Nutrient Requirements of Dairy Cattle[1]

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Proper feeding and good balanced rations remain the cornerstone of a successful dairy operation. Milk yield per cow and the cost of feed to produce milk have by far the greatest influence on profitability in a dairy operation. If a dairy is to be successful, the dairymen must continually strive to adopt practices that allow the greatest output of milk at the most economical cost. Successful dairying in the future will depend on high levels of milk production, culling for low production, controlling feed costs, and using good replacements.

Cow identification and good records make good feeding practices possible. Without milk production records, it is difficult to feed according to milk production or to use any well-designed group feeding system.

Milk yields per cow continue to increase annually as reported by the USDA National Agricultural Statistics Service. Average production per cow in the United States reported in 1975 was 10,360 lbs as compared to 14,213 lbs in 1988. Much of this increase in milk production is due to better nutrition and feeding, overall management practices and the genetic improvement of the cow population.

FEEDING STANDARDS

Feeding standards have been used since the late 1800s to help guide nutritionists and livestock producers in formulating rations and feeding livestock. Periodically, the standards are updated to encompass the most current research information available. The standards that are now available, entitled "Nutrient Requirements of Dairy Cattle," were updated in 1988 by a subcommittee on Dairy Cattle Nutrition of the National Research Council.

Table 1, Table 2 and Table 3 show the nutrient requirements of dairy cattle as developed by the National Research Council (1988).

Energy

The energy requirements used from this publication are expressed as net energy for maintenance (NEM), net energy for lactation (NEL) and total digestible nutrients (TDN). Even though both TDN and NEL are acceptable measures of energy, NEL is expressed as megacalories (Mcal) whereas TDN is given in pounds.

The NEL is defined as the energy contained in the milk produced. Since milk fat is high in energy, cows producing a higher fat testing milk require more energy per pound of milk (Table 2).

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Protein

As milk production increases, it becomes important that some dietary protein escape degradation in rumen fermentation. Protein that bypasses the rumen is degraded to amino acids and absorbed from the small intestine for utilization. These essential amino acids are needed by the high producing cow and must come either from dietary protein that escapes degradation or microbial protein produced during rumen fermentation and passed along to the small intestine.

The 1988 Nutrient Requirements of Dairy Cattle discussed for the first time both absorbed and crude protein. The dietary intake protein is described as undegradable intake protein (UIP) and degradable intake protein (DIP). Although a specific percent UIP is not stated, the calculations suggest 35 to 40% bypass protein.

Processing or heat treatment of feedstuffs increases the amount of bypass protein in the feedstuff. Commonly used bypass protein supplements are distillers' grains, brewers' grains, corn gluten meal, blood meal, meat and bone meal, feather meal and heat treated soybeans (Table 4).

For faster usage and convenience, Table 3 has been developed to contain the combined requirements for maintenance and milk production for different sized dairy cows producing milk containing 3.5% fat. The compiled information in Table 3 will save time in calculating requirements.

FEEDS AND THEIR COMPOSITION

Table 4 contains a list of the more common feed ingredients used in Florida. Values given on ingredients are dry matter (DM); crude protein (CP); bypass protein (BP); total digestible nutrients (TDN); net energy for lactation (NEL); fat, calcium (Ca); phosphorus (Phos); sodium (Na); magnesium (Mg); potassium (K); and sulfur (S). The TDN and NEL refers to the energy content of the feed; either may be used in formulating rations. Table 5 shows the mineral composition of feeds commonly used in dairy cattle rations (U.S. Fed.).

Table 1. Daily nutrient requirements for maintenance of mature lactating cows.*

Body Wt. (lb)	Crude Protein (lb)	NEL (Mcal)	TDN (lb)	Ca (lb)	Phos (lb)	- Vitamins - A -(1000 IU)-	D
1000	.98	7.86	7.58	.041	.029	34	14
1200	1.18	9.02	8.70	.049	.034	41	16
1400	1.37	10.12	9.76	.057	.040	48	19

*Add 20% for growth of lactating cows during first lactation.

Table 2. Milk production -- nutrients per pound of milk of different fat percentages.

