UNIVERSITY OF MINNESOTA
Extension
SERVICE

DIET FORMULATION

Lesson 5

One of the real opportunities in controlling costs in a beef cow herd is carefully planning feed needs. Harlan Hughes, Extension Livestock Economist, North Dakota State University, reports that in North Dakota, the high-profit herds spent $45 less for total feed than the low-profit herds, yet they produced more pounds of calf per cow. Data from Minnesota beef producers would show a similar trend. Controlling feed costs is a prime way to improve the bottom line.

What to Feed

While controlling costs is important, long-term profitability can only be maintained by feeding a ration carefully balanced to match the nutritional needs of the herd. The first three lessons of this course provided a background in nutrition basics, winter cow feeding, and replacement heifer feeding. As described in Lesson 4, a good place to begin on most operations is taking an inventory and analysis of forage feeds on hand. Forages and low-cost home grown feeds are the foundation of beef herd nutrition programs. For example, in southeastern and central Minnesota, hay, corn silage, sweet corn silage, and corn stalks may be available, while other parts of the state have wheat straw, and sugar beet and ethanol processing waste.

Using the available forage inventory, diets should be balanced for energy (TDN) and crude protein (CP) based on the forage analysis. Minerals and vitamins can then be supplemented as needed.

It is impossible to determine nutrient composition accurately by visual inspection. A factor to keep in mind is that forages become less digestible as they mature. Protein and energy values decrease as related in Table 1.

Table 1. Effect of maturity on nutrient composition

Forage	TDN %	CP %
Alfalfa hay, early bloom	60	19.9
Alfalfa hay, mid-bloom	58	18.7
Alfalfa hay, full bloom	55	17.0

Source: Table 11-1, NRC, 1996.

Experienced producers will adjust feeding practices by watching for changes in body condition score as described in lesson one. If cows begin to lose body condition, the quality or quantity of forages fed are not meeting nutrient requirements, or the nutrients are not properly balanced to ensure proper digestion and utilization. If supplementation is required, it is important to select the lowest cost feed that will supply nutrients that match the animals' needs properly. Corn is the most common energy supplement used in Minnesota because of availability and relatively low price. Common protein supplement sources include legume hay (such as alfalfa) and soybean meal. Appendix A included at the end of this lesson lists the average nutrient composition for many feeds available in Minnesota.

How Much to Feed

A producer who understands nutrition basics and knows the nutrient values of the feedstuffs that are available, still must determine how much to feed each group of animals each day. The remainder of this lesson will give examples of methods which can be used to balance diets for energy and protein.

As in many of the examples in previous lessons, rations in this lesson are formulated for a 1,200 pound mature cow, nine months after calving. This should roughly describe a cow being fed in January with an expected calving in early April. The methods described can then be used for any type of beef cattle after adjustments are made for age, stage of production, weather, etc. Examples will use commonly available feeds for Minnesota with nutrient values taken from Appendix A. Different areas of the state will have various opportunities for savings in feed costs based on what is commonly found in an area.

Example rations will be formulated on a dry matter (DM) basis, meaning they were calculated as if moisture-free. After this calculation, reformulation can be made to an as-fed basis (accounting for moisture in feed when fed) for feeding. You will need to know the moisture content, especially of silage, to determine the amount to feed. For example, to provide 12 pounds of dry matter from silage at 70% moisture (30% DM), a cow must be fed 40 pounds, but if the moisture were 40% (60% DM), only 20 pounds would be required to supply the same amount of nutrients. If DM for dry hay is not calculated, use 10% moisture (90% DM) as an average value.

Method 1. Meeting Minimum Energy And Protein With A Single Feed

Ration for a 1200 lb mature cow - 9 months after calving
Requirements can be found in Appendix B - Beef Cow Nutrient Recommendations, 1996 National Research Council, prepared by Alfredo DiCostanzo.

TDN = 12.2 lb per day CP = 1.9 lb per day

Determine the amount of feed necessary to meet daily requirements using this equation:

Amount of Feed Required/Day = Cow requirement (TDN, CP) divided by (TDN,CP in feed)
dry matter (DM) of feed

Example 1. Feeding Only Corn Silage

Feed	TDN%	CP%	DM%
Corn silage, well eared	70	8.1	33

Amount of corn silage to feed to meet TDN requirement -

12.2 lb TDN divided by 70% TDN = 17.4 = 52.7 lb of corn silage as fed
33% DM .33

Amount of corn silage to feed to meet protein requirement -

1.9 lb CP divided by 8.1% CP = 23.5 = 71.2 lb of corn silage as fed
33% DM .33DM

Thus, to meet both the TDN and CP requirement, 71.2 lb of corn silage would need to be fed.

