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The Feed Increment Method for Evaluating the Net Energy of Feedstuffs for Milk Production

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A feeding-trial procedure was employed as a means for estimating the net energy value of feedstuffs for milk production, using an adaptation of the feed increment principle. The reported observations were made over a period of three years in four trials with Latin-square designs. Basal rations made up of 70 per cent alfalfa and 30 per cent barley were tested against increments of alfalfa hay, barley, dried beet pulp, dried beet pulp with molasses, dried beet pulp with concentrated Steffen's filtrate, and milo.

Results indicated that the procedure could be useful for routine evaluation of feeds. Repeatability appeared encouraging as shown by net energy values of 71.8, 68.4 and 68.8 mcal/100 lb. dry matter, determined with three different lots of barley in as many years.

The main problem yet to be solved is the determination of milk energy equivalent of liveweight change. In this regard the greatest source of error was the estimating of liveweight change.

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The Feed Increment Method for Evaluating the Net Energy of Feedstuffs for Milk Production[1]

INTRODUCTION

LOFGREEN AND OTAGAKI (1960) have used a procedure which has promise for routine evaluation of feedstuffs for milk production. Feeds may be assayed in relative terms of replacement equivalents of a basal ration. In addition, by a concurrent difference-trial technique, referred to by these authors as the "feed increment method," the net energy value for milk production of the basal ration, and hence of the test feeds, may be determined. When used in Latin-square change-over designs, there is satisfactory efficiency in terms of yield of information in relation to number of cows and time required for the assays.

The procedure partially embodies desirable principles of measuring food values by feeding trials as discussed by Kleiber *et al.* (1945). Rather than using a reference substance as a portion of the ration, the entire basal ration serves as the reference standard. This should permit reliable estimates of replacement equivalents provided that the basal ration is well specified in terms of ingredients and a pertinent chemical description is given.

A combination of alfalfa hay and barley appears to have possibilities for this purpose. While such a ration may be relatively high in protein, it has the advantage of being simple and reasonably typical of common rations in use, especially under California conditions. The hay can be described and selected on the basis of the fiber test developed by Meyer and Lofgreen (1956), and barley selected to conform to a specified bushel weight or other criteria. Replacement of as much as 25 per cent of the energy of this ration with a single test feed will not disturb the protein: energy ratio drastically. Intakes of the diet can be restricted to 75 per cent below full feed without limiting protein requirements.

A series of trials have been conducted using common feeds to evaluate this procedure.

EXPERIMENTAL PROCEDURE

Four trials were conducted, in each of which eight cows were allotted to four different treatments in Latin-square, change-over designs. In the first three trials the extra-period design (Lucas, 1957) was used, but since no significant carry-over effects were encountered, the fourth trial was conducted with a balanced Latin-square design (Cochran *et al.*, 1941). The cows were all first-lactation, grade Holsteins selected to be comparable in stage of lactation. Trials were initiated after all cows had reached peak of lactation; trials 1, 2, and 3 were carried out with five 28-day observation periods, and trial 4 with four 35-day periods. Each observation period was preceded by a

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TABLE 1

COMPOSITION OF DRY MATTER OF FEEDS

Feed	Trial no.	C. P.*	E. E.†	C. F.‡	NFE§	Ash
		per cent				
Alfalfa hay	1	18.7	1.2	28.6	39.9	11.6
Alfalfa hay	2 and 3	19.9	1.8	27.6	41.9	8.8
Alfalfa hay	4	20.8	2.5	25.0	42.0	9.7
Barley	1	9.6	1.7	6.1	79.6	3.0
Barley	1 and 2	11.2	1.7	6.1	77.8	3.2
Barley	4	11.0	2.6	5.1	78.5	2.8
Dried beet pulp	2	7.9	0.4	22.9	65.2	3.6
Dried beet pulp with molasses	3	10.3	0.2	17.4	66.1	6.0
C. S. F. ¶ dried beet pulp	3	14.7	0.4	17.7	54.4	12.8
Milo	4	13.0	2.3	2.1	80.4	2.2

* C. P. = crude protein.
† E. E. = ether extract.
‡ C. F. = crude fiber.
§ NFE = nitrogen-free extract.
¶ C. S. F. = concentrated Steffen's filtrate.

