



Concentrates for dairy cattle

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Topics Include:

- Types of concentrate ingredients
- Preparation of grains and feeds
- Appropriate uses of feed ingredients
- Nutritional specifications for concentrates
- Sample concentrate mixtures for dairy cattle
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INTRODUCTION

- A. Concentrates are low-fiber, high-energy feeds. They may be low, medium, or high protein. Most often they are fed to raise the energy level of the ration for dairy cattle and to compensate for any other deficiencies that remain beyond those provided by the forage portion of the ration:
 - 1. *energy*—nonfiber carbohydrates (NFC) and fat
 - 2. *protein*—crude protein, degradable intake protein (DIP), soluble protein (SP), and undegradable intake protein (UIP)
 - 3. *fiber*—neutral detergent fiber (NDF) and acid detergent fiber (ADF)
 - 4. *macrominerals*—calcium, phosphorus, magnesium, potassium, sodium, sulfur, chloride
 - 5. *microminerals*—manganese, copper, zinc, iron, selenium, cobalt, iodine
 - 6. *fat-soluble vitamins*—vitamins A, D, and E
- B. Concentrates may serve as carriers for various feed ingredients such as vitamins and minerals (macro and micro), as well as a variety of feed additives.
- C. Proper preparation and processing of grains, feed ingredients, or a concentrate mix are essential.
- D. Concentrates must be palatable to attain required levels of feed intake. Proper processing and attention to particle size are important for palatability and ruminal degradation of nutrients.
- E. Concentrates should meet nutritional and performance needs at a reasonable cost. Purchased feed, including limited amounts of forage, may represent 40 to 55% of the total expenses on farms.

TYPES OF CONCENTRATE INGREDIENTS

Concentrate ingredients can be divided into three basic groups: *cereal grains*, *protein sources*, and *by-product feeds*. The feed type and the manner of preparation influence how the dairy cow uses these ingredients.

Cereal grains

- A. Barley, corn, milo, oats, rye, triticale, and wheat are the most common cereal grains. The general nutritive characteristics of these grains are:
 - 1. high in energy and low in fiber and protein.
 - 2. comparable level of phosphorus when compared to forages.
 - 3. low in calcium.
- B. Corn is more widely fed, either as shelled corn or ear corn (20 to 25% cob, 70 to 80% grain if partitioned by weight).
- C. Due to palatability problems with rye, triticale, and wheat, limited amounts should be fed in rations for dairy cattle. (See Table 1.)
- D. The energy that cereal grains supply comes in the form of fats, starches, and sugars.
 - 1. More than 80% of the NFC in grain is composed of starch.
 - 2. The availability and rate of digestion of the starch depends on the grain source and processing method.
 - 3. The rate of digestion for the following grains is ranked from slow to fast: milo, corn, barley, wheat, and oats.
- E. The method of processing grains influences the rate and extent of digestion in the rumen.
 - 1. Starch in finely ground grains is degraded more rapidly by ruminal microorganisms than coarsely processed grain.

TYPES OF CONCENTRATE INGREDIENTS (continued)

2. Finely ground grains are higher in digestibility because there is more surface area to which the rumen bacteria can attach. Any finely ground grain not digested by the bacteria is available for enzymatic digestion in the small intestine.
3. The starch in high-moisture grains ferments more rapidly in the rumen than starch in dry grain. High-moisture grains should be fed rolled versus whole to optimize starch utilization by the bacteria.
4. Heating grains, such as steam flaking, enhances starch digestion. Steam-flaked grains should be rolled to a thin flake. The heating process gelatinizes the starch in a manner that increases fermentability in the rumen.

Protein sources

- A. The most commonly used protein sources come from either plant or animal origins.
- B. Using sources that are high in protein quality are essential when formulating concentrate mixtures. Protein quality refers to the types, amounts, and ratios of peptides and amino acids that are in a feedstuff. Therefore, it is recommended to feed various protein sources to animals so they receive adequate levels, both ruminally and post-ruminally, of the essential and limiting amino acids.
- C. Urea is the exception because it is not a protein supplement, but a source of nitrogen. This nitrogen is converted to ammonia, which is used by the rumen bacteria for protein synthesis. Urea works well in mixtures with plant proteins if soluble protein is needed, and it often lowers feed costs.
- D. There is numerous sources of protein supplements available to producers that can be fed to meet an animal's requirement for crude protein.
 1. These protein sources can provide UIP or SP.
 2. Limitations on some of these sources may be for palatability reasons and keeping the protein fractions within the recommended ranges (Table 1).

By-product feeds

- A. By-product feeds are the secondary materials generated in addition to the principle product being manufactured for human use.
 1. The most commonly used by-products are derived from cereal grains.
 2. The process used to produce the by-product feed will determine how it can be used in ration formulation(s).
 - a. Some contain high levels of fat, which can make a ration more energy dense.
 - b. Others may supply the diet with undegradable, degradable, or SP at various levels.
 - c. Some contain relatively high NDF content and are used to balance rations for total NDF.
 - d. Some supply high levels of minerals or vitamins to the ration.
 3. By-product feeds often are available in wet form. Higher variability in moisture content may necessitate periodic testing of dry matter and nutrient content. These products are usually economical if trucking costs are not prohibitive.
- B. Tables 1 and 2 provide nutrient specifications of various feeds and their limitations.