Example 2. Using Only Alfalfa (Legume) Hay
For the same cow:

Feed	TDN%	CP%	DM%
Hay, legume	59.3	18.0	90

Amount of alfalfa hay to feed to meet the TDN requirement -

12.2 lb TDN divided by .593 = 20.6 lb = 22.8 lb of alfalfa hay as fed
.90 DM .90 DM

Amount of alfalfa hay to feed to meet the protein requirement -

1.9 lb CP divided by .18 CP = 10.6 lb = 11.7 lb of alfalfa hay as fed

.90 .90

To meet both requirements feed 22.8 lb of alfalfa hay.

These examples demonstrate how the amount of feed can vary by the type of feed (22.8 lb versus 71.2 lb). Example 1 is over-supplying TDN to meet the protein requirement and Example 2 is a good illustration of over-supplying protein in order to meet the TDN requirements.

Method 2. Balancing Two Feeds Using Pearson Square

When formulating a ration, the goal is to provide the animal with the proper quantity of feed that will supply the necessary nutrients at a low cost. Today, least cost rations are often devised using computer programs. Computers have the advantage of including economics. This becomes a greater advantage when many sources of feed are available for the ration. If only two different feeds are available, the Pearson Square method can be used effectively to balance a ration.

Using the same 1200 lb mature cow - 9 months after calving and feed values listed in Appendix A.

TDN = 12.2 lb per day CP = 1.9 lb per day

Feed	TDN%	CP%	DM%
Hay, legume	59.3	18.0	90
Barley straw	40.0	4.3	91

Step 1. Estimate dry matter intake of cows. Depending on feed quality, ad-lib dry matter intake will range from 1.8 to 2.2% of the cow's weight. Personal experience will be the key in determining this actual amount.

Estimate = .020 x 1200 = 24 lb DM/day

Step 2. Determine if cow will meet her requirements (TDN or CP) on full feed of abundant, inexpensive forage.

TDN consumption = 24 lb straw x .40 = 9.6 lb TDN/day.

Check = Requirement - Intake

Check = 12.2 lb - 9.6 lb = deficiency of 2.6 lb TDN/day

Protein consumption = 24 lb straw x .043 CP = 1.03 lb CP/day

Check = 1.9 lb - 1.03 lb = .87 lb CP/day deficiency

Step 3. Balance ration for deficiencies. In this case we have a deficiency of both protein and energy. Select a feed to add to the ration based on price and practicality in your feeding program. Alfalfa hay will be selected in our example to balance the diet.

Step 4. Determine the percent nutrient (TDN, CP) required in diet for these cows. If energy (TDN) is limiting, balance for TDN first.

$$\% \text{ nutrient required in diet} = \frac{\text{lb required/day}}{\text{lb DM intake/day}} \times 100$$

$$\% \text{ TDN required in diet} = \frac{12.2 \text{ lb TDN/day}}{24 \text{ lb DM/day}} \times 100 = 50.8\%$$

Step 5. Balance ration with Pearson Square.

Alfalfa 59.3% TDN		10.8 parts Alfalfa
	50.8% TDN	
Straw 40.0% TDN		8.5 parts Straw 19.3 total parts

On the left-hand side of the square are the TDN percentages of alfalfa hay and straw. The 50.8% in the middle of the square is the energy requirement (expressed in % TDN) for the 1200 lb cow.

On the right-hand side of the square are parts of alfalfa and straw of the total ration. These parts are obtained by subtracting diagonally, the smallest % from the largest %.

59.3% - 50.8% = 8.5 parts 50.8% - 40.0% = 10.8 parts

Step 6. Convert parts of nutrients to % of nutrients in the ration by adding the parts and dividing the total into each individual part.

