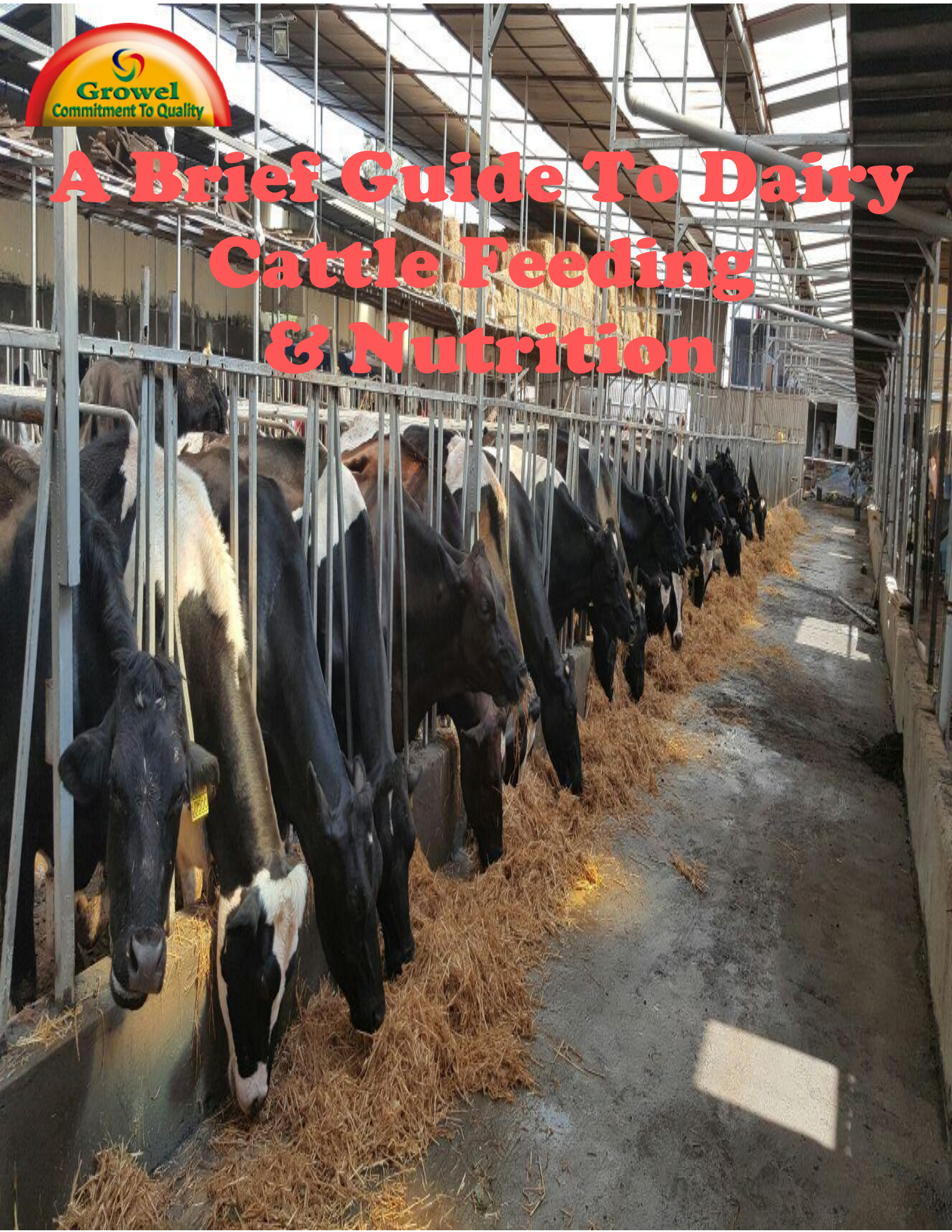

Growel
Commitment To Quality
A Brief Guide To Dairy Cattle Feeding & Nutrition

DAIRY CATTLE NUTRITION AND FEEDING

FEEDING DAIRY CALVES

1. **General**

   A. On a commercial scale, necessary to separate newborn calves form their dams as soon as possible. Essentially, no space for calves in milking system/facilities!
   B. Fresh cows need special nutrition and feeding facilities to maximize their milking ability, thus calves can be housed more efficiently in separate facilities.
   C. Health and vigor of calves at birth depend on the nutrition of the cow during the last 60 days or so of gestation; Developing about 70% of birth wt of the calf during that time.
   D. Colostrum:

      1) Not only provide antibodies that a newborn calf lacks, but also "laxative" to help starting digestive functions.
      2) Under commercial conditions, calves rarely receive colostrum from their own dams, but no apparent difference in the effectiveness among "fresh, frozen/thawed, and fermented" colostrum, so . . .

