Extension Bulletin 74

UPDATED

NRC Nutrient Requirements for Beef Cows

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To maintain adequate performance at a minimal cost, least-cost diet formulations are required. The basis of least-cost formulations is a list of available feeds, feed costs and nutrient concentrations and animal nutrient requirements. Estimates of nutrient requirements for beef cattle were revised in 1996. This bulletin contains tables of nutrient requirements for beef cows generated using the revised estimates.

NDSU EXTENSION SERVICE
North Dakota State University, Fargo, ND 58105

FEBRUARY 2000

The National Research Council (NRC) is the authority on nutrient requirements for livestock in the United States. The publication entitled *Nutrient Requirements of Beef Cattle* (6th edition) has been the nutritional basis for feeding beef cattle over the past decade. Nutrient requirements of beef cows were based on weight, expected average daily gain, stage of production (gestation or lactation) and level of milk production (average or superior). Cattle were assumed to be in average condition and managed in a thermo-neutral environment (neither heat nor cold stressed).

In 1996, the NRC released a 7th revised edition of *Nutrient Requirements of Beef Cattle*. This publication represents a significant revision of the 6th edition. One major improvement is the ability to describe different cattle types, management styles and feeding environments. As a result, there is a greater responsibility placed on the user to describe animals and feeding conditions.

Other improvements involve moving from a crude to a metabolizable protein system and the derivation of requirements using computer models. Two separate protein requirements are calculated. Ruminal requirements for protein are calculated from dietary dry matter digestibility, while metabolizable protein is used to express animal needs for protein to meet maintenance and productive functions. Metabolizable protein is supplied by microbial protein synthesized in the rumen and ruminally undegraded feed protein.

Currently, computer models are the only efficient and effective way of incorporating animal and environmental variation into the establishment of "site-specific" nutritional requirements. The use of a computer model is a major change for individuals familiar with the more traditional

Table 1. Diet nutrient density requirements of lactating beef cows (1,000 lb mature weight).[abc]

	Months since calving						
	1	2	3	4	5	6	7
15 lb Peak milk							
DMI, lb	22.8	23.5	24.2	23.5	22.8	22.2	21.8
Milk, lb/day	12.5	15.0	13.5	10.8	8.1	5.8	4.1
TDN, %DM	59.1	59.7	57.8	56.5	55.2	53.9	53.2
NE_m, mcal/lb	.58	.59	.56	.54	.52	.50	.49
MP, lb/d	1.47	1.60	1.53	1.39	1.25	1.14	1.06
CP, %DM	9.6	10.1	9.4	8.9	8.3	7.8	7.5
DIP_{opt}, %CP	79.8	76.9	79.8	82.7	86.4	89.6	92.7
Ca, % DM	.27	.29	.26	.24	.22	.20	.19
P, % DM	.18	.19	.18	.17	.16	.14	.14
20 lb Peak milk							
DMI, lb	24.0	25.0	25.4	24.4	23.5	22.7	22.1
Milk, lb/day	16.7	20.0	18.0	14.4	10.8	7.8	5.4
TDN, % DM	60.4	61.7	59.7	57.8	56.5	55.2	53.9
NE_m, mcal/lb	.60	.62	.59	.56	.54	.52	.50
MP, lb/d	1.69	1.87	1.76	1.58	1.39	1.24	1.13
CP, %DM	10.4	11.0	10.3	9.6	8.9	8.3	7.8
DIP_{opt}, %CP	75.5	73.1	75.7	78.4	82.6	86.8	90.0
Ca, % DM	.30	.32	.30	.27	.24	.22	.20
P, % DM	.20	.21	.19	.18	.17	.15	.14
25 lb Peak milk							
DMI, lb	25.2	26.4	26.6	25.4	24.2	23.2	22.5
Milk, lb/day	20.8	25.0	22.5	18.0	13.5	9.7	6.8
TDN, % DM	62.4	63.7	61.7	59.7	57.8	55.8	54.5
NE_m, mcal/lb	.63	.65	.62	.59	.56	.53	.51
MP, lb/d	1.91	2.13	2.00	1.76	1.53	1.34	1.20
CP, % DM	11.1	11.8	11.0	10.3	9.4	8.7	8.1
DIP_{opt}, %CP	73.0	70.4	72.8	75.7	79.7	83.4	87.4
Ca, % DM	.33	.35	.32	.30	.26	.24	.21
P, %DM	.21	.22	.21	.19	.18	.16	.15