PREPARATION OF GRAINS AND FEEDS

Dry grains

- A. Need to be adequately prepared or broken for animals to increase the digestibility of the grain and the entire ration.
 1. Preparation needs to be equivalent to grinding through a 1/2 to 5/8 inch screen.
 2. Cracked poultry corn is not fine enough for good digestibility.
 3. Steamed, crimped, steam rolled or steam flaked grains are approximately equal to ground grains in digestibility. Heat-processed grains should be limited, however, to 35 to 40% of the concentrate mix to avoid milk fat test depression.

PREPARATION OF GRAINS AND FEEDS (continued)

4. Mechanically crimped, rolled or flaked grains without heat are approximately equal to ground material if comparable particle size is attained. A roller mill must have more crimps to the inch to properly prepare small grains than the number for corn.

5. Pelleting
- a. Ingredients in a pellet generally must be finely ground (3/32 inch screen or finer) to enable efficient pelleting.
 - b. Heat in the form of steam is used in the pelleting process. Thus high-starch ingredients should be limited to 35 to 40% of the concentrate mix.
 - c. Must include sufficient fibrous ingredients in a formula that is to be pelleted to provide sufficient hardness and reduce fines (*Example* 15% wheat midds and 10 to 15% of a mid-protein ingredient such as corn gluten feed, brewers, or distillers)
 - d. Often contain binding agents to hold pellets together.

6. Coarse or special textured grains and feeds preferably should furnish only part of the concentrate; for example, a top-feed for high-producers, or 15 to 25% of the grains in a formula fed to all cows.

B. Young cattle under four to six months

- 1. Whole or more coarsely prepared grains may be fed since calves chew them adequately.

2. Some preparation may be necessary in some mixtures to prevent sorting and improve digestibility.

High-moisture grains (ensiled)

A. Proper preparation is necessary for several reasons:

- 1. To prevent sorting of ear corn during ensiling (cobs and grain).
- 2. To increase digestibility of the grain and the entire ration.
- 3. To minimize sorting during feeding.

B. Ensiled grains may be prepared more coarsely than dried grains.

- 1. Starch in ensiled grains is more soluble and degrades more quickly in the rumen than starches in dry grains.
- 2. This can be offset by somewhat coarser preparation.
- 3. Recommended preparation
 - a. Roller mill specifications for high-moisture grain:

	<i>Crimps per inch</i>	<i>Capacity Bu/hr</i>
Shelled corn	6.5 to 7	200+
Barley, wheat	8 to 10	400

- b. Most grains must be broken into several pieces when rubbed between the fingers or in the palm of the hand.
- c. Cob particles must be fine enough to prevent sorting.

Differences in extent of ruminal digestion of starches as affected by source and processing

<i>Processing</i>	<i>Percentage digestion in the rumen</i>				
	<i>Oats</i>	<i>Wheat</i>	<i>Barley</i>	<i>Corn</i>	<i>Milo</i>
Ensiled, high moisture, fine grind	99	99	98	85	--
Steam flaked, thin flake	99	98	97	86	84
Ensiled, high moisture, coarse rolled	--	--	--	82	80
Dry, fine grind	94	93	91	78	72
Dry, medium grind	89	88	87	74	68
Dry, coarse grind	79	78	77	65	61
Dry, whole	--	--	--	60	--

Source: Van Horn et al., Large Dairy Herd Management, IL. 1992.

APPROPRIATE USES OF FEED INGREDIENTS

A. Numerous cereal grains, protein sources, and by-product concentrate ingredients are used to supplement a forage ration. Using these ingredients can help meet the cow's requirements for UIP, SP, NFC, and NDF.

Some of these feeds can also be used to supply additional energy in the diet in the form of fat.

1. Ingredients high in crude protein (CP)

(> 40% CP on a dry matter basis):

soybean meal (44% or 48%)

corn gluten meal

urea

raw soybeans

canola meal

cottonseed meal

heat-treated soybeans

2. Ingredients high in UIP

(>45% of CP on a dry matter basis)

blood meal

corn gluten meal

fish meal

animal protein blends

brewers grain (wet and dry)

distillers grain

heat-treated soybeans

3. Ingredients high in SP

(>30% of CP on a dry matter basis)

corn gluten feed

whole cottonseed

wheat midds

raw soybeans

urea

4. Ingredients high in NFC

(>55% on a dry matter basis)

bakery product (i.e., bread)

barley

milo

rye

corn

hominy

oats

wheat

5. Ingredients high in fat

(>18% on a dry matter basis)

chocolate

bakery waste products

(i.e., donuts)

raw soybeans

whole cottonseed

candy waste products

tallow

heat-treated soybeans

6. Ingredients high in NDF

(>35% on a dry matter basis)

beet pulp

corn gluten feed

distillers grain

wheat midds

brewers grain (wet and dry)

whole cottonseed

soyhulls

B. The appropriate concentrate ingredients should be fed to compliment a forage ration. Listed are the expected nutrient specifications for UIP, SP, and NFC in a complete grain mixture, depending on the kinds of forages fed.

1. Forage rations consisting primarily of corn silage and hay may require the use of ingredients, which are higher in SP.

a. The expected range for UIP in these grain mixes as a percent of the crude protein is 34 to 42%.

b. The expected range for SP in these grain mixes as a percent of the crude protein is 21 to 29%.

c. NFC normally ranges between 50 to 61% on the lower protein grain mixes and 40 to 50% on the higher protein grain mixes.