7-day adjustment period to allow cows to become accustomed to changes in the feed regimes. Prior to the trials the cows were all handled alike and fed alfalfa hay free-choice with a high level of ground barley. A rationing plan based on Morrison's Standards was established for the duration of each trial on the basis of milk production predicted from a 10-day indexing period immediately preceding the initiation of the trial.

A basal ration consisting of 70 per cent alfalfa hay and 30 per cent barley, which was fed at full and at restricted levels of intake, accounted for treatments 1 and 2 in each of the feeding trials. The full-fed basal ration was estimated to meet the maintenance and production requirements of the cows, and the restricted basal was fed to furnish 75 per cent of the estimated net energy requirements. With this proportion of alfalfa hay in the ration, protein intake was adequate even at the restricted level of intake.

In treatments 3 and 4 test feeds were added in turn to the restricted basal ration in amounts estimated to support levels of production comparable to those for the full-fed basal ration. In trial 1, barley and alfalfa hay, respectively, were added in treatments 3 and 4; in trial 2, barley and dried beet pulp were involved for these treatments; in trial 3, dried beet pulp with molasses and concentrated Steffen's filtrate beet pulp were used; and in trial 4, barley and milo served as the test feeds.

Alfalfa hay was selected to contain approximately 26 per cent crude fiber on a dry matter basis and was procured in single lots sufficient in amount for each trial. Each of the other feeds was from large annual procurements.

Weighed amounts of hay were hand-fed twice daily after milking in individual stanchions, with two hours being allowed for eating at each feeding. Concentrates were fed twice daily in the milking barn. Representative samples of each feed were obtained at each feeding and combined in composites for weekly dry matter determinations and for proximate analyses for each period. The proximate analyses of the feedstuffs are listed in table 1.

The milk produced was weighed at each milking and a representative sample withdrawn and combined with weekly composites for determination of fat by the Babcock procedure. In trials 2, 3, and 4, total solids were estimated by the Golding bead method. In trial 1 total solids were determined by vacuum oven-drying of once-weekly samples obtained at random from each cow. A single sample was obtained at random from one day's production of each cow during each period for determination of heats of combustion of the milk solids. From these data the regression of energy value of milk solids on milk fat content was determined for use in calculating the energy of production of the cows on the basis of the weekly milk analyses.

In trial 1 cows were weighed three days in succession at the beginning and end of each period and on one regular day each week during the entire trial. In trials 2 and 3 cows were weighed on three regular days in succession each week during the entire trial, and in trial 4 cows were weighed daily. All weighings were made immediately following the afternoon milking, before cows were fed hay or allowed water. Average daily liveweight changes for each cow for each period were calculated from the regression of weights on time.

RESULTS AND DISCUSSION

Response to Treatments

The pertinent data regarding feed intake, milk production, and liveweight changes in trials 1, 2, 3 and 4 are summarized in tables 2, 3, 4 and 5, respectively. Responses to treatment in all trials were comparable, but some differences in trends were observed.

In the first three trials, daily milk production was reduced 5 lb. when the basal ration was restricted, but in trial 4 it was reduced only 3 lb. The percentage of milk fat was higher on restricted basal than on other treatments in trial 4, but in the other trials there were no differences in this regard between treatments. In trials 2, 3, and 4, in which solids-not-fat were measured, the latter decreased when energy intake was restricted to 75 per cent of full basal.

The addition of specific test feeds to the restricted basal restored milk production to levels not significantly different from those for full basal in all cases except for one treatment in trial 1. In this case, when barley was added to the restricted basal, milk production was increased significantly, but was still significantly lower than for other full-feed treatments in the same trial. Cows on the restricted basal plus barley ration consumed an equivalent of 0.4 lb. less basal feed than intended and than was consumed by other full-fed groups. This difference, however, representing only about 0.25 mcal net energy, would not account for 2 lb. less milk production.