[a] Adapted from NRC (1996).

[b] Intake and nutrient concentrations are expressed on a dry matter basis.

[c] DMI = dry matter intake, TDN = total digestible nutrients, NE_m = net energy for maintenance, MP = metabolizable protein, CP = crude protein, DIP_{opt} = degradable intake protein that minimizes dietary CP, Ca = calcium and P = phosphorus.

tabular format for presenting nutrient requirements.

Tables of dietary requirements cannot completely account for variations in nutrient requirements due to animal characteristics, feed ingredients and environment. Nonetheless, in many situations, tables of dietary nutrient requirements can be sufficiently accurate for everyday use. Therefore, requirements were computed and are presented in tabular format to serve as guidelines for simple ration formulation.

Tables 1, 2 and 3 present the energy, protein, calcium (Ca) and phosphorus (P) requirements for lactating cows with mature weights of 1000, 1200 and 1400 pounds, respectively. Requirements for dry, non-lactating cows are presented in Table 4. Weight categories were selected to represent a range in mature sizes that reflect most of the beef cattle found in the Northern Great Plains.

Within each weight class, requirements were computed for three different levels of milk production (15, 20 and 25 pound/day peak milk production) during a 29-week lactation period. Monthly milk production potential is predicted by the model from typical lactation curves. Lactation curves are computed from an estimate of peak milk production. The milk production levels chosen cover the range of expected peak milk production (Table 5) and should adequately represent cattle found in the Northern Great Plains. In practice, peak milk production can be estimated from mature cow weight or frame score and average expected 205-day steer weaning weight (Table 6). To reflect the dynamic effects of pregnancy and lactation on dietary nutrient requirements, recommendations are provided for each month of an annual reproductive cycle.

Table 2. Diet nutrient density requirements of lactating beef cows (1,200 lb mature weight).[abc]

	Months since calving						
	1	2	3	4	5	6	7
15 lb Peak milk							
DMI, lb	25.6	26.3	27.2	26.5	25.8	25.3	24.8
Milk, lb/day	12.5	15.0	13.5	10.8	8.1	5.8	4.1
TDN, % DM	57.8	59.1	56.5	55.8	54.5	53.2	52.6
NE_m, mcal/lb	.56	.58	.54	.53	.51	.49	.48
MP, lb/d	1.60	1.72	1.65	1.51	1.37	1.26	1.18
CP, %DM	9.3	9.7	9.1	8.6	8.1	7.6	7.3
DIP_{opt}, %CP	80.8	78.9	81.0	84.4	87.6	90.6	93.2
Ca, % DM	.26	.28	.26	.24	.22	.20	.19
P, % DM	.18	.19	.18	.17	.16	.15	.14
20 lb Peak milk							
DMI, lb	26.8	27.8	28.4	27.4	26.5	25.7	25.2
Milk, lb/day	16.7	20.0	18.0	14.4	10.8	7.8	5.4
TDN, % DM	59.7	61.1	58.4	57.1	55.8	54.5	53.9
NE_m, mcal/lb	.59	.61	.57	.55	.53	.51	.50
MP, lb/d	1.81	1.99	1.88	1.70	1.51	1.36	1.25
CP, %DM	10.0	10.6	9.8	9.2	8.6	8.1	7.6
DIP_{opt}, %CP	77.5	75.3	77.3	80.4	84.3	88.0	91.7
Ca, % DM	.29	.31	.29	.26	.24	.22	.20
P, % DM	.19	.21	.19	.18	.17	.15	.14
25 lb Peak milk							
DMI, lb	28.0	29.2	29.6	28.4	27.2	26.2	25.5
Milk, lb/day	20.8	25.0	22.5	18.0	13.5	9.7	6.8
TDN, % DM	61.1	63.1	60.4	58.4	57.1	55.2	54.5
NE_m, mcal/lb	.61	.64	.60	.57	.55	.52	.51
MP, lb/d	2.03	2.25	2.12	1.88	1.65	1.46	1.33
CP, % DM	10.7	11.3	10.5	9.8	9.1	8.4	7.9
DIP_{opt}, %CP	74.4	72.7	74.5	77.2	81.6	85.2	89.4
Ca, % DM	.31	.34	.31	.29	.26	.23	.21
P, % DM	.21	.22	.20	.19	.18	.16	.15