2. Forage rations consisting primarily of ensiled hay crop forage, along with some corn silage or hay may require the use of ingredients that are high in UIP.

a. The expected range for UIP in these grain mixes as a percent of the crude protein is 44 to 48%.

b. The expected range for SP in these grain mixes as a percent of the crude protein is 15 to 19%.

c. NFC normally ranges between 50 to 61% on the lower protein grain mixes and 40 to 50% on the higher protein grain mixes.

NUTRITIONAL SPECIFICATIONS FOR CONCENTRATES

- A. To ensure cows are receiving a properly formulated grain mix, balance rations periodically and whenever forage intakes or type change.
 - 1. Base concentrate feed programming on actual forage and feed analyses.
 - 2. Anticipate changes by using previous year's forage analysis or analysis prior to ensiling or book values. These can be confirmed later by tests and modifications in concentrates may be made if necessary.
- B. Numerous factors affect the nutrient levels needed in the concentrate portion of the diet.
 - 1. Forage type and analysis
 - a. Legumes are generally higher in crude protein and calcium than other forages.
 - b. Corn silage is low-protein, low mineral, relatively high-energy forage.
 - 2. Forage intake:
 - a. affects the nutritional specifications for a concentrate mixture considerably;
 - b. varies by as much as 25 to 50% in a herd or among herds due to environment, stage of lactation, and overall forage quality.
 - 3. Production level and milk composition
 - a. The nutrient density (*Example:* protein content) needed in a concentrate differs for most cows in a herd, but it is impractical to use a different mix for each animal.
 - b. Compromise by:
 - (1) using several TMR groups and a computer feeder dispensing one to two feeds;
 - (2) using top-feeds for high or low-producing cows.
- c. The forage component of a diet may influence the nutrient density of the concentrate. For example, high-producing cows may need a mix with less nutrient density than low-producing cows, especially on a high-corn silage ration. High-producing cows may need a ration with greater nutrient density, particularly on a high-legume forage ration.
- d. Cows or herds producing milk with a high fat or solids content need more concentrate than those with lower test, thus nutrient density may be affected.
- C. Suggested nutritional specifications which may be needed in concentrates to balance different forage rations for milk cows and dry cows may be found in Tables 4 and 5, respectively.
 - 1. These are based on large breed cows producing 60 lb/d of milk with a 3.7% milk fat and peaking at 80 lb/d.
 - 2. A typical forage analysis was used to develop Tables 4 and 5. See Table 3.
 - 3. A forage dry matter intake of 1.8 to 2.0 lb per cwt of body weight was assumed for milk cows and 1.6 for dry cows.
 - 4. Concentrate levels for the average milk cow ranged from 17 to 19 lb per head daily for the all-corn silage ration to 22 to 24 for the other forage rations.
 - 5. Concentrate levels for dry cows ranged from 3 lb for the all-corn silage ration to 4.5 lb per head daily for the other forage rations.
 - 6. *These suggested specifications should serve as a guide only. They are not meant to replace forage analysis and proper ration balancing.*

SAMPLE CONCENTRATE MIXTURES FOR DAIRY CATTLE

- A. Various formulae meeting the nutrition specifications given in Tables 4 and 5 may be found in Tables 6 and 7. These are designed to serve as examples of grain mixes to use with the specific forages used in these rations. See Table 3.

NOTE: These rations should be used as guides only. Accurate forage analyses and feed programming are needed.

- 1. Mixtures containing oats can be substituted with barley.

SAMPLE CONCENTRATE MIXTURES (continued)

2. Formulae containing molasses can be substituted with corn or another low protein ingredient.
3. Mixtures containing distiller's grains can be substituted with dried brewers grain.
 - a. These mixtures are given mainly to provide additional UIP.
 - b. Some herds may respond profitably to more UIP at various times, while others may not.
4. Heat-treated soybeans are included in the concentrate mixture to supply added fat and UIP.
 - a. Adjustments in the level of calcium, phosphorus, and magnesium are necessary when fats from oilseeds or bypass fat are fed.
 - b. Soybeans that have been heat-treated provide additional rumen UIP.
5. Ingredients used include some of the more widely available ones.
6. Some of the micro-ingredient sources could be replaced with similar products with different vitamin or mineral contents if care is taken to provide reasonably equal levels of nutrients and to avoid excessive intakes.

B. The formulas given on a percentage or lb/cwt basis may be expanded to any batch size by multiplying the batch size by the ingredient level as a decimal or by multiplying the percent in the formula by the batch size in cwt.

Example: For a 3000 lb batch with oats at 25% of the mix:

$$3000 \times .25 = 750 \text{ lb or } 30 \times 25 = 750 \text{ lb}$$

C. Rounding

1. Levels of major energy and protein ingredients may be rounded to suit individual needs.

2. Ingredients used at less than 1% should be rounded carefully, if at all, since considerable changes in vitamin and trace element content could result.

D. In order to determine the concentrate mixture that most closely matches the forage ration, the proportion of forage dry matter in the diet needs to be calculated. For example, list the amount and dry matter content of each forage consumed on an *as fed* basis.