Liveweight decreased significantly on restricted basal in all trials. Among cows on full-fed rations within trials there were no significant differences in weight gains, although these were quite variable. Standard errors of means of weight changes were quite high and were comparable among the various methods used to estimate liveweight (compare trials 1 vs. 2, and 3 vs. 4). As discussed later, this perhaps is the greatest source of error in the entire procedure.

Calculation of Net Energy

Significant differences in apparent productive (net) energy between restricted basal and full-fed rations permitted calculations by difference of increments of net energy associated with increments of feed intake. As discussed by Lofgreen and Otagaki (1960), maintenance requirements were assumed to remain constant throughout the trial, and productive energy was adjusted in accordance with liveweight changes. Results of these calculations are presented in tables 6 through 9.

To exemplify the calculations of net energy on the basis of feed increments, those for trial 1 (summarized in table 6) are outlined step by step on pp. 385–386. When sample calculations are presented for one treatment, it is understood that the other values (seen in the various rows of table 6) were arrived at in the same way. All feed amounts are on a dry matter basis.

TABLE 2

FEED INTAKES, AMOUNT AND COMPOSITION OF MILK PRODUCED, AND LIVEWEIGHT CHANGES: TRIAL 1

Factor	Ration				Standard error of means
	Restricted basal	Full basal	Restricted basal + barley	Restricted basal + alfalfa hay	
Feed intake, DM* (lb./day):					
Alfalfa hay	14.7	19.4	14.4†	22.9	.....
Barley	6.4	8.5	11.1	6.4	.....
Total	21.1	27.9	25.5	29.3	.....
Increment	....	6.8	4.8†	8.2	.....
Milk production (lb./day)	26.2[a]	31.2[b]	29.3[b,c]	31.4[b]	0.530
Fat, av. (per cent)	3.5	3.4	3.4	3.5	0.032
Total solids, av. (per cent)	11.5	11.9	11.5	12.0	‡
Liveweight change (lb./day)	−0.7[a]	0.3[b]	0.3[b]	0.4[b]	0.219

* DM = dry matter.
† Note lower intake of basal portion of ration compared to the restricted basal treatment: 14.4 lb. hay and 6.3 lb. barley, vs. 14.7 lb. hay and 6.4 lb. barley.
‡ Not sampled in the same manner as fat. See Experimental Procedure.
[a,b,c] Values with different superscripts are significantly different, $P < .05$.

TABLE 3

FEED INTAKES, AMOUNT AND COMPOSITION OF MILK PRODUCED, AND LIVEWEIGHT CHANGES: TRIAL 2

Factor	Ration				Standard error of means
	Restricted basal	Full basal	Restricted basal + barley	Restricted basal + beet pulp	
Feed intake, DM* (lb./day):					
Alfalfa hay	15.8	20.6	15.8	15.8	.....
Barley	6.8	9.1	12.6	6.8	.....
Beet pulp	....	....	....	5.8	.....
Total	22.6	29.7	28.4	28.4	.....
Increment	....	7.1	5.8	5.8	.....
Milk production (lb./day)	32.0[a]	37.0[b]	36.4[b]	35.9[b]	0.498
Fat, av. (per cent)	3.5	3.4	3.4	3.4	0.064
Solids-not-fat, av. (per cent)	8.4[a]	8.8[b]	8.8[b]	8.8[b]	0.065
Liveweight change (lb./day)	−0.8[a]	0.1[b]	0.2[b]	0.5[b]	0.154

* DM = dry matter.
[a,b] Values with different superscripts are significantly different, $P < .05$.

