COW/CALF NUTRITION

Supplementing Beef Cow Rations

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INTRODUCTION

In the upper Midwest, supplementing beef cow rations becomes necessary during winter months. Some summer supplementation may be necessary during drought, or under other conditions that may result in reduced forage availability.

Generally, winter feeding is accomplished with harvested forages--hays and silages. Producers are encouraged to test their winter forage supply early in the wintering season to develop a feeding (and supplementation) program fitted to their specific needs. Tables 1 and 2 list nutrient requirements of beef cows and heifers and nutrient concentrations of some grains and forages. This paper summarizes some practical concepts to keep in mind when formulating energy or protein supplements for beef cow rations.

SUPPLEMENTING BEEF COW RATIONS

The first step in supplementing beef cows appropriately is to supplement only when absolutely necessary. For the most part, supplements are formulated to meet specific nutrient demands not met by the basic diet the cow is offered. Therefore, two things are required to be known before deciding whether a supplement is needed: 1) cow nutrient requirements for the period under evaluation, and 2) cow diet nutrient content for the period under evaluation.

Nutrient requirements of beef cows are based on a cow maintaining body weight to which production functions such as lactation or fetal growth are added (Table 1). This table is organized to account for additional needs of cows which are initiating lactation (phase 1; 85-d), during mid-lactation (phase 2; 120-d), during time of fastest fetal growth (phase 4; 50-d), or during time between weaning and before fetal growth is at a maximum (maintenance level; phase 3; 110-d). Table 1 is based on the NRC (1984) and estimates requirements for beef cows at various stages of production. A column representing energy needs in relative feed value (RFV) was added to facilitate application of lab test results to formulating supplements (Table 1).

A third item that must be known or estimated as close to reality as possible is the cow's dry matter (DM) intake of the base diet. This is because diet (forage) nutrient content is expressed as concentration/weight unit (lb; see Tables 2 and 3) and nutrient requirements are expressed as nutrient amounts/day (see Table 1). Intake estimation is required to determine whether nutrient requirements are being met. Table 4 lists nutrient supply by forages of varying energy and protein content with DM intake estimates varying between 1.8 and 2.2% of the cow's BW. It is evident that, for the lactating 1,200-lb beef cow and heifer, TDN concentration must be at 60% and DM intake at

2.2 of BW. Dry matter intakes of forage containing either 12 or 16% CP between 2.0 and 2.2% of BW meet CP requirements of 1,200-lb lactating cows and 950-lb lactating heifers in this example. Therefore, a measure of intake is required to determine the total pounds or megacalories of nutrients that a cow may consume daily. A recent study at the

University of Minnesota demonstrated that under wintering conditions, pregnant (>200-d) beef cows consumed 1.8, 2 or 2.2% of their BW in DM when forage quality was considered poor, average or good, respectively. Estimates of intake are not to be confused with forage disappearance from hay racks or feed bunks. Normally, a certain amount of waste ranging from 10 to 45% occurs at the feeding site.

Steps to formulate a supplement for beef cows can be summarized as follows:

1. Evaluate current feed (forage) supply using a laboratory to analyze nutrient content of feeds.
2. Determine nutrient requirements of groups to feed. Some adjustments for cold temperatures are included. A practical rule of thumb is to increase energy intake by 1% for every degree of coldness below the lower critical temperature of a cow. For practical purposes, a 20˚ F temperature can be used as the lower critical temperature. Thus, if outside temperature is 0˚ F with calm wind speed, then energy intake will have to be adjusted 20%. If the daily TDN requirement during this period is 11.2 lb, then an additional 2.24 lb TDN are required to prevent environmental stress on the cow. Because wind increases the effective temperature cattle perceive, a wind chill table (Table 5) is provided to adjust thermometer temperature readings. Also, a table (Table 6) to estimate lower critical temperature is provided. This table takes into consideration hair coat thickness.
3. Estimate dry matter intake.
4. Compare nutrient intake with nutrient requirements and determine what nutrient(s) need to be supplemented.
5. Select supplement based on its nutrient content and price.
6. Determine amount of supplement to use.
7. Feed supplement according to determined amounts.
8. Evaluate cow performance (i.e., body weight or condition changes) as a result of supplementation.