Fat (%)	Crude Protein (lb)	NEL (Mcal)	TDN (lb)	Ca (lb)	Phos (lb)
3.0	.073	.29	.280	.0027	.0017
3.5	.079	.31	.301	.0030	.0018
4.0	.086	.33	.322	.0032	.0020
4.5	.092	.36	.343	.0035	.0021
5.0	.100	.38	.364	.0037	.0023
5.5	.105	.40	.385	.0039	.0024

Table 3. Combined requirements for maintenance and milk production at various levels for cows of three different sizes producing 3.5% milk fat (NRC 1988.)

	Daily Nutrient Requirements					
lb Milk	Body Wt (lb)	CP (lb)	NEL (Mcal)	TDN (lb)	Ca (lb)	Phos (lb)
30	1000	3.35	17.2	16.7	.131	.083
	1200	3.55	18.3	17.4	.139	.088
	1400	3.74	19.4	18.8	.147	.094
40	1000	4.14	20.3	19.7	.161	.101
	1200	4.34	21.4	20.8	.169	.106
	1400	4.53	22.5	21.8	.177	.112
50	1000	4.93	23.4	22.7	.191	.119
	1200	5.13	24.5	23.8	.199	.124
	1400	5.32	25.6	24.9	.207	.130
60	1000	5.72	26.5	25.7	.221	.137
	1200	5.92	27.6	26.8	.229	.142
	1400	6.11	28.7	27.9	.237	.148
70	1000	6.51	29.6	28.7	.251	.155
	1200	6.71	30.7	29.8	.259	.160
	1400	6.90	31.8	30.9	.267	.166
75	1000	6.91	31.1	30.2	.270	.170
	1400	7.30	33.4	32.4	.280	.180
80	1000	7.30	32.7	31.7	.281	.173
	1400	7.69	34.9	33.9	.297	.184
85	1400	8.10	36.5	35.4	.312	.193
90	1400	8.48	38.0	36.9	.327	.202
100	1400	9.27	41.2	40.8	.360	.230
110	1400	10.06	44.2	42.9	.390	.240
120	1400	10.85	47.4	45.9	.420	.260

Table 4. Composition of feeds commonly used in dairy cattle rations (as fed).

	DM (%)	CP (%)	NEL BP* (%)	NEL TDN (%)	NEL Milk (Mcal)	Fat (%)
Alfalfa hay, early bloom	89	18.0	20	52	53	2.0
Alfalfa hay, full bloom	89	13.0	30	48	48	1.8
Alfalfa, haylage	50	8.0	25	28	28	1.5
Alfalfa pellets	90	17.0	35	50	50	1.8
Alfalfa silage	35	6.0	20	20	20	1.0
Bahia hay	88	6.0	30	42	43	1.4
Bakery, dried product	91	10.0	20	80	82	13.6
Barley, grain	89	11.0	27	74	77	1.8
Beet pulp, dried	91	7.2	45	70	74	0.6
Bermuda hay (coastal)	89	9.0	35	42	40	1.7
Bermuda silage	32	3.8	30	19	18	0.6
Bermuda pellets	89	8.5	40	46	44	0.9
Blood meal	92	80.0	82	61	63	1.3
Brewers grains	91	24.0	54	62	62	5.3
Brewers grains, wet	30	7.9	50	21	21	1.7
Canola meal (Rapeseed)	91	35.0	30	63	64	----
Carrot, roots	12	1.2	50	10	10	0.2
Citrus pulp	90	6.2	35	70	72	3.0
Citrus pulp, silage	20	1.3	30	17	17	1.6
Citrus pulp, pelleted	90	6.2	40	72	72	3.0
Clover hay, alsike	88	12.3	35	50	48	2.4
Clover hay, ladino	90	17.0	35	54	52	2.5
Clover-grass mix	88	11.0	50	50	48	2.8
Corn meal	89	8.6	50	80	82	3.5
Corn, high moisture	72	6.2	70	63	65	2.8
Corn, high moisture ear	70	6.7	50	52	53	2.4
Corn ear, snapped	89	7.8	40	70	70	2.9
Corn silage	30	2.4	30	20	20	----
Corn cobs, ground	90	2.5	40	45	40	0.4
Corn gluten feed	90	21.5	25	74	74	2.2
Corn distillers	92	27.0	52	78	80	9.0
Corn gluten meal	91	60.0	55	81	82	2.2
Corrugated boxes, ground	92	----	--	70	72	---
Cottonseed, whole	91	22.0	25	89	91	21.0
Cottonseed meal	92	41.0	40	70	71	3.6
Cottonseed hulls	90	4.0	40	40	34	1.0
Cowpea hay	90	16.0	30	42	40	2.5
Fats and oils	99	----	--	80	36	---
Feather meal	90	80.0	70	63	64	2.5
Fish meal	90	60.0	65	63	64	7.2
Hominy feed	89	10.5	50	82	83	6.0
Lespedeza hay	92	12.0	30	44	42	2.8
Linseed meal	91	35.0	35	73	74	5.0
Malt sprouts	90	25.0	40	65	67	---