[a] Adapted from NRC (1996).

[b] Intake and nutrient concentrations are expressed on a dry matter basis.

[c] DMI = dry matter intake, TDN = total digestible nutrients, NE_m = net energy for maintenance, MP = metabolizable protein, CP = crude protein, DIP_{opt} = degradable intake protein that minimizes dietary CP, Ca = calcium and P = phosphorus.

Energy requirements are expressed as total digestible nutrients (TDN) and net energy (NE_m, mcal/lb dry matter). Crude protein (CP), TDN, Ca and P requirements are expressed as percentages of dietary dry matter. The calculation of protein requirements changed significantly in the 7th edition. Requirements for protein (ammonia, amino acids, peptides) to support the microbial population in the rumen are considered independently of the metabolizable protein (MP) requirements of the cow. Metabolizable protein is supplied by microbial protein synthesized in the rumen and undegraded feed protein. Crude protein requirements can be calculated from MP by assuming average microbial efficiencies, ruminal protein degradability and intestinal protein digestibility.

Table 7 summarizes dietary requirements and maximal tolerable concentrations of selected vitamins and minerals. Sufficient information is available to suggest higher dietary requirements for magnesium, potassium, sodium and manganese for breeding and lactating cows compared to growing and finishing cattle. Evidence also exists to suggest that chromium, molybdenum and nickel are essential dietary nutrients for cattle. However, there are insufficient data on which to base specific dietary requirements for these minerals.

The nutrient requirements presented in Tables 1 through 4 were generated with the table generator option of the modeling software. Several model simplifications and assumptions (see Appendix) were necessary to generate the generalized requirements. Using this approach limits the applicability of the requirements as presented. However, for everyday use, the level of accuracy achieved using this approach is acceptable.

Table 3. Diet nutrient density requirements of lactating beef cows (1,400 lb mature weight).[abc]

