8	44.0	9.1	......	......
1958	90.3	15.2	11.1	2.7	24.8	50.2	7.2	4.43	2.61
1959	90.4	15.5	10.7	2.1	30.1	43.8	7.1	4.40	2.45
1960	91.5	15.7	11.3	2.3	27.9	47.1	7.0	4.47	2.53

Table 2. Coefficients of digestibility of the diet[a] fed at Dubois.

Item	% of diet
Dry matter	56
Crude protein	71
Ether extract	42
Crude fiber	30
Nitrogen-free extract	71
Digestible energy	57

[a]Alfalfa hay 87.5%, oats 12.5%

Table 3. Concentrate mixture and net energy values of feeds fed at Moscow[a].

Feed stuff	Crude fiber	Per kilogram NE_m	Per kilogram NE_g
Barley	40	1.93	1.27
Oats	29	1.66	1.12
Wheat bran	20	1.52	1.01
Linseed meal	10	1.61	1.08
Salt	1	......	......

[a]Lofgreen and Garrett, 1968.

After completion of feeding 46 Rambouillet ram lambs were used to determine the DE (digestible energy) and coefficients of digestibility of the diet (Price et al. 1965).

Proximate analyses, GE (gross energy), and DE (digestible energy) of the diet for 4 different years are presented in table 1. These values were determined by the collection method. Values for coefficients of digestibilities are shown in table 2.

The second source of data included 40 Suffolk ewe lambs individually fed for 77 days at the University of Idaho Agricultural Experiment Station, Moscow, during July, August, and September 1948. They were divided into groups of 8 and fed 5 ratios of concentrate to alfalfa hay (Davison, Keith, and Hickman, 1950). Ingredients of the concentrate mixture are shown in table 3. Fiber content of alfalfa hay used in the Moscow trials averaged 31%.

Ambient temperature at the Dubois Station averaged close to 0° C during feeding periods. Ambient temperatures at Moscow during July, August, and September averaged 17° C.

Initial and final weights were used to calculate observed gains. Requirements for NE_m and NE_g were determined with an equation for sheep derived by Garrett et al. (1959). This equation is

$$NE_{m+g} = 63 W^{0.75} (1 + 4.0 g)$$

where NE_{m+g} is in kcal, W is the mean body weight in kilograms and g is daily gain in kilograms.

Computed ADG (average daily gain) was calculated from energy required per unit gain ($NE_m \times 4.0$ g) and energy available for gain in the diet per day. (Example: If $NE_m = 1.08$ Mcal/day and NE_g/day $=$ 0.83 Mcal, then $1.08 \times 4.0 = 4.32$; $0.83 \div 4.32 = 0.19$ kg/day.) Values for NE available for gain, daily fiber intake, and digestible energy (DE) intake were determined for ram and ewe lambs (table 4). DE values for ram and ewe experiments at the Dubois Station (table 1) were computed from the factor 2.53 kcal/g (average of 3 determinations). DE values for the ewes fed 5 ratios of concentrate to alfalfa hay at Moscow Station (table 4) were computed by using the factor 4.4 Mcal/kg of total digestible nutrients (N.R.C., 1968).

Computed ADG were determined for 3 fiber percentages of the alfalfa hay for each diet. Tables presented by Lofgreen and Garrett (1968) for cattle have 3 NE_m and NE_g values for 3 fiber levels of alfalfa hay. All 3 sets of values were used for the alfalfa hay fed to these lambs to determine which NE_m and NE_g values would yield computed gains nearest to the observed gains (tables 5 and 7). All data were corrected by the method of least squares (Harvey, 1960).

Table 4. Data used to calculate observed and computed gains of ram and ewe lambs using NE values assigned to 21% fiber content of alfalfa hay.*

Item	1957		1958		1959		1960	
Sex	Ram	Ewe	Ram	Ewe	Ram	Ewe	Ram	Ewe
No. of lambs	24	24	24	22	23	22	24	23
Initial wt. kg	42.2	35.7	45.7	37.4	44.1	38.2	45.4	38.1
Standard deviation	5.7	4.4	5.2	4.0	4.2	3.8	6.1	4.5
Final wt. kg	68.3	52.3	69.7	51.5	68.8	53.0	71.1	54.2
Standard deviation	7.5	5.5	6.3	5.4	5.7	6.1	6.7	6.3
$W^{0.75}$, kg	20.3	17.1	20.9	17.2	20.6	17.5	21.1	17.7
Observed ADG, kg	0.31[a]	0.20[b]	0.29[a]	0.17[c]	0.29[a]	0.18[bc]	0.31[a]	0.19[bc]
Computed ADG, kg	0.25[a]	0.19[d]	0.21[c]	0.16[e]	0.22[b]	0.16[e]	0.22[b]	0.19[d]
Ratio of observed to computed ADG	1.24[d]	1.02[c]	1.38[a]	1.08[f]	1.32[c]	1.14[e]	1.36[b]	1.02[f]
Feed intake kg/day	2.70	1.95	2.48	1.74	2.57	1.78	2.63	1.98
NE_m, Mcal/day	1.28	1.08	1.32	1.09	1.30	1.11	1.34	1.12
Computed NE value of feed Mcal/day								
NE_m	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
NE_g	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
NE_g available Mcal/day	1.28	0.83	1.08	0.68	1.17	0.69	1.20	0.83
Fiber intake, kg/day	0.80	0.58	0.61	0.43	0.83	0.54	0.53	0.55
DE intake, Mcal/day	6.83	4.93	6.47	4.54	6.30	4.36	6.65	5.01

