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Beef Feeding

Using Net Energy to Formulate Beef Cattle Rations

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Feed energy measures are used to estimate the energy required for a specific animal at various performance levels and to evaluate feeds to supply this energy. The most frequently used measures of feed energy are

- total digestible nutrients (TDN),
- digestible energy (DE),
- metabolizable energy (ME), and
- net energy (NE).

Figure 1 shows energy losses during the digestion and metabolism of food. Note the losses that are accounted for in the various dietary energy measures.

Total Digestible Nutrients (TDN). TDN is the energy measure with which cattle producers are most familiar. It is a measure of the digestibility of the nutrients in a feed and their comparative, metabolic, caloric value. The apparent digestibilities of carbohydrates, protein, and fat are determined in a digestion trial. Then, TDN is calculated by **TDN = digestible protein + digestible crude fiber + digestible nitrogen-free extract + (2.25 × digestible fat).** TDN does take into consideration some urinary loss since the caloric value of digestible protein is actually 1.3 times that of carbohydrates (5.2 versus 4.0 kilocalories per gram).

TDN is limited as a measure of food energy because it does not account for the energy lost in rumen gases (methane, etc.) expelled during digestion. These losses are relatively larger for roughages than concentrates. Thus, the TDN system over estimates the productive energy value of roughages in relation to concentrates.

Scientists prefer to use the energy measures of digestible energy (DE), metabolizable energy (ME), and net energy (NE) rather than TDN for measuring food energy and describing the requirements of animals. With DE, ME, and NE the calorie is the unit which measures heat or energy, while the pound, a weight measure, is the unit for TDN.

Figure 1. Partition of dietary energy.

Intake of Gross Energy in Food (IE)
↓ energy loss in feces (FE)
Digestible Energy (DE)
↓ energy loss in urine (UE)
Total Digestible Nutrients (TDN)
↓ energy loss in fermentation gases, methane, etc. (GE)
TDN is not energy, but theoretically fits roughly in this part of the scheme.
Metabolizable Energy (ME)
↓ energy lost as heat increment (HI) or specific dynamic action (SDA)
Net Energy
↓ energy required for maintenance - NEm 03
Net Energy
energy required for production - NEm used for gains, reproduction, milk, work, etc.

Digestible Energy (DE). DE takes into account only the digestible losses. Apparent digestible energy is determined in a digestion trial by measuring the intake of gross energy in the feed (IE) and the gross energy in the feces (FE) with a bomb calorimeter. **DE = IE − FE.**

There is a constant relationship between DE and TDN. DE can be estimated from the TDN values of feed by the formula **2 megacalories of DE per pound of TDN or the percent of TDN multiplied by .02 = the megacalories of DE per pound of feed**. The ability of TDN and DE to predict animal performance is equal, and their limitations are the same.

Metabolizable Energy (ME). ME accounts for urinary, fecal, and with herbivores, the energy losses of combustible reticulorumen gases (GE). **ME = IE − (FE + UE + GE).**

ME is superior to DE as a measure to express feed values and energy requirements because it considers losses of energy in the urine (UE) and combustible gases (GE). However, ME has many of the same deficiencies as DE because UE and GE are predictable from DE. Therefore, 1 megacalorie ME is considered to be equal to 0.82 megacalorie DE. There is 1.64 megacalorie ME per pound of TDN (2 megacalories × .82).

ME accounts for all losses except for heat loss in metabolizing the absorbed nutrients. The increase in heat production after the consumption of food is called heat increment (HI). In a very cold environment, the heat increment may be used to maintain body temperature. In this case, the ME value approaches the net energy value of the feed or ration.

Net Energy (NE). NE accounts for all losses in metabolism and is the most exact measure of food energy. It is the portion of the food energy left for the animal to use for maintenance and production of meat, milk, wool, work, fur, etc. **NE = ME − HI.**

The net energy system for growing and finishing beef cattle separates the energy required for maintenance and for gain. The net energy system takes into account the higher energy value of a feed when it is used for maintenance than when the same feed is used to produce gain. (See UMC Guide 3051, "Feed Composition Table.")

However, if cattle are lactating, the partial efficiencies of ME use for maintenance and fattening are similar to lactation. Thus, a single energy value, net energy for lactation (NE_L), is used to define all requirements for the lactating cow and to describe the energy value of feeds. The energy requirements for mature, pregnant and lactating beef cows are expressed in net energy for maintenance levels in the 1984 National Research Council (NRC) Nutrient Requirements of Beef Cattle. (See tables in UMC Guide 2068).