Example 8.5 +10.8 = 19.3 total parts

Percent Alfalfa = 10.8 divided by 19.3 = .559 or 56%
Percent Straw = 8.5 divided by 19.3 = .440 or 44%

Step 7. Calculate the pounds (DM) of each fed ingredient in total ration by multiplying the % of nutrient in the ration by estimated intake from above.

24 lb feed x 56% alfalfa = 13.4 lb Alfalfa 24 lb feed x 44% straw = 10.6 lb straw

Step 8. Check nutrient level.

Feed	DM, lb	TDN, lb		CP, lb	
Alfalfa	13.4	(13.4 x .59)	7.91	(13.4 x .18)	2.41
Straw	10.6	(10.6 x .40)	4.24	(10.6 x .043)	.47
Total	24.0		12.2		2.87

The ration meets the requirement for TDN (12.2) and protein (1.90).

Step 9. Change from a dry matter to an as-fed basis for feeding. To do this, divide dry feed (lb) from Step 7, by decimal of % dry matter found in Appendix A.

Alfalfa = $\frac{13.4 \text{ lb}}{.90 \text{ (alfalfa dry matter, estimated)}}$ = 14.9 lb/day

Straw = $\frac{10.6 \text{ lb}}{.91 \text{ (straw dry matter, from Appendix A)}}$ = 11.6 lb/day

The final ration will consist of 14.9 lb of alfalfa hay and 11.6 lb of straw per head per day.

Method 3. Ration Balancing Worksheet For Wintering Beef Cows

Producers are encouraged to analyze their forage supply and to know the nutrient content of the supplement they plan to use. Balancing a ration for pre- and post-calving periods in the early- and late-calving cows and determining winter feed costs is then accomplished according to the following steps: (Worksheets are included in this lesson.)

Step	Action
1.	Enter the average cow body weight in pounds (BW) at the beginning of the feeding period on line 1.
2.	Determine TDN requirements (lb/d) from NRC table (Appendix B) and enter this value in line 2.
3.	Select BCS desired at calving (pre-calving column) and at breeding (post-calving column) by multiplying the bodyweight in line 1 by the value corresponding to fat (7), thin (3) or moderate (5) condition. Write this value in line 5.
4.	Adjust for expected average temperature in the pre- or post-calving period by multiplying the value in line 5 by the value corresponding to no (20°F), mild (10°F), severe (0°F), or extreme (-10°F) cold stress. *Note: This is effective temperature corrected for windchill and humidity*. Write this value in line 8.
5.	Using the TDN concentration of the forage in line 9, estimate the pounds of forage needed by dividing line 8 by line 9. Write this value in line 10.

6. Multiply the average body weight of the cow (line 1) by the appropriate intake estimate according to good (2.2%), average (2.0%) or poor (1.8%) forage quality to estimate her maximum forage intake. Enter this value in line 13.

7. If value in line 13 is less than value in line 10, then write the difference in line 14. However, if value in line 13 is greater than value in line 10, then write 0 in line 14.

8. Determine correct value for line 15 as follows:

   a) If line 14 is zero and forage is continuously available to cows, enter value from line 13 on line 15.
   b) If line 14 is zero and forage is hand-fed daily, enter value from line 10 on line 15.
   c) If line 10 is greater than line 13, enter value from line 13 on line 15.

9. Multiply line 15 by line 9 and write value in line 16.

10. If value in line 16 is less than that in line 8, then write the difference in line 17, otherwise write 0 in line 17.

11. Write down TDN% of Supplement I in line 18. This worksheet balances the cow's energy requirements first, then the protein requirements. Therefore, choose an energy-rich supplement as Supplement I if energy is limiting. If energy is not limiting (value in line 17 is zero), skip forward to step #14.

12. Because intake is limited to the value in line 15, any supplement used substitutes for some of the forage intake. Therefore, the energy contribution of forage must be subtracted from that of Supplement I. Subtract line 9 from line 18 and enter result on line 19.

13. Divide line 17 by line 19 to obtain the amount of supplement required to balance forage energy supply. Write this value in line 20.

14. Subtract line 20 from line 15 and enter result in line 21. This is the amount of forage DM intake after accounting for Supplement I DM intake.