Table 1. Daily nutrient requirements of beef cows

Weight, lb	RFV	DMI, lb/d	TDN, lb/d	NE_m, Mcal/d	NE_g, Mcal/d	CP, lb/d	Ca, g/d	P, g/d	Vitamin A, 1000 IU
Dry mature cows - last third of pregnancy									
1000	81	19.6	10.5	9.72	-	1.6	23	18	26
1100	79	21.0	11.2	10.28	-	1.6	25	20	28
1200	76	22.3	11.8	10.83	-	1.7	26	21	29
1300	74	23.6	12.5	11.37	-	1.8	28	23	30
1400	72	24.9	13.1	11.90	-	1.9	29	24	32
Cows nursing calves - 20 lb milk/d									
1000	107	20.6	13.8	14.38	-	2.5	36	25	36
1100	103	22.3	14.5	14.94	-	2.6	38	27	38
1200	98	23.8	15.2	15.49	-	2.7	39	28	41
1300	94	25.3	15.9	16.03	-	2.8	41	30	43
1400	91	26.7	16.5	16.56	-	2.9	42	31	46
Cows nursing calves - 10 lb milk/d									
1000	89	20.2	11.5	10.98	-	2.0	25	20	37
1100	85	21.6	12.1	11.54	-	2.0	27	22	40
1200	82	23.0	12.8	12.09	-	2.1	28	23	42
1300	80	24.3	13.4	12.63	-	2.2	30	25	45
1400	78	25.6	14.0	13.15	-	2.3	31	26	47
Dry pregnant mature cows - middle third of pregnancy									
1000	69	18.1	8.8	7.57	-	1.3	15	15	23
1100	67	19.5	9.5	8.13	-	1.4	17	17	25
1200	66	20.8	10.1	8.68	-	1.4	18	18	26
1300	64	22.0	10.8	9.22	-	1.5	20	20	28
1400	63	23.3	11.4	9.75	-	1.6	21	21	30
Pregnant yearling heifers - last third of pregnancy									
950[a]	84	19.0	10.3	9.44	-	1.5	23	17	24
950[b]	95	19.8	11.7	9.44	1.09	1.7	26	19	25
950[c]	106	20.0	13.0	9.44	2.38	1.8	29	19	25
Two-year old heifers nursing calves - 10 lb milk/d									
950[d]	102	20.0	12.5	10.69	1.09	2.0	28	21	35
1000[d]	100	20.8	12.9	10.98	1.14	2.1	29	22	37

[a] Gaining 0.9 lb/d.
[b] Gaining 1.4 lb/d.
[c] Gaining 1.9 lb/d.
[d] Gaining 0.5 lb/d.

NRC (1984)

Table 2. Fiber, energy and protein contents of various forages and feedstuffs

Feedstuff	DM, %	CF	ADF	NDF	TDN	CP
Minnesota samples		----------	----------	% DM	----------	----------
Hay						
legume			38.0	50.7	59.3	18.0
legume-grass			39.3	55.4	58.3	15.6
grass-legume			40.4	59.2	57.4	13.6
grass			40.4	63.7	57.4	10.3
Hay-crop silage						
legume			39.2	46.7	58.4	19.0
legume-grass			40.8	50.5	57.1	16.5
grass-legume			39.3	53.5	58.3	14.6
grass			42.8	57.4	55.6	13.1
Corn silage						
normal			28.0	47.7	68.2	8.0
sweet			36.0	59.0	62.6	8.0
popcorn			32.0	51.0	65.4	9.0
stover			39.0	67.0	60.5	6.0
NRC, 1984						
Barley						
grain	88.0	5.7	7.0	19.0	84.0	13.5
hay	87.0	27.5	-	-	56.0	8.7
straw	91.0	42.0	49.0	80.0	40.0	4.3
Beet pulp, dehy.	91.0	19.8	33.0	54.0	74.0	9.8
Brome hay						
late vegetative	88.0	30.0	35.0	65.0	60.0	16.0
late bloom	89.0	37.0	43.0	68.0	55.0	10.0
Canary grass, hay	91.0	33.0	30.0	64.0	55.0	10.3
Corn plant						
stover	85.0	34.4	39.0	67.0	50.0	6.6
silage, well eared	33.0	23.7	28.0	51.0	70.0	8.1
silage, few ears	29.0	32.3	-	-	62.0	8.4
silage, no ears	31.0	31.3	35.0	68.0	55.0	6.3
Corn grain						
dry rolled	89.0	-	3.0	9.0	88.0	10.0
high moisture grain	70.0	-	4.3	11.2	89.0	10.6
high moisture ear	66.7	-	10.2	16.6	79.3	9.3
snaplage	44.0	-	14.0	42.5	74.0	8.9
gluten feed	90.0	9.7	-	-	83.0	25.6
Orchard hay						
early bloom	89.0	31.0	34.0	61.0	65.0	15.0
late bloom	91.0	37.1	45.0	72.0	54.0	8.4
Prairie hay	92.0	34.0	-	-	51.0	5.8
Timothy hay, full bloom	89.0	32.0	38.0	68.0	56.0	8.1