	Months since calving						
	1	2	3	4	5	6	7
15 lb Peak milk							
DMI, lb	28.3	29.0	30.1	29.4	28.7	28.2	27.8
Milk, lb/day	12.5	15.0	13.5	10.8	8.1	5.8	4.1
TDN, % DM	57.8	58.4	55.8	55.2	53.9	53.2	52.6
NE_m, mcal/lb	.56	.57	.53	.52	.50	.49	.48
MP, lb/d	1.71	1.84	1.76	1.63	1.49	1.38	1.30
CP, %DM	9.1	9.5	8.8	8.4	7.9	7.5	7.3
DIP_{opt}, %CP	82.9	80.2	82.4	85.8	88.7	92.0	94.3
Ca, % DM	.26	.28	.25	.24	.22	.20	.19
P, % DM	.18	.19	.17	.17	.16	.15	.14
20 lb Peak milk							
DMI, lb	29.5	30.5	31.3	30.3	29.4	28.6	28.1
Milk, lb/day	16.7	20.0	18.0	14.4	10.8	7.8	5.4
TDN, % DM	59.1	60.4	57.8	56.5	55.2	53.9	53.2
NE_m, mcal/lb	.58	.60	.56	.54	.52	.50	.49
MP, lb/d	1.93	2.10	2.00	1.81	1.63	1.48	1.38
CP, %DM	9.7	10.2	9.5	9.0	8.4	7.9	7.5
DIP_{opt}, %CP	79.1	76.9	79.0	82.0	85.6	89.0	92.1
Ca, % DM	.28	.30	.28	.26	.24	.22	.20
P, % DM	.19	.20	.19	.18	.17	.16	.15
25 lb Peak milk							
DMI, lb	30.7	31.9	32.5	31.3	30.1	29.2	28.4
Milk, lb/day	20.8	25.0	22.5	18.0	13.5	9.7	6.8
TDN, % DM	60.4	61.7	59.7	57.8	56.5	55.2	53.9
NE_m, mcal/lb	.60	.62	.59	.56	.54	.52	.50
MP, lb/d	2.15	2.36	2.23	2.00	1.77	1.58	1.45
CP, % DM	10.3	10.9	10.2	9.5	8.8	8.2	7.8
DIP_{opt}, %CP	76.1	73.7	76.4	78.9	83.1	87.2	90.2
Ca, % DM	.31	.33	.30	.28	.25	.23	.21
P, % DM	.20	.22	.20	.19	.17	.16	.15

[a] Adapted from NRC (1996).

[b] Intake and nutrient concentrations are expressed on a dry matter basis.

[c] DMI = dry matter intake, TDN = total digestible nutrients, NE_m = net energy for maintenance, MP = metabolizable protein, CP = crude protein, DIP_{opt} = degradable intake protein that minimizes dietary CP, Ca = calcium and P = phosphorus.

Table 4. Diet nutrient density requirements of dry beef cows (1000, 1200 and 1400 lb mature weight).[a,b,c]

	Months since calving				
	8	9	10	11	12
1,000 lb cow					
DMI, lb	19.8	20.3	20.9	21.0	21.4
Milk, lb/day	0.0	0.0	0.0	0.0	0.0
TDN, % DM	48.2	48.8	50.1	53.2	57.1
NE_m, mcal/lb	.41	.42	.44	.49	.55
MP, lb/d	.87	.91	.97	1.08	1.24
CP, %DM	6.7	6.9	7.1	7.8	8.8
DIP_{opt}, %CP	92.9	92.5	91.3	88.5	84.8
Ca, % DM	.16	.16	.24	.24	.24
P, % DM	.12	.12	.15	.15	.15
1,200 lb cow					
DMI, lb	22.7	23.3	23.9	24.1	24.6
Milk, lb/day	0.0	0.0	0.0	0.0	0.0
TDN, % DM	48.2	48.8	50.1	53.2	57.1
NE_m, mcal/lb	.41	.42	.44	.49	.55
MP, lb/d	1.00	1.04	1.12	1.25	1.44
CP, %DM	6.8	6.9	7.2	7.9	8.9
DIP_{opt}, %CP	92.7	92.4	91.0	87.9	83.9
Ca, % DM	.16	.16	.25	.25	.25
P, % DM	.12	.12	.16	.16	.16
1,400 lb cow					
DMI, lb	25.5	26.2	26.8	27.0	27.6
Milk, lb/day	0.0	0.0	0.0	0.0	0.0
TDN, % DM	48.2	48.8	50.1	53.2	57.1
NE_m, mcal/lb	.41	.42	.44	.49	.55
MP, lb/d	1.12	1.17	1.26	1.41	1.64
CP, % DM	6.8	6.9	7.2	7.9	8.9
DIP_{opt}, %CP	92.8	92.2	90.5	87.3	83.3
Ca, % DM	.17	.17	.26	.26	.26
P, % DM	.13	.13	.17	.17	.17

[a] Adapted from NRC (1996).