15. In line 22, write crude protein concentration of forage.

16. Multiply line 21 by line 22 and write in line 23.

17. Enter the CP concentration of Supplement I on line 24.

18. Multiply line 20 by line 24 and enter result on line 25.

19. Add lines 23 and 25, enter result on line 26. This is the projected daily CP intake.

20. In line 27, write protein requirement of cows from Table 3.

21. If the value in line 27 is greater than that in line 26, then write the difference in line 28, otherwise write zero in line 28.

22. Enter the CP concentration of Supplement II on line 29. If the diet is only protein limiting, then Supplement II is the only supplement used. Choose Supplement II to contain high protein concentration and TDN concentration equal or greater than that of the forage used. If the diet is energy and protein limiting, Supplement II is the second supplement needed. In this case, choose Supplement II to contain high protein and a TDN concentration equal or greater than that of Supplement I.

23. Because intake is limited to the value in line 15, Supplement II will substitute for forage and/or Supplement I intake. Therefore, if both energy-rich and protein-rich supplements are needed, subtract line 24 from line 29 and enter on line 30. If Supplement II is the only supplement used, subtract line 22 from line 29 and enter on line 30.

24. Divide line 28 by line 30 to obtain the amount of Supplement II needed to balance the protein supply. Enter the result on line 31.

25. Write down the TDN % of Supplement II in line 32.

26. Subtract line 31 from line 21. Enter the result on line 34 in the intake column. Multiply that value in the intake column by line 9, and enter the result in the TDN column. Then, multiply the value in the intake column by line 22, and enter result in the CP column. These are the DM, TDN, and CP contributions of the forage.

27. Subtract line 31 from line 20, enter the result in line 35 in the intake column.

28. On line 35, multiply the value in the intake column by line 18 and enter result in the TDN column. Then, multiply the value in the intake column by line 24 and enter result in the CP column. These are the DM, TDN, and CP contributions of Supplement I.

29. On line 36, enter the value from line 31 in the intake column. Multiply the value in the intake column by line 32 and enter result in the TDN column. Then, multiply the value in the intake column by line 29 and enter in the CP column. These are the DM, TDN, and CP contributions of Supplement II.

30. Compare totals with values in lines 8, 15, and 27.

31. Enter the number of days for the feeding period in line 37.

32. Multiply line 34 (intake column) by line 37 and enter in line 38. This is the forage DM requirement for the period under evaluation.

33. This worksheet allows adjustments for three bale-feeding methods (through a hay ring/rack, by unrolling bale on ground, or by permitting cows to eat from a rolled bale.) Similar adjustments for corn silage should be made to account for silage waste. Silage waste also ranges from 10 to 35%. Multiply line 38 by value chosen in line 40, enter result in line 41.

34. Enter forage DM concentration in line 42.

35. Divide line 41 by line 42. Enter this value in line 43.

36. Enter forage cost/lb. on line 44.

37. Multiply line 43 by line 44. This is the total amount (dollars) projected for forage feeding/cow in this period.

38. Multiply line 20 by line 37. Enter result in Supplement I column. Multiply line 31 by line 37, enter result in Supplement II column. If a supplement mix is preferred, values entered in columns labeled Supplement I and Supplement II can be added together and the total entered in the Supplement Mix column.

39. Enter DM concentration of each supplement under their respective columns. For a supplement mix, write on a separate sheet the amounts of Supplement I and II DM required to balance diets from line 35 and 36 respectively. Add these values. This is the total supplemental DM needed. Calculate as-fed amounts of each supplement used by dividing the values in lines 35 and 36, respectively, by DM concentrations entered in line 47 for each supplement. Add as-fed values of each supplement. This is the total Supplement Mix as-fed. Divide total supplemental DM by total as-fed supplement required. This is the Supplement Mix DM concentration.

40. Divide values in line 46 under their respective columns by those in line 47. These are the pound of Supplement I, Supplement II, or Supplement Mix needed for the feeding period.

41. Enter the cost/lb. of Supplement I or II in their respective columns. If it is preferred, calculate the percentage composition of each supplement in the mix by dividing the values in line 48 (columns labeled Supplement I and II) by the value in line 48 (column labeled Supplement Mix). Multiply values obtained by the cost/lb. of each supplement and add the resulting values to determine the pro-rated supplement cost/lb.

42. Multiply the values in line 48 under their respective columns by those entered in line 49. The result is the supplement cost on a per supplement basis, if Supplement I and II columns are used; or, on a Supplement Mix basis if that column is used.