The net energy requirement for maintenance (NEm) is related to the body weight of an animal. It is the energy needed to maintain life or the heat produced by an animal at rest and not consuming food. The NEm requirements in megacalories per day for beef cattle listed in the 1984 Nutrient Requirements of beef cattle are calculated by the equation $NEm = 0.077W^{0.75}$ with weight in kilograms. Because NEm values are related to the actual weight of the cattle, they are similar for the various breeds of cattle. However, there are differences in maintenance requirements based on sex, breed and physiological age. This variation is estimated to range from 3 percent to 14 percent. Extreme temperatures, rain, mud and abrupt changes in weather affect the maintenance requirements of animals.

The net energy for gain (NEg) requirements of cattle varies with sex and with the energy content of the gain produced. It takes more energy for a 1,000-pound steer to gain 1 pound a day than for a 350-pound steer to gain a pound. The gain on the 1,000-pound steer will be mostly fat, while the gain on the 350-pound steer will be mostly protein and water. This difference in the energy content of the gain is the reason that species, breed, body size, rate of growing and sex affect the NEg required for a pound of gain. Because heifers mature at a lighter weight than steers, a separate set of tables is used for each.

Cattle with larger mature weight will require less net energy for gain when at the same body weights as smaller type cattle because less of the gain will be fat for the larger type cattle. The net energy for gain figures in the 1984 NRC Requirement are given for (1) medium-frame steer calves; (2) larger-frame steer calves and compensating medium-frame yearling steers; (3) medium-frame bull calves and compensating large-frame yearling steers; and (4) large-frame bull calves and compensating large-frame yearling steers. (See MU Guide 2067 and 2068 for the NRC requirements for the various classes of male and female cattle).

Using the Net Energy System

The net energy system is popular because of its improved prediction of animal performance by determining whether the feed energy is being used for maintenance (NEm) or growth (NEg). The main problem in using net energy values is in predicting feed intake and the proportion of the daily feed intake that will be used for maintenance or growth. Some producers have used only NEg in formulating rations. But if you use NEg alone to formulate rations, you will overestimate the feeding value of concentrates relative to roughages. Other producers have used the NEm plus the NEg (NEm + g). This value applies only if half of the daily feed intake is used for maintenance.

High energy finishing rations are often formulated only on the basis of net energy for gain with a value of NEg of .60 to .62 megacalories per pound of ration dry matter.

The most accurate way to use these NE values to formulate rations is to use the NEm value, plus a multiplier, times the NEg, divided by one, plus the multiplier. The multiplier is the pounds of feed intake **above** maintenance divided by the pounds of beef **for** maintenance. For example, if a 750-pound steer is expected to eat 18 pounds of feed, 8 pounds of which will be required for maintenance, then the multiplier would be 10/8 and NE value of the ration would be

$$NE = \frac{NEm + (10/8)(NEg)}{1 + (10/8)}$$

This formula, which is used to arrive at a composite

Net energy requirement tables for growing and finishing beef cattle (Megacalories/Head/Day)

Body wt., lbs	300 NEm 3.07		400 NEm 3.81		500 NEm 4.50		600 MEm 5.16	
	NEg		NEg		NEg		NEG	
Daily Gain lbs	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves
Steers								
0.5	0.44	0.39	0.54	0.48	0.64	0.57	0.73	0.65
1.0	0.93	0.83	1.16	1.03	1.37	1.21	1.57	1.39
1.5	1.46	1.29	1.81	1.60	2.14	1.89	2.45	2.17
2.0	2.00	1.77	2.48	2.20	2.93	2.60	3.36	2.98
2.5	2.55	2.26	3.17	2.80	3.75	3.31	4.29	3.80
3.0	3.12	2.76	3.87	3.42	4.57	4.05	5.24	4.64
3.5	3.69	3.27	4.58	4.06	5.42	4.79	6.21	5.50
Heifers								
0.5	0.52	0.46	0.65	0.57	0.76	0.68	0.88	0.78
1.0	1.13	1.00	1.40	1.24	1.66	1.47	1.90	1.69
1.5	1.78	1.58	2.21	1.96	2.61	2.31	2.99	2.65
2.0	2.46	2.18	3.05	2.70	3.60	3.19	4.13	3.66
2.5	3.15	2.79	3.91	3.47	4.63	4.10	5.30	4.70
3.0	3.87	3.43	4.80	4.25	5.67	5.03	6.50	5.76
3.5	4.60	4.07	5.70	5.05	6.74	5.96	7.73	6.85

[1]National Research Council 1984
[2]Also includes compensating medium-frame yearlings

net energy value, must be applied to the NEm and NEg value for the ration and for each of the feed ingredients used in the ration formulation. Remember, however, that this particular composite net energy value applies to an animal of a specified weight, consuming a specified amount of this ration daily. The proportion of the daily feed used for maintenance will change if feed intake or the weight of the animal changes for a particular ration.

