Balancing Rations For Producing Dairy Cows

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A successful dairy cow feeding program must be based on the greatest portion of total dry matter coming from forages. Regardless of the quality of forages, a dairyman is likely to feed what he has. Therefore, the flexibility he has in his overall feeding program is in the concentrate mixture that must be tailored to his forage.

Nutrient Composition of Forage

Dairymen must know the nutrient composition of forages in order to know the amount of concentrate supplement required as well as the level of protein and minerals it should contain. Hay, haylage and silage may be evaluated for **dry matter (DM), crude protein (CP)** and **crude fiber (CF).** These three items serve as a useful guide for balancing a ration and an overall feeding program.

Dry Matter

Any feed contains water and dry matter (DM), and the nutrients (energy, protein, minerals and vitamins) are contained in the DM. Nutrients in any feed may be expressed on the dry matter basis for ease of calculation. In final calculations, it may be converted back to an "as fed" basis.

Dry matter content of hay and grains is between 85-90 percent, corn and small grain silages range between 30 and 40 percent, and haylages range from 40 to 60 percent. At these levels, cows will eat the greatest amount of dry matter.

Total dry matter (feed) intake by a cow will depend on (1) body weight; (2) milk and butter fat she is producing; (3) amount of fiber in the ration; and (4) other ration characteristics such as palatability and balance of nutrients.

Table 1 contains guidelines for estimating dry matter intake as a percent of body weight according to production level of 4 percent FCM*.

Table 1. Estimated dry matter intake at various levels of milk production as percent of body weight[a]

Milk[b] (lbs/day)	Body Weight (1b) 1000	1200	1400	1600	1800
33	2.6	2.5	2.4	2.3	2.2
44	2.9	2.8	2.7	2.5	2.4
55	3.2	3.1	2.9	2.7	2.6
66	3.5	3.3	3.1	2.9	2.8
77	3.8	3.5	3.3	3.1	3.0
88	---	3.7	3.5	3.3	3.2

[a]Derived from National Research Council (NRC, 1978)
*[b]Milk adjusted to 4% Fat Corrected Milk (FCM) which is equal to: (0.4 x daily pounds of milk + 15 x daily fat)

If desired, Table 1 can be used to estimate dry matter intake. Many times it is more convenient to use the following formula: 2% of cow's body weight + ⅓ of daily FCM. Using this formula a 1400 pound cow producing 70 pounds of 3.5% milk could eat approximately 49 pounds of dry matter as calculated below:

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$$(.02 \times 1400) + \frac{(.4 \times 70 + 15 \times (70 \times .035)}{3} =$$

$$28 + \frac{(28 + 15(2.45)}{3} = 28 + \frac{28 + 36.75}{3}$$

$= 28 + 21.58 = 49.6$ pounds of dry matter.

Crude Protein

Protein is an essential nutrient for various metabolic processes in the cow, including milk production. When protein is underfed, the cow may look good and be in good flesh but will not produce as much milk as expected. A shortage of protein will cause a reduction in digestibility of all the feeds that are fed. This also slows the rate of passage of the feed through the cow, therefore lowering the total feed consumption. The protein content of corn and other small grain silage is lower than any type of legume feed, such as alfalfa.

NRC recommends the protein content of a ration for lactating cows to be between 13 and 16 percent of dry matter depending upon the body weight and level of production (Table 2).

Table 2. Guidelines of Recommended nutrients in total ration dry matter for dairy cow

Weight of cow (lbs)	Level of milk production (lbs/day)			
				Over
900	18	18-29	30-40	40
1100	24	24-37	38-51	51
1300	31	31-46	47-64	64
1550	40	40-57	58-78	78
Nutrient				
Crude protein, %	13	14	15	16
Crude fiber[a], %	17	17	17	17
Acid detergent fiber, %	21	21	21	21
Energy				
NE Mcal/lb	.64	.69	.73	.78
TDN, %	63	67	71	75
Calcium, %	.43	.48	.54	.60
Phosphorus, %	.31	.34	.38	.40
Salt, %	.46	.46	.46	.46

[a]May vary with total energy need as well as dry matter intake.

Crude Fiber

The percentage of fiber in the dry matter of small grain silage, haylage or hay is a good indicator of the available energy content. The lower the crude fiber content, the higher the energy content. Therefore, high fiber forages will contain less net energy per pound of dry matter than low fiber feeds. Because the cow has limited capacity for intake, more energy cannot be supplied if she is filled up with high fiber feeds.