TABLE 4

FEED INTAKES, AMOUNT AND COMPOSITION OF MILK PRODUCED, AND LIVEWEIGHT CHANGES: TRIAL 3

Factor	Ration				Standard error of means
	Restricted basal	Full basal	Restricted basal + molasses beet pulp	Restricted basal + CSF* beet pulp	
Feed intake, DM† (lb./day):					
Alfalfa hay	15.0	19.8	15.0	15.0	.....
Barley	6.5	8.6	6.5	6.5	.....
Dried beet pulp with molasses	....	....	5.3	....	.....
CSF* beet pulp	....	....	....	5.3	.....
Total	21.5	28.4	26.8	26.8	.....
Increment	....	6.9	5.3	5.3	.....
Milk production (lb./day)	29.9[a]	34.9[b]	34.1[b]	33.7[b]	0.519
Fat, av. (per cent)	3.4	3.4	3.3	3.4	0.046
Solids-not-fat, av. (per cent)	8.5[a]	8.7[b]	8.6[a,b]	8.7[b]	0.069
Liveweight change (lb./day)	−0.8[a]	0[b]	0.5[b]	0.3[b]	0.188

* Concentrated Steffen's filtrate.
† DM = dry matter.
[a,b] Values with different superscripts are significantly different, $P < .05$.

TABLE 5

FEED INTAKES, AMOUNT AND COMPOSITION OF MILK PRODUCED, AND LIVEWEIGHT CHANGES: TRIAL 4

Factor	Ration				Standard error of means
	Restricted basal	Full basal	Restricted basal + barley	Restricted basal + milo	
Feed intake, DM* (lb./day)					
Alfalfa hay	14.1	18.4	14.1	14.1	.....
Barley	6.0	7.9	10.8	6.0	.....
Milo	....	....	....	4.3	.....
Total	20.1	26.3	24.9	24.4	.....
Increment	....	6.2	4.8	4.3	.....
Milk production (lb./day)	26.7[a]	29.7[b]	30.6[b]	30.8[b]	0.499
Fat av. (per cent)	3.4[a]	3.2[b]	3.2[b]	3.1[b]	0.035
Solids-not-fat av. (per cent)	8.0[a]	8.3[b]	8.3[b]	8.3[b]	0.043
Liveweight change (lb./day)	−0.5[a]	0.6[b]	0.5[b]	0.3[b]	0.203

DM = dry matter.
[a,b] Values with different superscripts are significantly different, $P < .05$.

TABLE 6

CALCULATION OF NET ENERGY OF FEED INCREMENTS: TRIAL 1
(Dry matter basis)

Factor	Ration			
	Restricted basal	Full basal	Restricted basal + barley	Restricted basal + alfalfa hay
Milk solids (gm/day)	1,368	1,685	1,530	1,710
Heat of combustion (kcal/gm solids)*	5.63	5.60	5.60	5.63
Milk energy (kcal/day)	7,701	9,436	8,568	9,627
Energy of liveweight change (kcal/day)	−1,586	755	755	755
Adjusted productive (net) energy (kcal/day)	6,115	10,191	9,323	10,382
Energy increment (kcal/day)	.....	4,076	3,447†	4,267
Feed increment (lb./day)	.....	6.8	4.8	8.2
Net energy of feed increment (kcal/lb.)	.....	599	718	520
Net energy of feed increment (mcal/100 lb.)	.....	59.9	71.8	52.0

* Calculated from: Y = 4.516 + 0.321X; X = % fat; Y = kcal/gm milk solids.
† Adjusted for lower intake of restricted basal; 9,323 − [6,115 − (0.4 × 599)].

TABLE 7

CALCULATION OF NET ENERGY OF FEED INCREMENTS: TRIAL 2
(Dry matter basis)

Factor	Ration			
	Restricted basal	Full basal	Restricted basal + barley	Restricted basal + beet pulp
Milk solids (gm/day)	1,729	2,049	2,016	1,988
Heat of combustion (kcal/gm solids*)	5.63	5.60	5.60	5.60
Milk energy (kcal/day)	9,734	11,474	11,289	11,132
Energy of liveweight change (kcal/day)	−1,812	604	604	604
Adjusted productive (net) energy (kcal/day)	7,922	12,078	11,893	11,736
Energy increment (kcal/day)	.....	4,156	3,971	3,814
Feed increment (lb./day)	.....	7	5.8	5.8
Net energy of feed increment (kcal/lb.)	.....	585	684	657
Net energy of feed increment (mcal/100 lb.)	.....	58.5	68.4	65.7

* Calculated from: Y = 4.516 + 0.321X; X = % fat, Y = kcal/gm milk solids.