Table 3. Nutrient composition of various by-product and non-typical feedstuffs (DM basis)

Feedstuffs	DM	TDN	ME	NE_m	NE_g	CP	Ether extract	Ash	Ca	P	K
	%	%	--------Mcal/lb--------			----------%----------					
Animal fat	99	177	2.91	2.16	1.60	.0	99.5	.0	.00	.00	.00
Apple pomace	40	56	.92	.54	.28	5.6	5.2	3.5	.13	.12	.49
Bakery waste	95	95	1.55	1.06	.73	11.2	12.7	4.4	.14	.26	.53
Barley	88	84	1.38	.94	.64	13.0	2.1	2.6	.05	.38	.47
Beet pulp	91	74	1.22	.80	.52	9.7	.6	5.4	.69	.10	.20
Blood meal	92	66	1.08	.64	.37	86.0	1.4	5.8	.32	.26	.10
Brewers grains (wet)	23	66	1.09	.69	.41	27.0	6.5	4.8	.33	.55	.09
Brewers grains	91	66	1.09	.69	.41	27.2	7.2	3.9	.33	.55	.09
Broiler litter	89	66	1.09	.69	.41	24.5	3.0	22.0	3.16	1.78	1.68
Canola meal	90	76	1.25	.83	.54	36.5	7.9	7.5	.72	1.14	.90
Carrots	12	84	1.38	.94	.64	9.9	1.4	8.2	.40	1.35	2.80
Cookie meal	90	93	1.52	1.05	.73	7.0	14.0	4.4	.14	.26	.53
Corn	87	90	1.48	1.02	.70	9.5	4.2	1.4	.02	.35	.37
Corn cobs	90	50	.82	.44	.19	3.2	.7	1.7	.12	.04	.87
Corn gluten feed (wet)	40	83	1.36	.92	.62	26.2	2.4	7.5	.36	.82	.64
Corn gluten feed	92	83	1.36	.92	.62	26.2	2.4	7.5	.36	.82	.64
Corn gluten meal	90	89	1.46	1.00	.69	67.2	2.4	1.8	.08	.54	.21
Corn silage	35	70	1.15	.74	.47	8.0	3.1	4.5	.23	.22	.96
Cottonseed hulls	91	42	.69	.31	.07	4.1	1.7	2.8	.15	.09	.87
Cottonseed meal	90	80	1.31	.83	.54	44.0	1.6	7.1	.18	1.21	1.52
Cottonseeds	93	96	1.58	1.10	.77	23.9	23.1	4.8	.16	.75	1.21
Cull beans	90	84	1.38	.94	.64	25.3	1.5	5.2	.18	.59	1.47
Distillers grain	93	86	1.41	.96	.66	23.0	9.8	2.4	.11	.43	.18
Feather meal	93	70	1.15	.74	.47	91.3	3.2	3.8	.28	.72	.31
Fish meal	90	74	1.22	.76	.48	67.0	8.0	21.0	5.90	3.30	.60
Hay	89	55	.90	.52	.26	13.0	2.3	8.4	.30	.35	2.32
Hominy feed	90	95	1.55	1.02	.75	11.5	7.7	3.1	.05	.57	.65
Meat/bone meal	93	66	1.09	.65	.40	50.4	10.4	31.5	11.06	5.48	1.43
Molasses	78	79	1.30	.87	.58	8.5	.2	11.3	.17	.03	6.07
Oat hulls	92	35	.58	.19	.00	3.9	1.8	.6	.15	.15	.62
Oat screenings	90	77	1.26	.78	.54	12.9	4.6	2.5	.08	.49	.55
Potato by-products	53	87	1.43	.99	.68	5.3	.4	3.4	.04	.18	1.38
Soy hulls	90	66	1.08	.65	.39	8.0	2.1	5.1	.49	.21	1.27
Soybean meal	89	84	1.38	.94	.64	44.0	1.5	7.3	.33	.71	2.14
Sunflower meal	93	65	1.07	.67	.40	49.8	3.1	8.1	.44	.98	1.14
Sweet corn waste	32	72	1.18	.77	.49	7.7	5.2	4.9	.30	.90	1.15
Thin stillage	5	88	1.45	.99	.68	29.7	9.2	7.8	.35	1.37	1.80
Vegetable fat	100	177	2.91	2.16	1.60	.0	99.9	.0	.00	.00	.00
Whole soybeans	92	91	1.50	1.03	.71	42.8	18.8	5.5	.27	.65	1.82