Experiences of dairymen as well as research studies have emphasized the importance of maintaining the proper level of fiber in the total dairy ration. Cows receiving low fiber rations (14 percent or lower) may produce milk with lower than normal amounts of butterfat. A ration containing 15-18 percent crude fiber would provide the highest practical intake of energy and is the one to feed to high producing cows. A ration with 19-21 percent crude fiber would be more economical for cows producing 40-60 pounds daily. A ration containing 22-24 percent crude fiber would be adequate for late lactation cows.

Balancing the Ration

Balancing a ration to meet the requirements of a dairy herd requires consideration of: (1) size of cow, (2) amount of milk, (3) percent of milk fat in milk, (4) age of cow, and (5) stage of gestation.

All of these items have an effect on the amount of the various nutrients a dairy cow requires as well as amount of feed a dairy cow will eat in a 24 hour period.

Quality of feed, particularly forage will affect the amount of feed a cow can eat simply because feed high in fiber requires a longer passage time. Since two-thirds of the total milk is produced during the first one-third to one-half of a cow's lactation, the ration needs to be higher in nutrient density at that time compared to later in lactation.

Forage supplies about 35 to 40 percent of the DM intake during early lactation. Forage intake will provide about 50 percent of the dry matter intake during mid-lactation. Toward the end of the lactation, forage may supply two-thirds or more of the cows' dry matter intake.

The allowances should be increased by 20 percent over the guildelines for young lactating dairy cows in their first lactation and by 10 percent for dairy cows in their second lactation. The NRC requirements also indicate that an additional allowance should be made for the last two months of the gestation period. The amount of this allowance needs to be adjusted according to condition of the cow. This may require as much as one-third additional energy allowance.

How to determine what kind and how much grain should be fed:

1. Determine quality of forage. This can be estimated by use of tables as to kind and stage of maturity at harvest. Actual tests are more helpful.
2. Estimate or measure amount of intake.
3. Weigh or estimate weight of cow.

4. Determine production goals expressed as milk per day and butterfat content.
5. Make a list of feeds available.

Example: It is determined that: (1) Cow weighs 1400 pounds, (2) production goal 70 pounds 3.5 percent milk, (3) about 40 percent dry matter consumed from forage. Forage source on the dry matter basis consists of equal parts of alfalfa hay and corn silage. (4) Oats, barley, soybean oil meal and minerals are all available at current prices.

The first step is to estimate how much feed (on a dry matter basis) this cow can be expected to eat. In this example, dry matter intake is about 49 pounds/day (see dry matter paragraph).

It was assumed 40 percent total ration dry matter is coming from the forage dry matter. This amounts to about 20 pounds (49.4 × .4) of dry matter from forage. The example also assumed that the forage would consist of equal parts of alfalfa hay and corn silage. This would mean that the cow will receive 10 pounds of hay (20 lb × .5) and 10 pounds of corn silage dry matter.

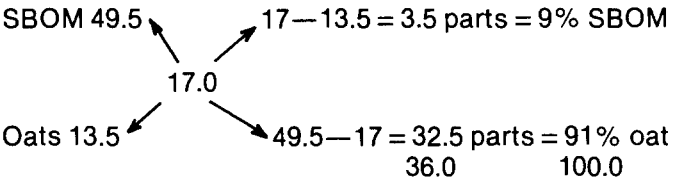
The grain ration must be expected then to supply 29 pounds of dry matter (49 minus 20 pounds). It must be high enough in energy and protein concentration to meet the ration requirements listed in Table 2. (15 percent protein and .73 Mcal/lb). Total required is: NE_L: .73 × 49 = 34.3 Mcal
Protein: .15 × 49 = 7.35 pounds

From Table 3, determine how much energy and protein this cow will receive from silage and hay, and this will show how much must be in the grain ration. That is:

	NE_L (Mcal)	Protein (lb)
Nutrients needed	34.3	7.35
Amounts supplied from:		
Silage	7.2 (10 × .72)	.80 (10 × .08)
Hay	5.7 (10 × .57)	1.60 (10 × .16)
Amounts required from grain	21.4	4.95

The above calculation shows that 29 pounds dry matter from concentrate mixture must supply 21.4 Mcal of energy and 4.95 pounds of protein. This would indicate that the energy content of grain mix must be .73 Mcal/lb concentrate dry matter (21.4/29) and the protein content of concentrate dry matter must be 17 percent (4.95/29).