TABLE 8

CALCULATION OF NET ENERGY OF FEED INCREMENTS: TRIAL 3
(Dry matter basis)

Factor	Ration			
	Restricted basal	Full basal	Restricted basal + molasses beet pulp	Restricted basal + CSF* beet pulp
Milk solids (gm/day)	1,615	1,917	1,842	1,851
Heat of combustion (kcal/gm solids†)	5.60	5.60	5.57	5.60
Milk energy (kcal/day)	9,044	10,735	10,259	10,365
Energy of liveweight change (kcal/day)	−1,812	604	604	604
Adjusted productive (net) energy (kcal/day)	7,232	11,339	10,863	10,969
Energy increment (kcal/day)	.....	4,107	3,631	3,737
Feed increment (lb./day)	.....	6.9	5.3	5.3
Net energy of feed increment (kcal/lb.)	.....	595	685	705
Net energy of feed increment (mcal/100 lb.)	.....	59.5	68.5	70.5

* Concentrated Steffen's filtrate.
† Calculated from: Y = 4.516 + 0.321X; X = % fat, Y = kcal/gm milk solids.

TABLE 9

CALCULATION OF NET ENERGY OF FEED INCREMENTS: TRIAL 4

(Dry matter basis)

Factor	Ration			
	Restricted basal	Full basal	Restricted basal + barley	Restricted basal + milo
Milk solids (gm/day)	1,382	1,550	1,597	1,594
Heat of combustion (kcal/gm solids*)	5.60	5.54	5.54	5.51
Milk energy (kcal/day)	7,739	8,587	8,847	8,782
Energy of liveweight change (kcal/day)	−1,133	1,057	1,057	1,057
Adjusted productive (net) energy (kcal/day)	6,606	9,644	9,904	9,839
Energy increment (kcal/day)	.....	3,038	3,298	3,233
Feed increment (lb./day)	.....	6.2	4.8	4.3
Net energy of feed increment (kcal/lb.)	.....	490	687	751
Net energy of feed increment (mcal/100 lb.)	.....	49.0	68.7	75.1

* Calculated from: Y = 4.516 + 0.321X; X = % fat, Y = kcal/gm milk solids.

I. Calculation of adjusted productive energy.

A. From basic information in table 2, the amounts of milk solids were calculated and recorded in the top row of figures in table 6:

(26.2 lb. milk × 11.5% total solids × 454 gm/lb) ÷ 100 = 1,368 gm milk solids

B. Milk energy was calculated from the appropriate heats of combustion of milk solids (these factors are discussed later):

1,368 gm milk solids × 5.63 kcal/gm = 7,701 kcal milk energy

C. Productive energy was adjusted for liveweight change (recorded in table 2) by using the factor 2,266 kcal per lb. liveweight change (the factor is discussed later):

1. −0.7 lb. × 2,266 kcal = −1,586 kcal equivalent of liveweight change

2. 7,701 kcal − 1,586 kcal = 6,115 kcal, adjusted productive energy

N.B. In the case of treatment 1, there was a *loss* of liveweight; therefore this was a *negative* adjustment. In other treatments, when weight was gained, the adjustments were *positive* and were added to the milk energy.

II. Calculation of net energy of feed increments.

A. The adjusted productive energy on restricted basal was deducted from each of the other treatments to determine the energy increments:

10,191 kcal − 6,115 kcal = 4,076 kcal, energy increment, full over restricted basal.

B. The energy increment is the productive or net energy of the corresponding feed increment; hence the net energy of that feed, expressed usually per unit weight of feed:

4,076 kcal energy increment, full over restricted basal ÷ 6.8 lb. feed increment, full over restricted basal = 599 kcal/lb. basal
or
(599 kcal ÷ 1,000) × 100 = 59.9 mcal per 100 lb. basal feed

C. Occasionally, slight adjustments need to be made because of differences in the amount of restricted basal consumed among treatment groups. Thus, in treatment 3, when barley was added to the restricted basal, note (table 2) that slightly less of the *basal portion* of the ration was consumed than in treatment 1.