Adapted from Rust, 1991.

Table 4. Importance of intake estimate on nutrient supply for lactating beef cows

	DMI, % BW					
	1,200-lb cows[a]			950-lb heifers[b]		
Nutrient	2.2	2.0	1.8	2.2	2.0	1.8
TDN, %						
60	15.8	**14.4**	**13.0**	12.5	**11.4**	**10.3**
55	**14.5**	**13.2**	**11.9**	**11.5**	**10.5**	**9.4**
50	**13.2**	**12.0**	**10.8**	**10.5**	**9.5**	**8.6**
CP, %						
16	4.2	3.8	3.5	3.3	3.0	2.7
12	3.2	2.9	**2.6**	2.5	2.3	2.1
8	**2.1**	**1.9**	**1.7**	**1.7**	**1.5**	**1.4**

[a] TDN and CP requirements are 15.2 and 2.7 lb/d, respectively.

[b] TDN and CP requirements are 12.5 and 2.0 lb/d, respectively.

Table 5. Windchill values for cattle[a]

Wind speed,	Temperature, °F						
mph	-10	-5	0	5	10	15	20
0	-10	-5	0	5	10	15	20
5	-16	-11	-6	-1	3	8	13
10	-21	-16	-11	-6	-1	3	8
15	-25	-20	-15	-10	-5	0	4
20	-30	-25	-20	-15	-10	-5	0
25	-37	-32	-27	-22	-17	-12	-7
30	-46	-41	-36	-31	-26	-21	-16
35	-60	-55	-50	-45	-40	-35	-30
40	-78	-73	-68	-63	-58	-53	-48

[a] From Better Beef Business (1981).

Additionally, requirements for vitamins and minerals must not be neglected. Injectable vitamin A (2 to 4 million IU) may be the easiest method to supply the requirement for this vitamin. An injection in the winter (when cows are dry lotted, and one at pasture turnout would be adequate. However, if a mineral premix is to be used to supplement phosphorus and other minerals, a vitamin A premix may be added.

Requirements for phosphorus range from 15 to 31 g/d, and hay provides roughly 60% of these requirements. Therefore, producers should be prepared to provide from 6 to 12 g supplemental P. This supplemental need can be met by feeding .2 lb of a 50:50 mixture of salt-dicalcium phosphate.

Supplementation of trace minerals may be necessary, especially for cows fed corn silage. Requirements for Mn, Cu and Zn may be higher than those described by NRC (1984). Manganese, supplemented to provide 55 ppm promoted improved reproductive performance in cows wintered

on a corn silage based diet.