Using the Net Energy System to Predict Performance

The ration must be balanced for the protein, minerals and vitamins for adequate projection of performance with net energy values.

To illustrate the use of the system let's estimate the daily gain of a large-frame 500-pound steer consuming 15 pounds daily of alfalfa hay with 0.54 megacalories per pound of NEm and 0.31 megacalories per pound of NEg. Net energy value for feeds are given in UMC Guide 2051, "Feed Composition Tables." The daily maintenance requirement of 4.50 megacalories of NEm must be met first. Notice above that it takes 8.3 pounds of hay for maintenance, which

	NEm megacalorie/ pound	NEg megacalorie/ pound
Alfalfa hay	.54	.31
Requirements for 500-pound steer	(4.50 megacalorie NEm)	
Pounds hay for maintenance	8.3	(4.5 ÷ .54)
Pounds hay left for gain	6.7	(15 − 8.3)
NEg, megacalorie	2.08	(6.7 × .31)
Daily gain	1.64	(See table)

leaves 6.7 pounds of hay for gain. The 6.7 pounds of hay would supply 2.08 megacalories of NEg, which would give 1.64 pounds daily gain for the large-frame 500-pound steer.

The following example shows how the NEm and NEg are computed for a mixed ration and used to project the daily gain of 800-pound cattle consuming 20 pounds of the ration daily.

Sample Calculations

- A cattle producer is feeding the following ration to his cattle. How much NEm and NEg does it

Net energy requirement tables for growing and finishing beef cattle (Megacalories/Head/Day)

Body wt., lbs	700		800		900		1000		1100	
	NEm 5.79		NEm 6.40		NEm 6.99		MEm 7.57		NEm 8.13	
	NEg		NEg		NEg		NEg		NEg	
Daily Gain lbs	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves	Medium-frame calves	Large-[2] frame calves
Steers										
0.5	0.82	0.73	0.91	0.81	1.00	0.88	1.08	0.95	—	1.02
1.0	1.76	1.56	1.95	1.73	2.13	1.89	2.30	2.04	—	2.19
1.5	2.75	2.44	3.04	2.69	3.32	2.94	3.60	3.18	—	3.42
2.0	3.77	3.34	4.17	3.69	4.56	4.03	4.93	4.36	—	4.69
2.5	4.82	4.27	5.33	4.72	5.82	5.15	6.30	5.58	—	5.99
3.0	5.89	5.21	6.51	5.76	7.11	6.29	7.69	6.81	—	7.31
3.5	6.97	6.17	7.71	6.82	8.42	7.45	9.11	8.06	—	8.66
Heifers										
0.5	0.98	0.87	1.09	0.96	1.19	1.05	1.28	1.14	—	1.22
1.0	2.14	1.89	2.36	2.09	2.58	2.29	2.79	2.47	—	2.66
1.5	3.36	2.98	3.72	3.29	4.06	3.60	4.39	3.89	—	4.18
2.0	4.64	4.11	5.13	4.54	5.60	4.96	6.06	5.37	—	5.77
2.5	5.95	5.28	6.58	5.83	7.19	6.37	7.78	6.89	—	7.41
3.0	7.30	6.47	8.07	7.15	8.82	7.81	9.54	8.46	—	9.08
3.5	8.68	7.69	9.59	8.50	10.47	9.28	11.34	10.05	—	10.79

[1]National Research Council 1984
[2]Also includes compensating medium-frame yearlings

contain?

- The producer has a group of 800-pound medium-frame steer calves on this ration. They are consuming 20 pounds (as fed basis) of the above ration. What is the expected daily gain?

	% As Fed	Composition NEm/lb	Supplied NEm	Composition NEg/lb	Supplied NEg
Corn silage	15	.28	4.20	.18	2.70
Corn (No. 2)	78	.92	71.76	.60	46.80
SBM (Solv.)	5	.78	3.90	.53	2.65
Alfalfa meal	2	.56	1.12	.31	0.62
Total	100	× × ×	81.98	× × ×	52.77
Answer:	NEm is	.82	Megacalorie per pound		
	NEg is	.53	Megacalorie per pound		

Solution

1. NEm required is 6.40 megacalories.
2. Pounds of feed required for maintenance:
   $$\frac{\text{NEm requirement}}{\text{NEm per pounds of feed}} = \text{pound feed required}$$
   for maintenance $\frac{6.40}{.82} = 7.80$
3. Pounds of feed left for gain. Daily feed intake minus feed required for maintenance is 20 − 7.80 = 12.0.
4. NEg/pound of feed × lbs feed remaining is 0.53 × 12.20 = 6.47 megacalories NEg.
5. Expected daily gain is 3.0 lbs (see table).

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