Since none of the grains available meet the protein requirement and all (oats, barley and corn) meet necessary energy concentration, additional protein must be added. Determination of amount may be done using what is known as the Pearson square technique. Assume 44 percent (49.6 percent dry matter basis) soybean oil meal is used as supplement and oats is the grain, then



Summary for the feeding program

	Amount (lb/day)	
	Dry	As fed[a]
Forage		
Corn silage	10	28.6
Alfalfa hay	10	11.1
Concentrate		
Soybean oil meal	2.6	2.9
Oats	26.4	29.7
Total	49.0	72.3

[a]As fed basis = dry weight of the feed / percent dry matter of the feed
Example; corn silage, 10 lb dry weight and 35% dry matter. As fed = 10/.35 = 28.6 lb.

This ration will satisfy the objective, which was to feed 49 pounds of dry matter containing at least 34.3 Mcal of energy (or .73 Mcal/lb) and 7.35 lb. of protein (or 15 percent protien).

This has only shown how to balance for energy and protein. The same consideration must be given to other nutrients, particularly calcium and phosphorus, but all are important.

The energy content of this ration is 35.9 Mcal (10 × .72 + 10 × .57 + 2.6 × .84 + 26.4 × .79). A slightly excess supply of energy over the requirement (34.3 Mcal) was necessary to balance the protein within the estimated dry matter intake.

Examples of rations with two protein supplements[a]

	Soybean Meal			Sunflower meal		
	Dry basis		As fed	Dry basis		As fed
	(lb)	(%)	(lb)	(lb)	(%)	(lb)
Alfalfa hay	7.0	17.5	7.8	5.6	14.0	6.2
Corn silage	10.5	26.3	30.0	8.4	21.0	24.0
Concentrate	(22.5)	(56.2)	(25.0)	(26.0)	(65.0)	(29.0)
Corn	8.5	21.2	9.4	9.4	23.5	10.4
Barley	8.5	21.2	9.4	9.4	23.5	10.4
Soybean meal, 48	5.0	12.5	5.6	—	—	—
Soybean meal, 34	—	—	—	6.7	16.7	7.4
Minerals	0.5	1.3	1.3	0.5	1.3	1.3
Energy (NE_L, Mcal/lb)	.73			.73		
Protein (%)	15.0			15.0		

[a]Two rations, contained same amounts of energy (29.2 Mcal) and protein (6 lb), will support a cow weighing 1500 lb, consuming 40 lb dry matter, and producing 45-70 lb of milk — 3.5% fat test.

Table 3. Composition of feeds commonly used by North Dakota dairymen. (Dry Matter basis*)