*Within comparison groupings, means not containing a common superscript letter are significantly different ($P \leq 0.05$)

Results

As shown in table 4, the ADG of ram lambs are significantly greater than ADG for the ewe lambs ($P \leq .01$). Assigned NE_m and NE_g values for 21% alfalfa hay gave computed ADG nearest the observed ADG for ewes. Ratios of the observed to computed ADG for rams for the 4 years were higher, ranging from 1.24:1 to 1.38:1 (table 4). Average fiber content of alfalfa hay fed in the 1958 trial had the lowest fiber percentage, approximately 25%.

Table 5 shows comparative computed gains of ram and ewe lambs for 3 NE_m and NE_g assignments to the 3 fiber levels of alfalfa hay. Data in table 5 show the variation in ADG of the same lambs during two stages of the feeding period and ADG for the entire period.

Data in table 6 show observed and computed gains of ewe lambs fed 5 ratios of concentrate to alfalfa hay at Moscow during July, August, and September. NE values for 21% fiber alfalfa hay gave computed ADG very close to observed ADG for diets containing 50% of alfalfa or less (table 7).

Table 5. Computed gains for NE values assigned to 21, 24 and 29% fiber contents of alfalfa hay for ram and ewe lambs at Dubois.

Item	First 42 days		Last 42 days		Total 84 days	
Sex	Ram	Ewe	Ram	Ewe	Ram	Ewe
No. lambs	95	91	95	91	95	91
Observed ADG, kg	0.30	0.17	0.31	0.19	0.32	0.20
Computed ADG, kg						
Fiber contents alfalfa hay						
21%	0.22	0.18	0.23	0.17	0.22	0.17
24%	0.17	0.13	0.18	0.13	0.17	0.13
29%	0.11	0.08	0.11	0.07	0.11	0.08
Ratio of observed to computed ADG						
21%	1.34	1.00	1.39	1.19	1.37	1.10
24%	1.75	1.32	1.80	1.60	1.78	1.48
29%	2.86	2.34	2.94	2.83	2.91	2.62

Table 6. Observed and computed gains of ewe lambs fed 5 rations of concentrate to alfalfa hay 77 days at Moscow.*

Item	Ratio of concentrate to alfalfa hay				
	2:3	1:1	3:2	2:1	5:2
No. lambs	8	8	8	8	8
Initial wt. kg	39.0	38.6	39.0	38.4	38.0
Standard deviation	5.4	5.9	5.4	4.7	4.7
Final wt. kg	46.0	49.1	51.0	50.7	51.3
Standard deviation	5.6	6.3	6.6	4.1	6.4
$W^{0.75}$, kg	16.6	17.0	17.4	17.2	17.3
Observed ADG, kg	0.10^{b}	0.14^{a}	0.16^{a}	0.16^{a}	0.17^{a}
Computed ADG, kg	0.12^{c}	0.14^{bc}	0.16^{ab}	0.17^{a}	0.18^{a}
Ratio of observed to computed ADG	0.80^{d}	1.03^{a}	1.00^{b}	0.96^{c}	0.99^{b}
Feed intake, kg/day	1.30	1.36	1.42	1.45	1.45
NE_m, Mcal/day	1.05	1.08	1.10	1.09	1.09
NE content of diets					
NE_m, Mcal/kg	1.42	1.47	1.52	1.56	1.58
NE_g, Mcal/kg	0.88	0.92	0.96	1.00	1.02
NE available for gain, Mcal/day	0.49	0.58	0.68	0.75	0.77
CF in diet, %	20.0	18.0	16.0	14.0	13.0
CF intake, kg/day	0.26	0.24	0.23	0.20	0.19
DE intake, Mcal/day	6.34	7.59	8.04	8.40	8.55

*Within comparison groupings, means not containing a common superscript letter are significantly different ($P \leq 0.05$).