11.1 lb. total barley consumed – 4.8 lb. added barley (feed increment) = 6.3 lb. barley from basal

therefore,

6.3 lb. barley from basal + 14.4 lb. alfalfa hay in basal = 20.7 lb. total feed from basal

and

21.1 lb. basal consumed when fed at restricted level (column 1, table 2) – 20.7 lb. basal consumed when barley was added = 0.4 lb. less basal consumed when barley was added

Therefore, milk energy attributed to basal (6,115 kcal, table 6) had to be reduced accordingly before calculating the energy increment due to the added barley:

6,115 kcal – (0.4 lb. × 599 kcal) = 5,875 kcal

Then, to determine the energy increment due to the added barley, the procedure was followed as in II, A, above:

9,323 kcal – 5,875 kcal = 3,448 kcal, energy increment, added barley and as in II, B, above:

3,448 kcal energy increment, barley ÷ 4.8 lb. feed increment, barley = 718 kcal/lb. barley

or

(718 kcal ÷ 1,000) × 100 = 71.8 mcal per 100 lb. barley (dry matter basis)

D. In treatment 4, when alfalfa hay was added to the basal diet, the amount of basal consumed was the same as when restricted basal was fed alone, so that no adjustment was needed:

22.9 lb. alfalfa hay consumed –8.2 alfalfa hay added (feed increment) = 14.7 lb. alfalfa hay from basal

and

14.7 lb. alfalfa hay from basal + 6.4 lb. barley = 21.1 lb. total feed from basal (same as in column 1, table 2)

To determine the energy increment due to the added alfalfa hay, then, the procedure was followed as in II, A, above:

10,382 kcal – 6,115 kcal = 4,267 kcal, energy increment, alfalfa hay and as in II, B, above:

4,267 kcal energy increment, alfalfa hay ÷ 8.2 lb. feed increment, alfalfa hay = 520 kcal/lb. alfalfa hay

or

(520 kcal ÷ 1,000) × 100 = 52.0 mcal per 100 lb. alfalfa hay (dry matter basis)

Milk energy was calculated from the prediction equation

$$Y = 4.516 + 0.321X$$

where X is milk fat per cent and
Y is heat of combustion in kcal per gram of solids

This formula was devised by Lofgreen and Otagaki (1960), and results in the current trials yielded virtually identical formulas. Milk energy could be estimated with confidence by bomb calorimeter or could be predicted from the above equation. In fact, converting actual milk production to 4 per cent FCM (fat-corrected milk) and reckoning the usual 340 kcal per lb. 4 per cent FCM resulted in energy values in good agreement with the determined values.

Adjustment for energy equivalent of liveweight change, however, could not be done with the same confidence. First, as discussed above, liveweight change is itself difficult to determine. Second, though perhaps less important, the composition of weight change and its energy equivalent are difficult to estimate.

Lofgreen and Otagaki (1960) calculated 1,952 mcal net energy as equivalent to liveweight gain, based on Brody's (1945) indication of 2.1 lb. TDN (total digestible nutrients) equivalent per lb. of gain and the assumption of 1,616 kcal metabolizable energy per lb. TDN. Net energy was calculated on the basis of 57.5 per cent efficiency for weight gain (Forbes *et al.,* 1926). If it is to be accepted that partial efficiency for fattening is approximately 20 per cent lower than that for milk production (Kleiber, 1961), then the *milk energy equivalent* of weight *gain* should be higher than that calculated by these workers, or approximately 2.3 mcal per lb. weight gain.

In this respect, age of animals may have an important bearing. The relative partial efficiency of gain and milk production is based on fattening of adult steers. Presumably, if mature cows are involved, a similar relationship should be expected. On the other hand, if young cows are used as in this study, limited liveweight gains of about 0.5 lb. per day may represent growth with minimum fattening. Under this condition, differences between the efficiency of metabolizable energy transformation to milk or liveweight gain might not materially influence the final result.