Table 6. Critical temperatures for beef cattle[a]

Coat description	°F	°C
Summer, or wet	59	15
Fall	45	7
Winter	32	0
Heavy winter	18	- 8

[a]Ames (1978)

SUPPLEMENTAL FEED SOURCES

A table containing nutrient content of alternative feed sources for supplementing beef cows is included (Table 3). When evaluating alternative feed sources for supplement use, look at both the dry matter concentration and the concentration of the nutrient you are attempting to supplement. This is because supplement cost is dependent on both these concentrations. For instance, barley or wet corn gluten feed (WCGF) provide the same amount of energy on a DM basis; however, because of a difference in dry matter concentration, a producer would have to use twice as much WCGF as barley on an as-fed basis to meet a supplemental energy need. Thus, feed sources should be evaluated according to the following steps:

1. Find out the price/ton or price/lb.
2. Determine or have a laboratory determine DM, energy, protein and mineral content ofalternative feed sources.
3. Determine cost of 1 lb DM according to the expression:

   ($/lb)/DM concentration in decimal units

4. Determine cost of one unit of the nutrient you wish to supplement according to the expression:

   [($/lb)/DM concentration]/nutrient concentration in decimal units

Now, consider the barley and WCGF example described previously. Wet corn gluten feed and barley are priced at $30 ($.015/lb) and $65/ton ($.0325/lb), respectively. Using Table 3 to8 determine DM, energy and protein concentration, barley and WCGF price/lb DM are $.0369 (.0325/.88) and $.0375 (.015/.40), respectively. Energy (TDN) price/lb for barley and WCGF are $.044 (.0369/.84) and $.045 (.0375/.83), respectively. Protein price/lb for barley and WCGF are $.284 (.0369/.13) and $.143 (.0375/.262). Given this, it is easy to determine that if we need to supplement energy only, barley may be the best choice. However, if we need to supplement both energy and protein, or protein only, WCGF may be the best choice.

Feedstuffs listed in Table 3 are just a sample of the alternative feed sources available to producers for energy or protein sources. Producers are encouraged to apply the concepts of feed cost/lb DM and nutrient cost/lb to determine most economical energy or protein sources. From

Table 3 a list of energy, protein or both sources can be derived. Feeds chosen from among these categories are likely to provide the best value for their nutrient content.

Energy sources. Animal fat, apple pomace, bakery waste, barley, beet pulp, carrots, cookie meal, corn, corn cobs, corn silage, cottonseed hulls, hominy feed, molasses, oat hulls, oat screenings, potato by-products, soy hulls, sweet corn waste and vegetable fat.

Protein sources. Alfalfa hay, blood meal, broiler litter, canola meal, corn gluten meal, cottonseed meal, feather meal, fish meal, meat/bone meal, soybean meal and sunflower meal.

Energy and protein sources. Brewers grains (wet and dry), corn gluten feed (wet and dry),cottonseeds, cull beans, distillers grain, thin stillage and whole soybeans.

Table 4 was generated with formulas described above to estimate cost of each nutrient provided by selected ingredients. Effect of nutrient and DM concentrations reflect on the cost of each nutrient. For instance, barley TDN concentration is 93% that of corn grain; however, because of its lower price, 100 lb of barley TDN cost the same as 100 lb corn grain TDN. Also, although DM concentration of corn silage is quite low relative to either corn or barley, its high TDN concentration results in a lower corn silage TDN price/cwt than that of corn or barley. Because barley, corn and corn silage are primarily energy-concentrated feeds, protein prices/cwt from these feeds are higher than those from more protein-concentrated feeds.

Supplement requirements affect annual cow cost through the interaction between “real” and perceived need (is a nutrient really deficient?, or do I think it is deficient?), length of supplementation period, supplement cost and supplement nutrient concentration. Table 7 was generated to highlight this interaction. At low supplement cost ($80 to $160/ton DM) and low supplement need (1 lb TDN/d), supplementation cost stays below $12 for a 100-d supplementation period. The same supplement need, if met by using expensive ($320 to $400/ton DM) supplement sources, increases supplementation cost 100 to 150%. On the other hand, high supplement need, using expensive supplement sources increases supplement expense to approximately 20% of the total value of a 550 lb calf sold in a $75/cwt market.