2. **Birth to 4 Months of Age**

   A. Newborn calves have all the necessary organs associated with the ruminant digestive system, but their processes are similar to nonruminant species.
   B. The rumen is not populated with the typical microbes until close to 60 d of age, thus necessary to provide milk/milk replacer in the beginning.
   C. Common feeds for calves? - Including colostrum, whole milk replacers, and calf starters along with hay or pasture.

      1) Colostrum - Depends, but a calf may be left with its dam less than 24 hr, and then placed on one of several milk feeding programs.
      2) Whole milk - An excellent feed, but too expensive, especially in areas where a good milk market exists.
      3) Milk replacers - See the table:

Milk replacer (Aseltine, 1998)

Nutrient	Recommendation
Crude protein, %	22.0
Ether extract, %	10.0
Calcium, %	0.70
Phosphorus, %	0.60
Magnesium,%	0.07
Potassium,%	0.65
Sodium, %	0.10
Sulfur, %	0.29
Iron, ppm	100
Cobalt, ppm	0.10
Copper, ppm	10
Manganese, ppm	40
Zinc, ppm	40
Iodine, ppm	0.25
Selenium , ppm	0.30
Vitamin AIU/lb	1,730
Vitamin D, IU/lb	273
Vitamin E, IU/lb	18

* Should be considered as minimums. Many commercial products exceed the NRC on certain nutrients

      a) High milk by-product feeds that are sold as a powder and reconstituted with water for feeding.
      b) High-quality milk replacer should be used for, at least, the first 3 wk.
      c) Perhaps, too complex to mix at home, thus may want to purchase!?

d) A typical milk replacer contains dried skim milk or whey or both with 10 to 30% animal fat for energy and also contains supplemental vitamins, trace minerals, and antibiotic(s).

4) Calf starters:

a) At about 1 wk of age, calves should be offered a starter ration.
b) Starter rations - High-energy, high-protein (16 to 20%), and low-fiber grain mixes fed to young calves (Table).
c) Usually, based on corn and SBM, with added oats for bulk and palatability?
d) Usually, added Ca, P, trace minerals, and salt.
e) Low doses of antibiotic (10 mg/1b starter) may improve appetite, whereas therapeutic doses (100 to 500 mg/day) can combat scours.
f) Grains should be rolled or coarsely ground.

Suggested calf starter rations[a,b] (Jurgens, 2002)

	1	2	3	4	5	6
Ingredient, %						
Corn, rolled	50	39	54	50	34	28
Oats, rolled	35	-	12	26	34	30
Barley, rolled	-	39	-	-	-	-
Beet pulp	-	-	-	-	-	20
Corn cobs, gr.	-	-	-	-	14	-
Wheat bran	-	10	11	-	-	-
Soybean meal	13	10	8	17	16	15
Linseed meal	-	-	8	-	-	-
Molasses, liquid	-	-	5	5	-	5
Oicalcium phosphate	1	1	1	1	1	1
TM salt & vitamin[c]	1	1	1	1	1	1
	100	100	100	100	100	100
Calculated analysis;						
As-fed basis						
Crude protein, %	14.5	14.0	14.5	15.4	14.7	14.8
TDN, %	73.1	73.0	72.5	72.9	68.2	70.5
NEm, Mcal/kg	1.83	1.76	1.80	1.83	1.68	1.75
NEg, Mcal/kg	1.25	1.19	1.22	1.25	1.11	1.19
Calcium, %	0.29	0.29	0.35	0.34	0.32	0.45
Phosphorus, %	0.54	0.61	0.64	0.54	0.52	0.49
Dry matter, %	88.5	88.4	87.8	87.8	88.9	88.5
Dry matter basis						
Crude protein,%	16.4	15.8	16.5	17.5	16.5	16.7
TDN, %	82.6	82.6	82.5	83.0	76.7	79.7
NEm, Mcal/kg	2.07	1.99	2.05	2.08	1.89	1.98
NEg, Mcal/kg	1.41	1.35	1.39	1.42	1.25	1.34
Calcium, %	0.33	0.33	0.40	0.39	0.36	0.51
Phosphorus, %	0.61	0.69	0.73	0.61	0.58	0.55

[a]Formulations are on an as-fed basis. Rations I, 2, 3, and 4 recommended for calves weaned after 4 weeks of age and receiving forage. Rations 5 and 6 recommended for calves weaned after 4 weeks and not receiving forage.
[b]Calf starter should be fed from about 3 days of age until 12 weeks of age. Intake should be limited to about 3 to 4 Ib (1.4 to 1.8 kg) per calf daily.
[c]Vitamin premix should supply the following per pound (or kg) of ration: vitamin A, 2,000 IU (900) & vitamin D, 500 IU (225).