	<i>Lb</i> <i>as fed</i>		<i>%</i> <i>DM</i>		<i>Lb</i> <i>DM</i>	<i>%</i> <i>FDM</i>
Legume haylage	24	x	.47	=	11.3	44.7
Corn silage	26	x	.34	=	8.8	34.8
MML hay	6	x	.87	=	<u>5.2</u>	<u>20.5</u>
					25.3	100.0

1. Multiply the *as fed* amount by the percent DM as a decimal to obtain lb of DM.
Example $24 \times .47 = 11.3$.
2. Calculate the percent of the total dry matter furnished by each forage:
 $11.3 \div 25.3 \times 100 = 44.7$.
3. Total the contribution by each major type and choose a forage category for use in Table 4 through Table 7 (pages 10-17).
Corn Silage ~35%
Leg, MML ~65%
4. For this example, a forage ration with 25% corn silage and 75% mix mainly legume forage would best apply since corn silage is being fed somewhat higher than the 25% figure, and slightly more protein and calcium would be needed than for a ration with 75% legume forage.

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Table 1. Suggested maximum intakes for dairy cattle on various concentrate ingredients^a

<i>Item</i>	<i>Finished concentrate (% air-dried)</i>	<i>Total ration dry matter^b (% ingredient dry matter)</i>
Alfalfa, dehydrated	20	10
Animal protein blends	4.5	3
Apple pomace w/no hulls, chips	20 (cows)	10
Apple pomace w/no hulls, chips	50 (heifers)	10
Barley ^c	0, 35p	0, 14p
Beet pulp	25, 40p	10, 16p
Beans, peas	15, 20p	6, 8p
Blood meal	3	2
Bread, bakery product	20	10
Buckwheat	10, 15p	4, 6p
Brewers grains, dry	20, 30p	8, 12p
Brewers grains, wet	45	22
Corn ^c	0, 35p	0, 14p
Corn screenings ^c	0, 35p	0, 14p
Candy	15	5
Corn gluten feed with urea	15	8
Corn gluten feed without urea	20, 30p	8, 12p
Corn gluten meal	12, 12p	6, 6p
Citrus pulp	25, 40p	10, 16p
Coconut meal	20, 25p	8, 10p
Cottonseed meal ^c	20	8
Distillers grains, dry	25, 35p	10, 14p
Distillers grains, wet	35	17
Fats, oils	3.5	2
Fish meal	3	2
Hominy	40, 35p	16, 14p
Malt sprouts	10, 15p	4, 6p
Milo, sorghum	30, 40p	15, 20p
Molasses	10	3
Oats ^c	0, 40p	0, 16p
Peanut meal	10, 15p	4, 6p
Peanut skins	15	6
Potato waste	25	10
Rye ^c	10, 15p	4, 6p
Soyhulls	25	10
Soybeans, screenings	20	10
Spelt	20, 35p	8, 14p
Starch, as ingredient	25	12
Triticale	20, 35p	8, 14p
Urea: concentrate mix	1.5	0.60
Urea: TMR	2.0	1.00
Wheat ^c	20, 35p	8, 14p
Wheat bran	25, 35p	12, 15p
Wheat middlings	15, 20p	7, 10p
Total mineral ingredients	5, 6p	2.5, 3p
Total starchy ingredients	0, 35p	0, 14p
Whole cottonseed ^d	20	10

^aWhen two maximums are listed, the first refers to a meal-type finished feed, and the second (p) is given for use in a pelleted feed or as a heat-processed ingredient.

^bRefers to a percentage of ingredient dry matter as a percentage of total ration dry matter (TRDM).

^cThe "0" given for some ingredients indicates that there is no maximum for use in a meal or non-heat treated form. Heat-treatment via pelleting, steam rolling, steam crimping, extrusion, steam flaking, or roasting may depress milk fat test by .1 to .3 percent.

^dDo not use in rations for calves under four to six months old.

Table 2. Concentrate ingredients and their expected analysis (dry matter basis)