Thus, from Table 8 it can be derived that an increase in supplement cost of $.08/lb DM is equivalent to an increase in supplement need of 2 lb. Or, every increase in supplement cost of $.04/lb DM is equivalent to an increase in supplement need of 1 lb. Therefore, the greater the9 supplement need, the lower the price a supplement should be. Also, energy concentration of the supplement affects supplement cost. Supplement cost increases between $.50 and $3.00 per 100-d period for every 10 percentage point increase in TDN. Therefore, the greater the supplement need, the more concentrated the supplement should be. For instance, a supplement need of 3 lb can be met at a cost as low as $13.33/100-d period or as high as $85.71/100-d period. These values represent 3 or 21% of the total value of a 550 lb calf priced at $75/cwt.

Table 7. Nutrient composition and costs of various feeds (1995)

Feedstuffs	DM, %	TDN, %	CP, %	$/cwt as is	$/cwt DM	$/cwt TDN	$/cwt CP
Barley	88	84	13.0	3.25	3.69	4.40	28.38
Corn grain	87	90	9.5	3.50	4.02	4.47	42.32
Corn silage	35	70	8.0	.90	2.57	3.67	32.12
Molasses	78	79	8.5	4.80	6.15	7.79	72.35
Broiler litter	89	66	24.5	1.75	1.97	2.98	8.04
Soybean meal	89	84	44.0	7.50	8.43	9.47	19.16
Sunflower meal	93	65	49.8	3.50	3.76	5.79	7.55
Wet corn gluten feed	40	83	26.2	1.75	4.38	5.28	16.72
Distillers grain	93	86	23.0	6.00	6.45	7.50	28.04
Whole soybeans	92	91	42.8	7.50	8.15	8.96	19.04

Table 8. Effects of supplement DM cost and TDN concentration on supplement expense for a 100-d period

Supplement TDN, %DM	Supplement TDN, need lb/d	Supplement cost, $/lb DM ($/ton DM)				
		.04 (80)	.08 (160)	.12 (240)	.16 (320)	.20 (400)
90						
	1	4.44	8.89	13.33	17.78	22.22
	2	8.89	17.78	26.67	35.56	44.44
	3	13.33	26.67	40.00	53.33	66.67
	4	17.78	35.56	53.33	71.11	88.89
80						
	1	5.00	10.00	15.00	20.00	25.00
	2	10.00	20.00	30.00	40.00	50.00
	3	15.00	30.00	45.00	60.00	75.00
	4	20.00	40.00	60.00	80.00	100.00
70						
	1	5.71	11.43	17.14	22.86	28.57
	2	11.43	22.86	34.29	45.71	57.14
	3	17.14	34.29	51.43	68.57	85.71
	4	22.86	45.71	68.57	91.43	114.29

SUPPLEMENT FORMULATION

Once, forage nutrient concentration, cow nutrient requirements and approximate DM intake are known, or closely estimated, a balance between nutrient intake and nutrient requirements must be determined.

$$\text{Nutrient intake} = \left(\begin{array}{c} \text{Nutrient} \\ \text{concentration} \\ \text{(from lab results)} \\ \text{(in decimals)} \end{array} \times \begin{array}{c} \text{DM} \\ \text{intake} \\ \text{(estimated)} \end{array} \right)$$

Nutrient requirement is estimated from Table 1 adjusting for cold exposure

$$\text{Balance} = \left(\begin{array}{c} \text{Nutrient} \\ \text{intake} \end{array} - \begin{array}{c} \text{Nutrient} \\ \text{requirement} \end{array} \right)$$

If the balance is positive, supplementation is not required. If the balance is negative, that nutrient must be supplemented to permit adequate cow performance. If a need to supplement arises, available supplemental nutrient sources must be evaluated based on supplemental nutrient content and price. Once a decision is made, then the appropriate amount of supplement must be fed to prevent over- or under-feeding.