[b] Intake and nutrient concentrations are expressed on a dry matter basis.

[c] DMI = dry matter intake, TDN = total digestible nutrients, NE_m = net energy for maintenance, MP = metabolizable protein, CP = crude protein, DIP_{opt} = degradable intake protein that minimizes dietary CP, Ca = calcium and P = phosphorus.

Table 6. Predicting peak milk in beef cows[a]

		Peak Milk (lb/day)				
Mature Weight	**Frame Score[b]**	**6**	**12**	**18**	**24**	**30**
(lb)		Average expected 205-day steer weaning weight (lb)				
880	1	398	444	477	—	—
950	2	416	460	493	—	—
1030	3	431	475	510	546	574
1100	4	449	491	526	561	590
1170	5	464	506	541	576	607
1250	6	477	521	557	590	623
1320	7	491	537	572	605	638
1400	8	504	550	587	620	656
1470	9	517	565	601	634	671

[a] Fox et al., 1988. J. Anim. Sci. 66:1475-1495.

[b] Indicator of age-adjusted skeletal size. Scores range from 1 (very short mature size) to 9 (very tall mature size).

Table 5. Suggested breed-specific birth weights and peak milk production.[a]

Breed	Birth Wgt[b]	Peak Milk
	(lb)	(lb/d)
Angus	68.3	17.6
Braford	79.4	15.4
Brahman	68.3	17.6
Brangus	72.8	17.6
Braunvieh	86.0	26.5
Charolais	86.0	19.8
Chiarina	90.4	13.2
Devon	70.5	17.6
Galloway	79.4	17.6
Gelbvieh	86.0	25.4
Hereford	72.8	15.4
Holstein	94.8	33.1
Jersey	59.5	26.5
Limousin	81.6	19.8
Longhorn	72.8	11.0
Maine Anjou	88.2	19.8
Nelore	68.2	15.4
Piedmontese	83.8	15.4
Pinzgauer	68.2	24.3
Polled Hereford	72.8	15.4
Red Poll	79.4	22.0
Sahiwal	83.8	17.6
Salers	77.2	19.8
Santa Gertudis	72.8	17.6
Shorthorn	81.6	18.7
Simmental	86.0	26.5
South Devon	72.8	17.6
Tarentaise	72.8	19.8

[a] Adapted from NRC (1996).

[b] Birth wgt = birth weight, Peak Milk = estimate of milk production at peak production.

Table 7. Vitamin and mineral requirements and maximum tolerable concentrations[a,b]

	Unit	Requirements		Max. Tolerable Concentration
		Gestation	Lactation	
Vitamins required by beef cattle				
A	IU/kg	2800	3900	—
D	IU/kg	275	275	—
Minerals required by beef cattle				
Calcium	%	See tables 1-4	See tables 1-4	2.0
Chlorine	%	—	—	—
Chromium[c]	mg/kg	—	—	1,000.0
Cobalt	mg/kg	0.1	0.1	10.0
Copper	mg/kg	10.0	10.0	100.0
Iodine	mg/kg	0.5	0.5	50.0
Iron	mg/kg	50.0	50.0	1,000.0
Magnesium	%	0.12	0.2	0.4
Manganese	mg/kg	40.0	40.0	1,000.0
Molybdenum[c]	mg/kg	—	—	5.0
Nickel[c]	mg/kg	—	—	50.0
Phosphorus	%	See tables 1-4	See tables 1-4	1.0
Potassium	%	0.6	0.7	3.0
Selenium	mg/kg	0.1	0.1	2.0
Sodium	%	0.07[d]	0.1	—
Sulfur	%	0.15	0.15	0.4
Zinc	mg/kg	30.0	30.0	500.0
Minerals toxic to beef cattle				
Aluminum	mg/kg	—	—	1,000.0
Arsenic	mg/kg	—	—	50.0[e]
Bromine	mg/kg	—	—	200.0
Cadmium	mg/kg	—	—	0.5
Fluorine	mg/kg	—	—	40.0[f]
Lead	mg/kg	—	—	30.0
Mercury	mg/kg	—	—	2.0
Strontium	mg/kg	—	—	2,000.0

[a] Adapted from NRC (1996).