The energy equivalent of weight change is difficult to estimate. If a growth curve could be expressed in units of energy equivalent of liveweight against age, differentiation of the curve could be a means of determining the energy equivalent of liveweight change at given ages. Ellenberger *et al.* (1950) determined composition of carcasses of dairy animals from prepartum to maturity. From these data and accompanying information on empty body weights and liveweight, the energy content of carcass and its equivalent in liveweight can be calculated and plotted against age. A disturbing deficiency in these data is the absence of information for the period between the ages of 12 and 24 months, an important segment of a growth curve and a wide gap over which to extrapolate. Nonetheless, calculations on this basis resulted in an estimate of about 1,600 kcal per lb. gain in liveweight for cows between 24 and 30 months of age.

Trowbridge *et al.* (1918) analyzed in detail carcasses of two steers which had been fed so as to lose approximately 0.5 lb. per day for 6 and 11 months, respectively. With these data compared to data from comparable animals slaughtered at the beginning of the trial, caloric equivalents of weight loss were calculated to be 2,613 and 2,628 kcal per lb. From data from another steer which had been fed to gain approximately 0.5 lb. per day, the caloric equivalent calculated was 1,663 kcal per lb. gain. Current comparative slaughter studies and C-N balance observations with lactating Holstein heifers at the Davis Experiment Station (Bath, 1964) have suggested energy equivalents of 2,200 to 2,400 kcal per lb. liveweight loss.

Calculations from these various data suggested that energy eqivalents of liveweight loss and gain were not quantitatively the same. Recently, however, Meyer and Clawson (1964) found that with rats and sheep the composition of weight gain and loss were the same when *ad lib.* feeding was compared to underfeeding. Only during realimentation after underfeeding was there an apparent higher energy content in the gain. This latter suggestion may be of importance to interpretation of results of the present investigation as regards cows being switched from restricted basal ration to full feed (underfeeding followed by realimentation).

Work is being continued with the objective of obtaining better estimates of caloric equivalents of liveweight gains by which to adjust energy of milk production when assaying feeds for net energy. Current work (Bath, 1964) supports 2,266 kcal per lb. liveweight change as an average, and this has been used if for no more than illustrative purposes in calculations shown in this paper. Whenever liveweight changes were not significantly different among parallel treatments within trials, the pooled average was used to calculate a single caloric equivalent of liveweight change to adjust milk energy.

Results of these calculations of net energy from feeding trials offer encouragement to continue developmental work with the objective of adapting the procedure for routine feed evaluation. The values for three different lots of barley in as many years (trials 2, 3, and 4) ranged from 68.4 to 71.8 mcal per 100 lb. dry matter. Further study is needed, however, to assay repeatability both within and between lots of feed, as well as among animals and over a period of time.

The potential error with respect to adjusting productive energy for liveweight changes is disturbing. The greatest source of error in this respect seems to be with regard to estimating liveweight change, more so than with the caloric equivalent of that change. Current work (Bath, 1964) suggests that estimates of the *energy equivalent* of liveweight gain may vary ± 10 per cent of the mean. This would lead to errors in the final calculations of net energy per unit of feed of only ± 5 per cent approximately. On the other hand, the variability indicated in estimating *liveweight change* could result in relatively huge errors of approximately ± 30 per cent.

The gravity of this problem cannot be assessed adequately at the present time. Current studies are being directed to evaluation of the confidence of estimates of liveweight changes by various weighing procedures. If this problem can be solved satisfactorily, this procedure for routine evaluation of feedstuffs for milk production has excellent possibilities.

SUMMARY

Four trials were conducted to study the use of the feed increment method for determining the net energy value of feedstuffs for milk production. Reasonable agreement was observed between values found for the same feeds in different trials. The main problem encountered was associated with the estimating of milk energy equivalent of liveweight change. The principal source of error seemed to be the estimating of liveweight change.

Results offered encouragement for continuing developmental work with the objective of adapting the procedure for routine feed evaluation.

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