				NEL		
	DM (%)	CP (%)	BP* (%)	TDN (%)	Milk (Mcal)	Fat (%)
Meat and bone meal	93	50.0	49	66	68	9.6
Molasses, cane	70	6.0	--	62	65	---
Molasses, cane, dehyd.	96	4.8	--	80	82	---
Millet silage	30	1.8	20	13	14	---
Milo, grain	88	11.0	50	70	74	2.8
Oats, grain	89	11.0	40	70	72	4.4
Oat silage	30	3.1	25	18	18	1.0
Oat hay	88	7.4	30	48	46	2.7
Oats, fresh	20	2.1	20	14	15	0.6
Pangola hay	90	6.0	30	38	38	1.0
Pea seed, field	90	22.0	25	74	75	1.2
Peanut meal	92	50.0	25	74	74	1.0
Peanut hulls, coarse	89	6.0	30	20	16	1.0
Peanut hulls, pelleted	92	6.0	40	24	20	1.0
Peanut skins	90	17.0	40	60	62	16.0
Peanut hay	90	8.5	30	46	45	3.1
Ryegrass silage	28	2.5	22	16	17	0.5
Ryegrass hay	90	10.0	30	54	56	1.8
Rye seed, grain	89	12.0	40	74	74	2.1
Rye silage	28	3.4	25	16	16	1.0
Rice bran	91	12.4	35	60	62	12.0
Rice hulls, ground	92	2.8	60	15	10	0.9
Rice millfeed	90	6.0	30	30	32	3.0
Sorghum, grain, silage	30	2.4	50	18	17	---
Sorghum, forage silage	30	2.1	50	17	16	---
Soybean meal	89	44.0	28	74	76	4.5
Soybean meal	89	48.0	25	74	76	0.8
Soybean hulls	91	11.0	10	68	70	2.0
Soybeans	90	37.0	26	84	89	18.0
Soybean silage	32	17.0	40	17	16	1.0
Soybean hay	88	13.0	30	45	46	2.4
Sudex silage	26	2.1	30	13	12	0.8
Sugarcane bagasse	92	1.8	40	40	35	---
Sugarcane silage	30	0.8	--	19	18	---
Sunflower meal	90	28.0	30	58	62	1.0
Sunflower meal	90	40.0	30	64	65	1.0
Urea	99	281.0	--	--	--	---
Wheat, whole	89	12.6	22	78	82	1.6
Wheat, midds	89	16.0	21	76	74	4.5
Wheat silage	26	3.0	30	18	16	1.0
Whey, lacto	61	44.0	--	68	70	---
Whey, dehy.	93	13.0	--	72	75	---
Yeast, brewers	93	44.0	42	72	75	1.0

*BP = bypass or escape protein.

Table 5. Mineral composition of feeds commonly used in dairy cattle rations (as fed).