Because DM intake is a limiting factor in diet formulations, DM in the supplement substitutes forage (base diet) DM intake. Thus, the actual contribution of nutrient(s) from the supplement is calculated as the difference between nutrient concentration in the supplement and nutrient concentration in the forage (base diet). This formulation method maximizes forage intake. When balancing for energy, if protein is not limiting, energy supplement must provide at least as much protein as the forage. On the other hand, when balancing for protein, if energy is not limiting, protein supplement must contain at least as much energy as the forage. These strategies ensure that both energy and protein requirements are met.

$$\text{Nutrient differential} = \left(\begin{array}{c} \text{Nutrient} \\ \text{concentration} \\ \text{of supplement} \end{array} - \begin{array}{c} \text{Nutrient} \\ \text{concentration in forage} \\ \text{(in decimals)} \end{array} \right)$$

Now, we divide the nutrient deficit by the nutrient differential (in decimals) to determine the amount of supplement DM to feed to meet deficient nutrient needs.

$$\text{Supplement requirement, lb DM} = \frac{\text{Nutrient deficit}}{\begin{array}{c}\text{Nutrient differential} \\ \text{(in decimals)}\end{array}}$$

This figure is then calculated back to an as-fed basis by dividing supplement requirement lb DM by the DM concentration of the supplement (in decimals).

$$\text{Supplement requirement, lb as - fed} = \frac{\text{Supplement requirement, lb DM}}{\begin{array}{c}\text{DM concentration of} \\ \text{supplement (in decimals)}\end{array}}$$

The complete ration must be checked for nutrient requirements to be met.

$$\text{Nutrient intake} = \left(\begin{array}{c}\text{Adjusted}\\ \text{forage intake}\\ \text{(base diet)}\end{array} \times \begin{array}{c}\text{Forage}\\ \text{nutrient}\\ \text{concentration}\\ \text{(in decimals)}\end{array}\right) + \left(\begin{array}{c}\text{Supplement}\\ \text{intake}\end{array} \times \begin{array}{c}\text{Supplement}\\ \text{nutrient}\\ \text{concentration}\\ \text{(in decimals)}\end{array}\right)$$

Supplement formulations are our best estimates to meet cow nutrient needs, but are not absolute values that guarantee the performance we are seeking. Other factors such as weather, competition among herd (group) mates, conditions of feeding sites and health affect the cow's response to supplementation.

An example for a group of lactating (20 lb milk/d) cows averaging 1,200 lb and a group of lactating (10 lb milk/d) heifers averaging 950 lb is represented in Table 9. This example assumes that forage TDN and CP concentrations are 55 and 12%, respectively, with an estimated DM intake of 2% of the BW. Thus, both the cow and heifer rations will be limited in energy.

Using Table 7, it is determined that corn grain may be the energy supplement of choice for this example (it is assumed that corn silage or other energy-rich feeds are not available). Therefore, TDN concentration of the supplement is 90%. Because DM intake is a limiting factor in diet formulations, corn grain DM in the supplement substitutes forage DM intake. Thus, the contribution of TDN from corn grain is calculated as the difference between TDN from corn and TDN from forage.

$$\text{TDN differential} = \left(\begin{array}{c}\text{Corn}\\ \text{TDN}\end{array} - \begin{array}{c}\text{Forage}\\ \text{TDN}\end{array}\right)$$

$$\text{TDN differential} = (90\% - 50\%) = 35\% \text{ (or .35)}$$

Now, we divide the TDN deficit by the TDN differential to determine the amount of corn DM to feed to meet energy needs of cows and heifers.

$$\text{Corn DM required} = \frac{\text{TDN deficit}}{\begin{array}{c}\text{TDN differential}\\ \text{(in decimals)}\end{array}}$$

$$\text{Corn DM required for cows} = \frac{2 \text{ lb}}{.35} = 5.7 \text{ lb}$$

$$\text{Corn DM required for heifers} = \frac{2.1 \text{ lb}}{.35} = 6 \text{ lb}$$

In this example, cows and heifers would require 5.7 lb or 6 lb corn DM. Because corn grain contains 87% DM, amount of corn to feed as fed would be 6.6 and 6.9 lb, respectively.

$$\text{Corn required for cows} = \frac{5.7 \text{ lb DM}}{.87} = 6.6 \text{ lb as - fed}$$

$$\text{Corn required for cows} = \frac{6.0 \text{ lb DM}}{.87} = 6.9 \text{ lb as - fed}$$

Lastly, a new balance check must be made based on DM intake from forage and supplement (Table 10) to ascertain that both energy and protein requirements are met.