Table 7. Computed gains for NE values assigned to 21, 24 and 29% fiber contents of alfalfa hay at Moscow.*

Item	Ratio of concentrate to alfalfa hay				
	2:3	1:1	3:2	2:1	5:2
Observed ADG, kg	0.10[b]	0.14[a]	0.16[a]	0.16[a]	0.17[a]
Computed ADG, kg					
Fiber content of alfalfa hay					
21%	0.12[c]	0.14[bc]	0.16[ab]	0.17[a]	0.18[a]
24%	0.10[d]	0.12[cd]	0.14[bc]	0.16[ab]	0.17[a]
29%	0.08[a]	0.10[a]	0.12[a]	0.14[a]	0.15[a]
Ratio of observed to computed ADG					
21%	0.80[d]	1.03[a]	1.00[b]	0.96[c]	0.99[b]
24%	0.96[d]	1.18[a]	1.11[b]	1.04[c]	1.06[c]
29%	1.27[b]	1.46[a]	1.28[b]	1.16[c]	1.16[c]

*Within comparison groupings, means not containing a common superscript letter are significantly different ($P \leq 0.05$).

Discussion

Results of this study indicate that NE values of 1.23 Mcal/kg for NE_m and 0.70 Mcal/kg for NE_g are reasonably accurate for alfalfa hay ranging from 24 to 31% fiber for growing-finishing lambs (tables 4, 5, 6, 7). NE_m and NE_g values for alfalfa hay containing 24 to 29% fiber (derived by Lofgreen and Garrett, 1968) are too low for sheep within the environmental area of Idaho. These values are too low, also, for growing-finishing cattle (Keith and Everson, 1967).

Observed ADG of ewes fed at the Dubois Station averaged higher than computed ADG (table 4), while observed ADG of ewes fed at the Moscow Station were not greatly different from computed ADG for 1:1, 3:2, 2:1 and 5:2 ratios of concentrate to alfalfa hay. Observed ADG of ewes fed concentrate-to-alfalfa hay ratios of 2:3 at the Moscow Station were 20% less than computed. Since this was a diet with a high percentage of alfalfa hay, the lower efficiency may be explained on the basis that higher temperatures at the Moscow Station decreased efficiency of energy utilization of HI (heat increment) of alfalfa hay. By the same line of reasoning the higher observed ADG of ewes at the Dubois Station were due to low environmental temperatures which increased efficiency of energy utilization of HI of diets with high levels of alfalfa hay. According to Armsby (1918), alfalfa hay has the highest ratio of HI to NE of the feed stuffs in these studies.

Computed ADG of ewe lambs were 21% nearer observed ADG than ram lambs (table 4). This may be explained on the basis of difference in method of utilization of energy by ram and ewe lambs (Bull, Reed, and Johnson, 1970). Ewe lambs mature earlier and tend to finish faster than ram lambs. Ewe lambs store fat and energy faster than ram lambs. The body of a ram lamb contains a higher percentage of water than ewe lambs at the same age interval. This difference in sex has been shown to be true for heifers and steers (Keith and Everson, 1967; Lofgreen and Garrett, 1968).

The equation for computing NE_g ($NE_m \times 4.0$ g) is as accurate for ewe lambs as should be expected. The fact that the environmental temperature affects the rate at which HI is eliminated, which in turn affects the percentage of the NE actually available for production, may account for the low ratio of observed to computed ADG of lambs fed 60% alfalfa hay (table 6).

Ratio of observed to computed ADG of ram lambs ranged from 18 to 34% higher than those of ewe lambs. Since there is no evidence that NE_m of the ewe and ram are greatly different or that utilization of NE_m and NE_g values of feed stuffs are affected by sex difference (Garrett et al., 1959), a modification of the gain factor 4.0 for ram lambs would be a logical adjustment. Since ratios of observed to computed gains are 18 to 34% higher for ram lambs, a factor for gain should be lower than 4.0.

The findings of this study—that sheep have approximately the same efficiency as cattle to utilize feed stuffs—are supported by studies on their comparative efficiency to digest and metabolize feed energy. The sources of loss are fecal, urinary, gas, and the energy cost of utilization. Brody (1945) states that "The absolute loss is the greatest for fecal energy. . . ." Watson et al. (1948) found that with most feeds differences in digestibility were not great. Cipolloni et al. (1951) made a statistical reevaluation of all available data in the literature on comparative efficiency of digestibility of cattle and sheep fed identical rations and concluded, "It does not seem possible to state outright that sheep have poorer or better digestive powers than cattle or that the two species are identical in this respect."

The accuracy of NE_{m+g} equation and NE_m and NE_g values of feeds for sheep is further substantiated by variation shown by performance of the same lambs during two stages of feeding (table 5). Since environmental temperature affects utilization of HI and NE, a deviation of 19% could be expected. The ratios of observed to computed gains for ram and ewe lambs were not greatly different between the first and last 42 days.

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