Forages	Dry Matter	NE Mcal/#	Crude Protein%	Crude Fiber%	Calcium%	Phosphorus%
Alfalfa						
Late vegetative (Pre Bloom)	90	.64	19.9	27	2.45	0.30
Early Bloom	90	.59	17.2	31	1.25	0.23
50% Bloom	89	.57	16.0	33	1.35	0.22
Full Bloom	88	.54	15.0	35	1.28	0.20
Mature	88	.52	13.5	37	1.17	0.17
Barley Straw	88	.49	4.1	42	0.24	0.09
Beet Pulp—Dried w/molasses	92	.81	9.9	17	0.61	0.11
Blue Grass (Early Bloom grazed)	36	.71	14.8	14.8	0.46	0.39
Brome Grass						
Grazed, Mature	56	.67	9.0	33	0.30	—
Hay, Late Bloom	90	.54	7.4	40	0.30	0.35
Clover Red						
Full Bloom, fresh	28	.66	14.9	30	1.01	0.27
Hay	88	.60	14.9	30	1.49	0.25
Clover Sweet, hay	87	.58	14.0	36	1.27	0.26
Corn						
Corn fodder (after picking)	87	.60	5.9	34.0	0.60	0.09
Cobs—Ground	90	.47	2.8	35	0.12	0.04
Stover Silage	27	.59	7.2	32	0.38	0.42
Silage—well eared	35	.72	8.0	24	0.27	0.20
Silage—not well eared	35	.67	8.4	32	0.34	—
Millet hay	86	.58	8.6	30	0.33	0.19
Oat						
Hay	88	.62	9.2	31	0.26	0.24
Straw	90	.48	4.4	41	0.26	0.07
Silage—late vegetative	30	.64	12.8	30	—	0.10
Silage dough	32	.60	9.7	34	0.47	0.33
Prairie Hay—FB	90	.56	6.2	33	.38	0.14
Prairie Hay—EB	90	.60	8.7	31	.49	0.19
Potato—Tuber Silage	25	.82	8.2	2	0.04	0.23
Rye						
Pasture	16	.71	28.0	—	—	—
Silage	28	.54	12.6	34	0.39	0.32
Sorghum, Sudan Grass						
Pasture (Mid Bloom)	23	.65	8.7	36	0.43	0.41
Hay	89	.60	11.0	29	0.56	0.31
Silage	23	.60	11.1	34	0.48	0.19
Soybean						
Hay, dough-stage	88	.61	16.8	28	1.29	0.33
Straw	88	.43	5.2	44	1.59	0.06
Silage	28	.58	5.4	28	1.25	0.49
Sunflower						
Silage	30	.61	3.5	9.6	.60	0.10
Hulls	90	.41	5.0	45	.32	0.14
Timothy						
Hay—Early Bloom	88	.64	10.0	32	0.53	0.26
Hay—Late Bloom	88	.56	7.7	33	0.38	0.18
Wheat						
Hay	86	.59	8.7	28	0.14	0.18
Silage	26	.64	11.9	27	0.27	0.27
Straw	90	.46	4.2	42	0.21	0.08
Grains						
Barley						
Grain	89	.87	13.9	6	0.05	0.37
Screenings	89	.84	13.5	9	0.46	0.36
Brewer's Grains						
Wet	24	.69	26	16	0.29	0.54
Dried	92	.68	26	16	0.29	0.54
Corn						
Ear Corn Silage	43	.75	8.8	12	0.06	0.27
Ground ear corn	87	.84	9.3	9	0.05	0.26
Grain (cracked)	89	.84	10.0	2	0.03	0.31
Grain (Ground)	89	.92	10.0	2	0.03	0.31
Oats						
Grain	89	.79	13.6	12	0.07	0.39
Potato						
Tuber Silage	25	.82	8.2	4	0.04	0.23
Tubers, fresh	25	.82	9.6	2	0.04	0.22
Soybean						
Seed	90	.99	41.7	6	0.28	0.66
Sunflowers						
Seeds (Confection)	90	1.02	24	22	0.18	0.60
Seeds (oil)	90	1.29	18	19	0.20	0.60
Wheat						
Bran	89	.72	18	11	0.12	1.32
Durum	89	.92	14.3	3	0.06	0.41
Hard Red	89	.92	14.4	3	0.05	0.45
Screenings	89	.80	16.0	8	0.17	0.40
Refuse screenings	90	.51	16	32	0.25	0.32
Whey—Dried	93	.81	14.0	0	0.98	0.81

Supplements	Dry Matter	NE Mcal/#	Crude Protein%	Crude Fiber%	Calcium%	Phosphorus%
Bone meal, steamed	95	—	12.7	2	30.5	14.31
Dicalcium Phosphate	6	—	—	—	23.7	18.84
Whole milk, dry	94	.91	26.9	—	0.89	0.72
Skim milk, dry	94	.90	36.0	—	1.25	1.03
Phosphate (deflorinated)	100	—	—	—	31.65	13.7
Sodium Phosphate	87	—	—	—		25.8
Sodium Tri Poly Phosphate	96	—	—	—	—	25.9
Soybean meal (44%)	89	.84	49.6	7	0.36	0.75
Soybean meal (48%)	89	.84	54.0	3	0.36	0.75
Sunflower meal (dehulled)	90	.79	42.0	12	0.37	0.37
Sunflower meal	90	.74	34.0	20	0.37	0.37
Linseed meal (mech. extd.)	91	.84	38.6	10	0.43	0.93
Limestone	100	—	—	—	36.07	0.02
Commercial 36% (natural)	90	.79	40	9.0	3.0	1.2
Urea	99	0	28.1	—	—	—
Commercial 50% (w/urea)	90	.70	55	9.0	4.0	1.3
Liquid 32	30	.63	45.7	.5	1.0	1.1

Adapted from NRC (1978) tables and commercial feed tags

GLOSSARY OF TERMS USED IN DAIRY FEEDING

CRUDE FIBER — The most fibrous and less digestible portion of a feed stuff.

CRUDE PROTEIN — Total protein contained in a feed stuff.

DRY MATTER — The part of a feed which remains after all water is removed. It contains protein, fat, fiber, nitrogen free extract and ash.

MEGACALORIE PER POUND (Mcal) — Unit of energy per pound. Equivalent to 1,000,000 calories (1 calorie of heat energy is required to change temperature of one gram of water 1° centigrade).

NET ENERGY (NE) — Energy available to the dairy animal after energy used for digestion is utilized. It is used for Maintenance (NE_m), Gain (NE_g) or Production of Milk (NE_L). Energy produced from fats and carbohydrates in diet.

TDN — Total digestible nutrients. Sum of digestible protein, digestible nitrogen-free extract, digestible crude fiber, and (2.25 x digestible fat).