	Percent															
	DM	CP	UIP*	SP*	ADF	NDF	NFC	Fat	Ash	TDN	NEL	Ca	P	Mg	K	S
Animal protein blend	94.0	69.1	66.0	6.9	1.6	2.1	0.0	7.0	21.8	77.0	.79	5.40	2.80	.53	.59	.64
Bakery product	92.0	11.0	20.0	30.0	7.0	16.0	55.9	12.7	4.4	89.0	.94	.14	.26	.18	.43	.14
Barley	89.0	12.8	27.3	31.3	7.4	21.0	61.4	2.0	2.8	83.0	.87	.10	.38	.14	.57	.17
Blood meal	91.0	93.0	81.7	7.5	1.0	2.0	0.0	1.3	4.0	66.0	.68	.32	.25	.13	.20	.67
Brewers grain, dry	92.0	27.1	49.0	7.4	24.0	46.0	15.3	7.2	4.4	66.0	.68	.33	.57	.18	.10	.36
Brewers grain, wet	22.0	28.0	45.0	10.0	22.0	49.0	11.2	7.3	4.4	66.0	.68	.32	.57	.18	.10	.36
Candy	94.0	5.2	15.0	60.0	0.0	0.0	66.6	22.4	5.8	104.0	1.10	.10	.17	.10	.37	.13
Canola	92.5	40.8	23.0	27.9	22.0	28.0	19.8	4.0	7.4	74.5	.77	.76	1.25	.60	1.40	.29
Chocolate	95.0	12.9	20.0	50.0	3.5	4.7	30.4	48.7	3.3	122.0	1.30	.10	.17	.10	.37	.13
Corn, ear	87.0	9.0	65.6	15.6	11.0	25.0	60.4	3.7	1.9	78.5	.81	.05	.27	.12	.53	.13
Corn, shelled	88.0	10.0	52.0	12.0	3.0	9.0	75.0	4.3	1.6	87.6	.90	.01	.31	.12	.40	.12
Cottonseed meal	91.0	45.6	43.0	22.0	19.0	26.0	19.8	1.6	7.0	76.0	.79	.20	1.21	.55	1.39	.34
Cottonseed, whole	90.0	22.0	35.0	33.0	38.0	48.0	7.5	18.0	4.5	94.0	.98	.16	.60	.37	1.20	.26
Distillers, dark	91.0	29.0	46.9	15.2	19.0	44.0	11.2	11.0	4.8	88.0	.93	.24	.84	.34	1.00	.41
Distillers, light	92.0	29.0	54.0	15.0	17.0	43.0	17.1	8.5	2.4	86.0	.90	.11	.43	.08	.18	.46
Donuts	82.0	8.0	20.0	50.0	.3	.4	64.8	25.6	1.2	108.0	1.10	.10	.10	.32	.78	.02
Fats and oils	99.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	177.0	2.65	0.0	0.0	.00	0.0	.00
Fishmeal, menhaden	92.0	66.7	60.0	12.0	1.1	1.5	.5	10.5	20.8	73.0	.76	5.65	3.16	.16	.76	.49
Gluten feed	90.0	23.0	25.2	52.0	12.0	40.0	27.0	3.0	7.0	83.0	.87	.06	.87	.38	1.10	.36
Gluten meal	90.0	67.2	55.0	5.1	5.0	14.0	14.5	2.5	1.8	89.0	.94	.05	.66	.10	.35	.72
Hominy	90.0	11.5	65.2	20.9	10.0	24.0	55.4	6.0	3.1	87.0	.91	.05	.51	.22	.61	.10
Meat and bone meal	93.0	54.1	49.0	14.8	0.0	0.0	4.0	10.4	31.5	71.0	.74	9.50	4.70	.25	.49	.45
Oats	89.0	13.0	16.9	26.9	16.0	31.0	47.5	4.9	3.6	77.0	.80	.10	.41	.15	.53	.19
Rye	88.0	13.8	18.8	28.3	4.0	14.0	68.6	1.7	1.9	84.0	.88	.07	.37	.14	.52	.17
Sorghum	89.0	10.4	54.8	12.5	9.0	18.0	66.3	3.2	2.1	80.0	.84	.04	.34	.18	.40	.18
Soybean meal, 44%	90.0	50.0	35.0	20.0	10.0	14.0	27.3	1.4	7.3	84.0	.88	.30	.68	.30	2.12	.37
Soybean meal, 48%	90.0	54.5	35.0	20.0	6.0	8.0	30.0	1.0	6.5	87.0	.91	.29	.70	.32	2.28	.48
Soybeans, cooked	90.0	41.8	50.0	17.0	11.0	13.8	21.0	18.3	5.1	94.0	.99	.28	.65	.26	1.89	.38
Soybeans, raw	90.0	41.8	26.0	40.0	10.0	13.0	21.3	18.8	5.1	91.0	.96	.28	.65	.26	1.89	.38
Soyhulls	90.0	12.1	29.8	19.8	50.0	67.0	13.5	2.3	5.1	77.0	.80	.59	.21	.27	1.34	.11
Urea 45%	99.0	283.8	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.00	0.0	.00
Wheat	89.0	11.3	23.9	23.0	4.0	14.0	70.2	1.9	2.6	85.0	.89	.07	.36	.13	.46	.16
Wheat midds	89.0	18.0	21.0	40.0	10.0	37.0	35.3	4.5	5.2	69.0	.71	.13	.99	.40	1.13	.20

*% of CP

Table 3. Nutrient specifications of forages used to develop Tables 4 through 7

	<i>LEG^a</i>	<i>MML^a</i>	<i>GRA^a</i>	<i>MMG^a</i>	<i>Corn silage</i>
<i>Dry matter basis</i>					
Crude protein, %	19.0	17.5	11.0	13.0	8.0
TDN, %	59.0	56.0	54.0	55.0	68.0
NEL, Mcal/lb	.60	.57	.55	.56	.69
Calcium, %	1.30	1.10	.65	.81	.25
Phosphorus, %	.29	.29	.27	.27	.23
Magnesium, %	.25	.24	.19	.21	.18
Sulfur, %	.29	.27	.25	.24	.13

^a Forages: LEG=legume, MML=mixed mainly legume, GRA=grass, and MMG=mixed mainly grass

Table 4. Suggested nutritional specifications for finished feeds for milk cows on air-dried basis

(Note: This table is designed to serve as a guide pending forage testing and ration formulation)