	NEL					
	Ca (%)	Phos (%)	Na (%)	Mg (%)	K (%)	S (%)
Alfalfa hay, early bloom	1.40	0.20	0.13	.24	2.20	.24
Alfalfa hay, full bloom	1.30	0.20	0.13	.24	2.20	.24
Alfalfa, haylage	0.70	0.14	0.08	.14	1.10	.17
Alfalfa pellets	1.40	0.20	0.13	.20	2.30	.24
Alfalfa silage	0.50	0.10	0.05	.10	0.80	.12
Bahia hay	0.30	0.20	0.36	.18	1.30	.10
Bakery,dried product	0.05	0.10	0.32	.32	0.80	.02
Barley, grain	0.04	0.27	0.02	.10	0.31	.15
Beet pulp, dried	0.62	0.10	0.17	.24	0.18	.20
Bermuda hay (coastal)	0.30	0.15	0.36	.15	0.95	.26
Bermuda silage	0.16	0.06	0.14	.07	0.50	.03
Bermuda pellets	0.35	0.15	0.36	.15	0.95	.26
Blood meal	0.29	0.24	0.32	.22	0.09	.34
Brewers grains	0.30	0.48	0.24	.12	0.08	.34
Brewers grains, wet	0.10	0.15	0.07	.04	0.03	.11
Canola meal (Rapeseed)	0.68	1.10	---	.60	1.20	.09
Carrot, roots	0.04	0.04	0.12	.02	0.30	.02
Citrus pulp	1.50	0.12	0.09	.14	0.68	.06
Citrus pulp, silage	0.30	0.02	0.02	.03	0.11	---
Citrus pulp, pelleted	1.50	0.12	0.09	.14	0.68	.06
Clover hay, alsike	1.10	0.20	0.40	.28	0.10	.14
Clover hay, ladino	0.80	0.30	0.10	.40	1.80	.18
Clover-grass mix	0.90	0.30	0.10	.35	2.10	.18
Corn meal	0.02	0.30	0.01	.09	0.26	.12
Corn, high moisture	0.02	0.25	0.01	.08	0.24	.10
Corn, high moisture ear	0.03	0.16	0.03	.09	0.29	.12
Corn ear, snapped	0.04	0.20	0.04	.11	0.36	.15
Corn silage	0.09	0.06	---	.08	0.31	.02
Corn cobs, ground	0.10	0.03	0.01	.06	0.75	.36
Corn gluten feed	0.30	0.76	0.90	.30	0.60	.20
Corn distillers	0.09	0.36	0.09	.06	0.18	.42
Corn gluten meal	0.02	0.62	0.02	.13	0.41	.40
Corrugated boxes, ground	---	---	---	---	---	---
Cottonseed, whole	0.14	0.68	0.18	.27	0.82	.29
Cottonseed meal	0.15	0.90	0.05	.50	1.20	.38
Cottonseed hulls	0.14	0.10	0.27	.32	0.90	.23
Cowpea hay	1.20	0.30	0.24	.35	1.70	.20
Fats and oils	---	---	---	---	---	---
Feather meal	0.20	0.72	0.70	.20	0.27	1.40
Fish meal	5.3	3.1	0.50	.17	0.70	0.45
Hominy feed	0.04	0.60	0.08	.23	0.60	0.02
Lespedeza hay	0.90	0.20	0.06	.22	0.90	0.16
Linseed meal	0.39	0.82	0.10	.60	1.20	0.03
Malt sprouts	0.20	0.70	1.10	.18	0.20	---