43. Add the total for each supplement used in line 50 to line 45 to estimate the cost of winter feed for the selected period.

Method 4. Wintering Cow: A Computer Spreadsheet

A computer spreadsheet has been created that automates many of the calculations from Method 3. The spreadsheet is discussed in detail in Beef Cattle Management Update #44, recommended for additional reading with Lesson 2. The spreadsheet is written for Microsoft Excel, but has been successfully loaded into other spreadsheet programs. If you would like a copy of the Update and the Spreadsheet, please send your name, address, and phone to: A. DiCostanzo, University of Minnesota, Department of Animal Science, 205 Haecker Hall, 1364 Eckles Avenue, St. Paul, MN 55108-6118. You may also be able to obtain a copy of the spreadsheet from members of the MN Extension Beef Education Team.

Other Methods for Balancing Rations

Many local co-ops offer assistance in forage sampling and ration balancing at little or no charge. Obviously, their incentive is to sell supplements to be fed with the forages available on your farm. Many small operations will find this service to be convenient and useful.

Computer spreadsheets and more sophisticated ration programs are available from a number of land-grant universities and commercial sources. Depending on the complexity of the rations you wish to develop, you may find these useful.

Finally, nutrition consultants are available through feed companies and Extension to assist with difficult nutritional challenges.

A good nutrition program is the backbone of a profitable cow/calf enterprise. Feed costs and the costs associated with feed related reproductive and health problems represent over 60% of all costs of a healthy, weaned calf. A good cow herd manager can make more difference in the bottom line with a cost-effective balanced nutrition program than in any other management area.

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Worksheet 1: Ration Balancing Worksheet for Wintering Beef Cows

LINE	ITEM	CALVING DATE											
		EARLY						LATE					
		PRE-CALVING			POST-CALVING			PRE-CALVING			POST-CALVING		
		Cow BW			Cow BW			Cow BW			Cow BW		
1	NRC TDN Req, lb												
2	BCS	7	5	3	7	5	3	7	5	3	7	5	3
3	BCS Adjustment	1.05	1.00	1.20	0.70	1.00	1.36	0.90	1.00	1.15	0.70	1.00	1.37
4	BCS-Adjusted TDN, lb												
5	Temperature, °F	20	10	0	20	10	0	20	10	0	20	10	0
6	Cold Adjustment	1.00	1.10	1.20	1.00	1.10	1.20	1.00	1.10	1.20	1.00	1.10	1.20
7	Temp-Adjusted TDN, lb												
8	Forage TDN, %												
9	Forage Req, lb												
10	Forage Quality	Good	Average	Poor	Good	Average	Poor	Good	Average	Poor	Good	Average	Poor
11	Max. Forage Intake, % BW	2.2	2.0	1.8	2.2	2.0	1.8	2.2	2.0	1.8	2.2	2.0	1.8
12	Max. Forage Intake, lb												
13	Forage Intake Def, lb												
14	Forage Intake, lb												
15	TDN Intake, lb												
16	TDN Def, lb												
17	Supplement TDN, %												
18	Supplement Req, lb												
19	Forage CP, %												
20	CP Intake, lb												

21 NRC CP Req, lb				

Worksheet 1: Ration Balancing Worksheet for Wintering Beef Cows

LINE	ITEM	CALVING DATE											
		EARLY						LATE					
		PRECALVING			POSTCALVING			PRECALVING			POSTCALVING		
22	CP Def, lb												
23	Supplement CP, %												
24	Supplement Req, lb												
25	Supplement Need, lb												
26	Period, d												
27	Forage Need, lb												
28	Feeding Method	Feeder		No Feeder	Feeder		No Feeder	Feeder		No Feeder	Feeder		No Feeder
29	Waste Adjustment	1.10		1.45	1.10		1.45	1.10		1.45	1.10		1.45
30	Adjusted Forage, lb												
31	Forage DM, %												
32	Forage Req as Fed, lb												
33	Forage, $/lb												
34	Forage, $												
35	Supplement Need, lb	Energy	Protein	Both	Energy	Protein	Both	Energy	Protein	Both	Energy	Protein	Both
36	Supplement DM, %												
37	Supplement Req as Fed, lb												
38	Supplement, $/lb												
39	Supplement, $												

40 Winter Feed, $				

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