Forage rations^a

	All MML 3/4 LEG 1/4 CS	All MMG 3/4 MML 1/4 CS	All GRA 1/2 LEG 1/2 CS 1/2 MML 1/2 CS 3/4MMG 1/4 CS	1/4 LEG 3/4 CS 1/2 MMG 1/2 CS	1/4 MML 3/4 CS 1/2 GRA 1/2 CS	1/4 MMG 3/4 CS 1/4 GRA 3/4 CS	All CS	All LEG
<i>Concentrate:</i>								
Crude protein, %	14	16	18	20	22	24	26	12
ADF, % min	-	-	-	-	-	-	-	-
TDN, % min	66	66	66	66	66	66	66	66
NEL, Mcal/lb min	.68	.68	.68	.68	.68	.68	.68	.68
Calcium, % ^b	-	.40	.50	.75	.75	.90	1.15	-
Phosphorus, % ^b	.42	.42	.42	.42	.42	.45	.49	.42
Magnesium, % ^b	.22	.25	.25	.28	.30	.31	.31	.20
Sulfur, %	.18	.21	.24	.26	.28	.29	.33	.16
Salt, %	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.00
Manganese, ppm	30	30	32	33	38	38	46	26
Copper, ppm	14	14	17	18	18	18	20	13
Zinc, ppm	117	117	144	153	153	153	167	113
Iron, ppm	44	44	44	44	44	44	44	44
<i>Added:</i>								
Selenium, ppm ^c	.60	.60	.60	.60	.60	.63	.63	.60
Cobalt, ppm	.40	.40	.40	.40	.40	.46	.50	.40
Iodine, ppm	1.00	1.00	1.00	1.00	1.00	1.15	1.25	1.00
Vitamin A IU/lb	3600	3600	3800	3800	4000	4000	5000	3600
Vitamin D IU/lb ^d	1800	1800	1900	1900	2000	2000	2500	1800
Vitamin E IU/lb	25	25	27	27	28	28	35	25

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages (See Table 3): LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bIf added fat from oilseeds or inert sources are included in the grain mix, increase the level of calcium by .30%, phosphorus by .10%, and magnesium by .09%.

^cSelenium is added to provide .30 ppm to the total ration dry matter.

^dMaximum vitamin D content should not exceed the level given by more than 1000 units per lb of air-dried or "as-fed" concentrate mixture.

Table 5. Suggested nutritional specifications for finished feeds for dry cows on air-dried basis
(Note: This table is designed to serve as a guide pending forage testing and ration formulation)

Forage rations^a

	3/5 MML 2/5 CS 1/3 LEG 2/3 CS 2/5 LEG 3/5 GRA 1/2 MML 1/2 GRA	All MMG 1/3 MMG 2/3 GRA	All GRA 2/3 MMG 1/3 CS	2/3 GRA 1/3 CS	All CS ^b
<i>Concentrate:</i>					
Crude protein, %	9	14	20	22	34
TDN, % min	66	66	66	66	66
NEL, Mcal/lb min	.68	.68	.68	.68	.68
Calcium, %	.18	.21	.25	.66	2.09
Phosphorus, %	.50	.50	.54	.48	.73
Magnesium, %	.25	.34	.35	.36	.46
Potassium, %	.48	.70	.95	1.00	1.60
Sulfur, %	.12	.16	.21	.23	.49
Salt, %	1.46	1.46	1.46	1.46	1.9
Manganese, ppm	96	96	96	96	130
Copper, ppm	32	32	32	32	49
Zinc, ppm	275	275	275	275	375
Iron, ppm	156	156	156	156	255
<i>Added:</i>					
Selenium, ppm ^c	1.73	1.73	1.73	1.73	2.30
Cobalt, ppm	1.12	1.12	1.12	1.12	1.64
Iodine, ppm	2.80	2.80	2.80	2.80	4.10
Vitamin A IU/lb	8600	8600	8600	8600	10600
Vitamin D IU/lb ^d	3300	3300	3300	3300	4200
Vitamin E IU/lb	150	150	150	150	182

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages: LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bRestrict intakes of corn silage when it is the sole source of forage for dry cows to avoid obesity and health complications.

^cSelenium is added to provide .30 ppm to the total ration dry matter.

^dMaximum vitamin D content should not exceed the level given by more than 1000 units per lb of air-dried or "as-fed" concentrate mixture.

Table 6.1. Example concentrate mixtures for milking cows fed various forage rations

<i>Forage rations^a:</i>		All LEG				All MML		
						3/4 LEG		1/4 CS
<i>Concentrate:</i>	12% CP	12% CP	12% CP	12% CP	14% CP	14% CP	14% CP	14% CP
<i>Ingredients (lb/cwt):</i>								
Ear or shelled corn	83.4	69.5	78.9	80.2	78.5	64.6	71.8	74.2
Oats or barley	-	15.0	-	-	-	15.0	-	-
Brewers or distillers	-	-	8.0	-	-	-	12.0	-
Soybean meal, 48%	9.2	8.2	5.6	3.6	14.2	13.1	8.8	5.7
Cooked soybeans	-	-	-	8.0	-	-	-	12.0
Molasses ^b	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Plain salt	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
P.S. Trace min #4 ^c	.17	.16	.17	.17	.17	.17	.17	.17
Ground limestone	-	-	-	-	-	-	-	-
Dical phos 23 Ca 18P	.73	.67	.74	1.27	.63	.57	.65	1.15
Magnesium oxide	.12	.12	.14	.28	.13	.13	.14	.30
Dynamate 22% S	.07	.04	-	.07	.08	.06	-	.08
Selenium .06%	.10	.10	.09	.10	.10	.10	.09	.09
ADE 2.5M 1M 2.5T/lb ^d	.18	.18	.18	.18	.18	.18	.18	.18
Vitamin E 20T/lb	.09	.09	.09	.09	.09	.09	.09	.09

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages: LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bPart or all of the liquid molasses may be replaced by an equal amount of low-protein grain without appreciably altering nutrient content.