	NEL					
	Ca (%)	Phos (%)	Na (%)	Mg (%)	K (%)	S (%)
Meat and bone meal	9.0	4.4	0.71	1.00	1.32	0.25
Molasses, cane	1.00	0.08	0.20	.58	4.00	0.87
Molasses, cane, dehy.	0.82	0.25	0.15	.40	3.50	0.50
Millet silage	0.08	0.05	0.08	.10	0.40	0.04
Milo, grain	0.02	0.28	0.02	.16	0.32	0.16
Oats, grain	0.05	0.34	0.15	.16	0.36	0.20
Oat silage	0.12	0.10	0.35	.12	0.60	0.02
Oat hay	0.22	0.17	0.14	.13	1.20	0.15
Oats, fresh	0.06	0.06	0.02	.08	0.35	0.01
Pangola hay	0.30	0.20	0.25	.15	1.20	0.10
Pea seed, field	0.10	0.40	0.04	.10	1.00	0.15
Peanut meal	0.20	0.60	0.40	.02	1.10	0.29
Peanut hulls, coarse	0.20	0.06	0.20	.15	0.90	0.08
Peanut hulls, pelleted	0.20	0.06	0.20	.15	0.90	0.08
Peanut skins	0.34	0.18	0.02	.11	0.78	0.15
Peanut hay	1.00	0.15	0.08	.44	1.20	0.20
Ryegrass silage	0.18	0.08	0.02	.04	0.40	0.05
Ryegrass hay	0.54	0.27	0.08	.12	1.40	0.15
Rye seed, grain	0.06	0.32	0.02	.12	0.47	0.15
Rye silage	0.10	0.10	0.30	.10	0.60	0.02
Rice bran	0.06	1.40	0.02	.90	1.70	0.18
Rice hulls, ground	0.08	0.06	---	---	0.12	0.01
Rice millfeed	0.08	1.30	0.05	.35	0.90	0.09
Sorghum, grain, silage	0.09	0.05	0.01	.09	0.46	0.01
Sorghum, forage silage	0.08	0.05	0.01	.08	0.40	0.01
Soybean meal	0.30	0.65	0.27	.26	1.90	0.40
Soybean meal	0.30	0.65	0.27	.26	1.90	0.40
Soybean hulls	0.40	0.15	0.04	.14	0.72	0.09
Soybeans	0.30	0.65	0.28	.26	1.90	0.42
Soybean silage	0.40	0.15	0.02	.12	0.30	0.09
Soybean hay	1.10	0.18	0.10	.26	0.80	0.20
Sudex silage	0.07	0.05	0.01	.06	0.42	0.04
Sugarcane bagasse	0.80	0.20	0.18	.08	0.40	0.09
Sugarcane silage	0.07	0.05	0.04	.04	0.70	0.03
Sunflower meal	0.40	1.00	1.00	.60	0.90	0.25
Sunflower meal	0.40	1.00	1.00	.70	1.00	0.25
Urea	---	---	---	---	---	---
Wheat, whole	0.05	0.34	0.02	.10	0.42	0.15
Wheat, midds	0.10	0.90	0.17	.50	1.20	0.16
Wheat silage	0.07	0.07	0.02	.16	0.36	0.06
Whey, lacto	0.18	0.44	0.74	.07	1.20	0.04
Whey, dehy.	0.90	0.72	1.00	.12	1.10	0.95
Yeast, brewers	0.12	1.40	0.07	.20	1.70	0.38

FORMULATING DAIRY RATIONS

Rations are nutritionally balanced and formulated to meet the nutrient requirements of animals performing at different levels. The nutrient requirements for maintenance and milk production for different sized animals including energy, protein, calcium and phosphorus.

Consider the following example where a herd receives a known amount of corn silage as the primary roughage. First the crude protein (CP) and total digestible nutrients (TDN) of the roughage are determined and subtracted from the requirements. The remainder will need to be supplied by the concentrate as shown below.

The purchased concentrate should contain about 20% crude protein, 70% TDN, 0.80% Ca, and 0.50% phosphorus so that the 34.5 lb of concentrate provide the needed requirements. Most concentrates contain about 70% TDN (Example 1).

Calculations: 23.9 lb TDN needed divided by .70 (TDN) = 34.2% Conc. required.

6.49 lb needed CP divided by 34.2 lb conc. = .19 or 20.0% protein needed in conc.

The most critical period in the cow's lactation is from parturition until peak production which takes from 5 to 8 weeks postpartum. It is during this period that the stage is set for obtaining the highest possible peak in production and also for the onset of normal reproductive cycling which may occur as early as 2 to 3 weeks in some cows. To be successful, the best strategies must be applied that include many areas such as feeding and management practices, quality and balance of feed, feed bunk management, milk practices, and the maintenance of good health.

Example 1. The use of corn silage and a purchased concentrate.

	lb	CP (lb)	TDN (lb)	Ca (lb)	P (lb)
Requirements (80# Milk)	--	7.69	33.9	.290	.184
Provided by corn silage	50	1.20	10.0	.045	.030
Needed by concentrate		6.49	23.9	.255	.154
Provided by concentrate	34.5	6.90	24.2	.276	.172
(70% TDN, 20% CP, .80% Ca, .50% P)	+	+	+	+	+