[b] Concentrations are expressed on a dry matter basis; NRC, 1996.

[c] Evidence exists to indicate that there is a dietary requirement for this element. Data is not extensive enough to establish specific dietary concentration.

[d] Given as a range of .06 - .08% of diet dry matter.

[e] Organic forms of arsenic can have maximal tolerable concentrations of 100 mg/kg.

[f] Given as a range of 40 - 100 mg/kg of diet dry matter.

Sources of Information

NRC. 1984. Nutrient requirements for beef cattle (6th Ed.). National Academy Press, Washington, DC.

NRC. 1996. Nutrient requirements for beef cattle (7th Ed.). National Academy Press, Washington, DC.

Appendix

1) Nutrient requirements are expressed as dietary concentrations. Therefore, accurate estimates of the dry matter intake (DMI) are required. If actual DMI is over or underestimated, calculated dietary requirements will be adversely (and inversely) affected.

2) Dietary net energy concentrations are used to estimate DMI. The reliability of this estimate is based on the specific feeding situation and the accuracy of the calculated net energy concentration on the diet. In situations where energy requirements are extremely low (i.e. TDN < 49.5%), estimates of DMI were hand-calculated using the approach suggest by the NRC subcommittee. One modification was included in hand-calculated values. The constant .95 was applied to diets with less than .95 Mcal/kg net energy for maintenance instead of 1.00 Mcal/kg.

3) Neither DMI nor specific nutrient requirements are adjusted to reflect local variations due to cattle types (other than body weight and potential milk production), intake patterns, environmental conditions or the effects of ruminal conditions (e.g. pH) on cell wall digestion and microbial yield efficiency. The computer software must be used to effectively integrate these effects into dietary requirements.

4) Dietary CP requirements were computed differently from the method suggested in the appendix tables of NRC (1996; pg 188, 226-228). Dietary CP requirements (Tables 1, 2, 3 and 4) were calculated from estimates of degradable and undegradable intake protein requirements. Degradable intake protein requirement was calculated from total digestible nutrient intake (13% of TDN requirement, lb/d). Undegradable intake protein requirements were calculated as the difference between the metabolizable protein (MP) requirement (obtained from the model; NRC) and the amount of MP supplied by microbial protein synthesis. It was assumed that the digestibility of microbial protein and undegradable intake protein was 80%. It was further assumed that only 80% of microbial protein is actually true protein, the remaining 20% being primarily nucleic acids. Finally, optimum ruminal degradability and dietary crude protein were calculated. Optimal degradability is defined as the extent of protein degradation in the rumen (degradable intake protein as a proportion of dietary crude protein) that minimizes the dietary crude protein requirement. Although not perfect, this approach attempts to ensure adequate protein supply to the rumen so that ruminal fiber digestion, dietary energy concentration and microbial protein synthesized are maximized with a minimum amount of crude protein. Specific requirements for ruminally degradable protein are not clearly defined. This is particularly true for cattle consuming poorer quality roughages. As more quantitative information becomes available, modifications to the degradable protein requirement may be warranted. The computer software must be used if accurate predictions of fiber digestion, dietary energy concentrations and ruminal protein requirements for specific feeding situations are desired.

5) Three weight classes and three milk production levels were employed. Although these values were chosen to reflect a typical range in biological types, their use does place boundaries on the usefulness of the tabular requirements.

6) Calves born to 1200-pound cows were assumed to weigh 80 pound. A similar ratio of calf birth weight to cow mature weight was used for the other two weight classes. Typical birth weights for 28 breeds of cattle are included in table 5.

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1.5M-2-00

EB-74

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