^cPenn State Trace Mineral Premix #4 as available from some concerns. Formula specifications available on request. Trace mineral salt may be at least temporarily substituted at a level equal to salt and PSTM #4 combined.

^dAssumed vitamin premix contains 2.5 million units of vitamin A, 1 million of vitamin D₃, and 2500 units of vitamin E per pound. Others may be substituted at levels which provide approximately the same amounts of vitamin A and E and the same level of vitamin D per pound of finished feed.

Table 6.2. Example concentrate mixtures for milking cows fed various forage rations

<i>Forage rations^a:</i>		ALL MMG 3/4 MML 1/4 CS				ALL GRA 1/2 LEG 1/2 CS 1/2 MML 1/2 CS 3/4 MMG 1/4 CS			
		16% CP	16% CP	16% CP	16% CP	18% CP	18% CP	18% CP	18% CP
<i>Concentrate:</i>									
<i>Ingredients (lb/cwt):</i>									
Ear or shelled corn	73.1	59.2	64.8	67.4	67.8	53.9	59.5	62.2	
Oats or barley	-	15.0	-	-	-	15.0	-	-	
Brewers or distillers	-	-	15.0	-	-	-	15.0	-	
Soybean meal, 48%	19.2	18.2	12.5	8.7	24.2	23.2	17.6	13.7	
Cooked soybeans	-	-	-	15.0	-	-	-	15.0	
Molasses ^b	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Plain salt	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
P.S. Trace min #4 ^c	.17	.16	.17	.17	.21	.21	.21	.22	
Ground limestone	.34	.36	.36	.34	.60	.62	.59	1.05	
Dical phos 23 Ca 18P	.53	.48	.56	1.05	.44	.38	.47	.96	
Magnesium oxide	.16	.16	.21	.33	.13	.13	.18	.30	
Dynamate 22% S	.15	.12	.03	.15	.21	.18	.09	.21	
Selenium .06%	.09	.09	.09	.09	.09	.09	.09	.09	
ADE 2.5M 1M 2.5T/lb ^d	.18	.18	.18	.18	.19	.19	.19	.19	
Vitamin E 20T/lb	.09	.09	.08	.09	.10	.10	.09	.10	

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages: LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bPart or all of the liquid molasses may be replaced by an equal amount of low-protein grain without appreciably altering nutrient content.

^cPenn State Trace Mineral Premix #4 as available from some concerns. Formula specifications available on request. Trace mineral salt may be at least temporarily substituted at a level equal to salt and PSTM #4 combined.

^dAssumed vitamin premix contains 2.5 million units of vitamin A, 1 million of vitamin D₃, and 2500 units of vitamin E per pound. Others may be substituted at levels which provide approximately the same amounts of vitamin A and E and the same level of vitamin D per pound of finished feed.

Table 6.3. Example concentrate mixtures for milking cows fed various forage rations

Forage rations ^a		1/4 LEG 3/4 CS				1/4 MML 3/4 CS			
		1/2 MMG 1/2 CS				1/2 GRA 1/2 CS			
Concentrate:	20% CP	20% CP	20% CP	20% CP		22% CP	22% CP	22% CP	22% CP
<i>Ingredients (lb/cwt):</i>									
Ear or shelled corn	62.0	48.2	51.0	50.9		57.1	43.2	46.1	43.2
Oats or barley	-	15.0	-	-		-	15.0	-	-
Brewers or distillers	-	-	20.0	10.0		-	-	20.0	15.0
Soybean meal, 48%	29.3	28.3	20.4	14.4		34.3	33.3	25.4	17.1
Cooked soybeans	-	-	-	15.0		-	-	-	15.0
Molasses ^b	5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0
Plain salt	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
P.S. Trace min #4 ^c	.23	.22	.23	.23		.23	.22	.22	.22
Ground limestone	1.27	1.29	1.26	1.72		1.30	1.32	1.29	1.74
Dical phos 23 Ca 18P	.35	.29	.39	.89		.25	.22	.29	.80
Magnesium oxide	.16	.17	.24	.37		.18	.18	.26	.41
Dynamate 22% S	.23	.20	.07	.15		.25	.22	.09	.13
Selenium .06%	.09	.09	.08	.09		.09	.09	.08	.08
ADE 2.5M 1M 2.5T/lb ^d	.19	.19	.19	.19		.20	.20	.20	.20
Vitamin E 20T/lb	.10	.10	.09	.09		.11	.11	.10	.10

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages: LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bPart or all of the liquid molasses may be replaced by an equal amount of low-protein grain without appreciably altering nutrient content.

^cPenn State Trace Mineral Premix #4 as available from some concerns. Formula specifications available on request. Trace mineral salt may be at least temporarily substituted at a level equal to salt and PSTM #4 combined.

^dAssumed vitamin premix contains 2.5 million units of vitamin A, 1 million of vitamin D₃, and 2500 units of vitamin E per pound. Others may be substituted at levels which provide approximately the same amounts of vitamin A and E and the same level of vitamin D per pound of finished feed.