Table 9. Nutrient supply for lactating 1,200-lb cows and 950-lb heifers (example)

Item	DMI, lb/d	TDN, lb/d	CP, lb/d
Cows			
Intake	24.0	13.2	2.9
Required	24.0	15.2	2.7
Balance	+ .2	- 2.0	+ .2
Heifers			
Intake	19.0	10.4	2.3
Required	20.0	12.5	2.0
Balance	+ 1.0	- 2.1	+ .3

Table 10. Energy and protein contributions of corn and hay to balance cow and heifer diets (example)

Item	As fed intake, lb/d	DM intake, lb/d	TDN intake, lb/d	CP intake, lb/d
Cows				
Corn	6.6	5.7	5.13	.54
Hay	21.0	18.3	10.07	2.20
Total	27.6	24.0	15.20	2.74
Requirement		24.0	15.2	2.7
Heifers				
Corn	6.9	6.0	5.40	.57
Hay	14.9	13.0	7.15	1.56
Total	21.8	19.0	12.55	2.13
Requirement		19.0	12.5	2.0

Some examples of energy and protein supplementation with corn and soybean meal (SBM), respectively, were calculated for late gestating and lactating (20 lb/milk/d) mature wintering cows fed forages of varying quality (Table 11). From this table, some guidelines for protein supplementation can be derived.

- For gestating cows, the minimum CP concentration in the forage should be 8%. Add .5 lb of SBM or a suitable substitute for every 1 percentage unit CP below 8%.

- For lactating cows, the minimum CP concentration in the forage should be 11%. Add .5 lb of SBM or a suitable substitute for every 1 percentage unit CP below 11%.
- For gestating cows, the minimum TDN concentration in the forage should be 56%. Add 4 lb of corn or a suitable substitute when the TDN concentration of the forage is 54% and .5 lb of corn or a suitable substitute for every 1 percentage unit TDN below 54%.
- For lactating cows, the minimum TDN concentration in the forage is >60% TDN. When forage TDN concentration is 58% provide 5 lb of corn or a suitable substitute and increase this amount by .5 lb or corn/percentage unit TDN to 55% TDN. When forage TDN concentration is 54%, provide 10 lb or corn or a suitable substitute and increase this amount by .5 lb of corn/percentage unit TDN below 54%.

Table 11. Suggested energy and protein supplementation for late gestating and lactating wintering cows of various weights fed forage of varying quality

Mature cows last trimester of gestation[a]										
	Corn (lb DM/d) when forage TDN% is					SBM[b] (lb DM/d) when forage CP % is				
BW, lb	50	52	54	56	58	5	6	7	8	9
1,000	6.4	5.8	5.1	1.0	0	1.4	.9	.5	0	0
1,200	5.4	4.6	3.6	0	0	1.1	.6	.1	0	0
1,400	4.5	3.4	2.2	0	0	1.1	.5	0	0	0
Mature cows milking 20 lb/d[c]										
	Corn (lb DM/d) when forage TDN% is					SBM[b] (lb DM/d) when forage CP % is				
BW, lb	50	52	54	56	58	7	8	9	10	11
1,000	13.0	12.6	12.1	8.4	7.6	2.4	1.9	1.4	.8	.3
1,200	11.8	11.1	10.4	5.7	4.4	2.0	1.5	.9	.2	0
1,400	10.4	8.4	8.4	2.6	.9	1.8	1.1	.3	0	0

[a] For TDN concentration <54% DM intake was 1.8% BW; otherwise DM intake was 2% BW.
[b] Soybean meal.
[c] For TDN concentration <54% DM intake was 2% BW; otherwise DM intake was 2.2% BW.

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