Table 6.4. Example concentrate mixtures for milking cows fed various forage rations

Forage rations ^a :	1/4 MMG 3/4 CS				All CS			
	24% CP	24% CP	24% CP	24% CP	26% CP	26% CP	26% CP	26% CP
<i>Concentrate:</i>								
<i>Ingredients (lb/cwt):</i>								
Ear or shelled corn	51.7	37.8	40.7	37.8	45.6	31.7	34.5	39.9
Oats or barley	-	15.0	-	-	-	15.0	-	-
Brewers or distillers	-	-	20.0	15.0	-	-	20.0	-
Soybean meal, 48%	39.4	38.3	30.5	22.2	44.5	43.5	35.6	34.0
Cooked soybeans	-	-	-	15.0	-	-	-	15.0
Molasses ^b	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Plain salt	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1
P.S. Trace min #4 ^c	.22	.22	.22	.22	.25	.24	.24	.25
Ground limestone	1.62	1.64	1.61	2.07	2.2	2.2	2.1	2.6
Dical phos 23 Ca 18P	.32	.26	.36	.87	.45	.40	.49	.97
Magnesium oxide	.19	.19	.26	.41	.15	.15	.23	.32
Dynamate 22% S	.22	.19	.06	.10	.33	.30	.17	.33
Selenium .06%	.09	.09	.08	.08	.10	.10	.09	.10
ADE 2.5M 1M 2.5T/lb ^d	.20	.20	.20	.20	.25	.25	.25	.25
Vitamin E 20T/lb	.11	.11	.10	.10	.14	.14	.13	.13

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages: LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bPart or all of the liquid molasses may be replaced by an equal amount of low-protein grain without appreciably altering nutrient content.

^cPenn State Trace Mineral Premix #4 as available from some concerns. Formula specifications available on request. Trace mineral salt may be at least temporarily substituted at a level equal to salt and PSTM #4 combined.

^dAssumed vitamin premix contains 2.5 million units of vitamin A, 1 million of vitamin D₃, and 2500 units of vitamin E per pound. Others may be substituted at levels which provide approximately the same amounts of vitamin A and E and the same level of vitamin D per pound of finished feed.

Table 7. Example formulas for finished concentrate mixtures for dry cows

	3/5 MML 2/5 CS 1/3 LEG 2/3 CS 2/5 LEG 3/5 GRA		All MMG		All GRA	
<i>Forage rations:</i> ^a	1/2 MML 1/2 GRA		1/3 MMG 2/3 GRA		2/3 MMG 1/3 CS	
<i>Concentrate:</i>	9% CP	9% CP	14% CP	14% CP	20% CP	20% CP
<i>Ingredients (lb/cwt):</i>						
Ear or shelled corn	88.4	74.5	76.0	62.1	61.1	47.2
Oats or barley	-	15.0	-	15.0	-	15.0
Soybean meal, 48%	2.2	1.1	14.6	13.6	29.5	28.5
Molasses ^b	5.0	5.0	5.0	5.0	5.0	5.0
Plain salt	1.46	1.46	1.46	1.46	1.46	1.46
P.S. Trace min #4 ^c	.47	.47	.46	.45	.47	.46
Ground limestone	-	-	-	-	-	-
Dical phos 23 Ca 18P	-	-	-	-	-	-
Monosodium phos 26P	.93	.89	.76	.72	.71	.67
Magnesium oxide	.25	.24	.37	.37	.34	.34
Dynamate 22% S	-	-	-	-	-	-
Selenium .06%	.28	.29	.28	.28	.28	.28
ADE 2.5M 1M 2.5T/lb ^d	.33	.33	.33	.33	.33	.33
Vitamin E 20T/lb	.70	.70	.70	.70	.70	.70
<i>Forage rations:</i>	2/3 GRA 1/3 CS		All CS			
<i>Concentrate:</i>	22% CP	22% CP	34% CP	34% CP		
<i>Ingredients (lb/cwt):</i>						
Ear or shelled corn	55.8	41.7	19.0	-		
Oats or barley	-	15.0	-	20.7		
Soybean meal, 48%	34.5	33.5	65.6	64.0		
Molasses ^b	5.0	5.0	5.0	5.0		
Plain salt	1.46	1.46	1.90	1.90		
P.S. Trace min #4 ^c	.45	.44	.62	.61		
Ground limestone	.70	.72	3.60	3.66		
Dical phos 23 Ca 18P	.59	.54	1.47	1.37		
Magnesium oxide	.34	.34	.28	.28		
Dynamate 22% S	-	-	.76	.73		
Selenium .06%	.28	.28	.37	.37		
ADE 2.5M 1M 2.5T/lb ^d	.33	.33	.42	.42		
Vitamin E 20T/lb	.70	.70	.85	.85		

^aCombinations are given on a dry matter basis. Average analyses were used for the respective forages: LEG=Legume; MML=Mixed mainly legume; MMG=Mixed mainly grass; GRA=Grass; CS=Whole-plant corn silage

^bPart or all of the liquid molasses may be replaced by an equal amount of low-protein grain without appreciably altering nutrient content.

^cPenn State Trace Mineral Premix #4 as available from some concerns. Formula specifications available on request. Trace mineral salt may be at least temporarily substituted at a level equal to salt and PSTM #4 combined.

^dAssumed vitamin premix contains 2.5 million units of vitamin A, 1 million of vitamin D₃, and 2500 units of vitamin E per pound. Others may be substituted at levels, which provide approximately the same amounts of vitamin A and E, and the same level of vitamin D per pound of finished feed.