B. Milk feeding programs - Two general types:

1) Liberal milk system:

a) Veal calves - Calves fed for veal are given maximum amounts of milk or milk replacer, and also many diets/ratios contain high concentrations of lipids to increase energy intake.
b) Herd replacements

(1) An expensive system, especially where milk is sold! But, calves do quite well. In addition to milk, grain & salt would be fed/provided.
(2) Feed 8 to 10% of body wt (or an equivalent amount of milk replacer) until 3 to 4 mo of age.

2) Limited milk system

a) Conventional system

(1) Feed milk, milk replacer, or stored colostrum at 8 to 10% of body wt until they start consuming 2 to 3 lb starter/day, at which time "milk feeding" can be decreased & no milk by 4 to 7 wk of age.
(2) Start feeding hay at 1 wk of age. Or, perhaps, delay feeding hay until l mo of age to encourage early starter consumption.
(3) Most economical under the midwest conditions, i.e., abundant grain supply and generally good milk prices.

b) Early weaning

(1) Off milk entirely by 1 mo of age. Requires good management practices and early adjustment to starter feeding.
(2) Calves may not appear as thrifty at 1 mo of age, but may look no different vs. others at 3 to 4 mo of age.
(3) Suggested milk feeding program? - 4-6, 5-7, and 3-4 lb milk/d for 0-3, 4-24, and 25-31 d of age, respectively.
(4) At the time of weaning, in addition to milk, should be consuming "dry feed" at the rate of 1.5% of body wt.

C. Calf scours?

1) A major concern for calves before weaning.
2) With a mild case [i.e., not off-feed, depressed, and(or) no fever], providing an oral electrolyte solution usually may be beneficial.
3) Remove or substantially reduce the amount of milk or milk replacer offered?

a) Recommended practice by some, but others insist calves should be fed a usual amount of milk replacer!
b) Provide/feed electrolytes 3-6 times depending on how soon feces become firm. A 100-lb calf should consume about 5 qt (10% of body wt) daily?

D. Hay or silage for the young calf

1) May start nibbling a good quality hay as early as 5 to 10 days of age, but will not consume appreciable quantities before 8 to 10 wk of age.
2) Inconvenient to feed forages?

a) May want to incorporate a forage factor (i.e., fiber) into the starter ration (20 to 25%)?
b) Adequate fiber is essential for proper health of the rumen papillae and calves will crave roughage.

3) Silages should be limited before 3 mo of age because of the moisture content.

FEEDING HEIFERS, BULLS, AND DAIRY BEEF

1. **Four to 12 Months of Age**

A. If heifers are properly introduced to solid feeds before weaning, a growing ration can be changed gradually so that they reach puberty at 15 mo of age.

B. Rumen capacity? - Not sufficient for the animal to satisfy the energy need from forages alone, thus feeding some grain is necessary until l yr of age.

1) Summer - Pasture, hay, and grain mix (3-7 1b/d depending on body size and forage quality)?
2) Winter - Hay, silage, and grain mix (3 - 71b/d depending on body size and forage quality)?

C. The same forage and grain mix used for the milking herd can be used for heifers.

1) Should vary "inversely" the protein content between the grain mix & forage.
2) A free-choice mineral mix is recommended. Should include Ca, P, salt, and trace minerals with a poor forage.
3) Suggested grain mixes for the growing calf? - Should be limited to no more than 5 to 7 lb daily along with free-choice forage consumption (Table).

Suggested grower rations for 440-1b (200-kg) dairy calves (4-12 months of age)[a,b] [Jurgens, 2002]

Ingredients	1	2	3	4
Ingredient, %				
Corn, cracked	78	-	-	50
Oats, rolled	20	35	-	27
Barley, rolled	-	50	-	-
Gr. ear corn	-	-	76	-
Molasses, liquid	-	5	5	-
Soybean meal	-	8	17	20
Limestone	-	-	-	1
Dicalcium phosphate	1	1	1	1
Trace mineral salt	1	1	1	1
	100	100	100	100
Calculated ana/ysis:				
As-fed basis				
Crude protein, %	9.2	13.8	13.9	16.7
TDN, %	74.9	70.0	71.1	72.8
NEm,Mcal/kg	1.87	1.71	1.84	1.82
NEg,Mcal/kg	1.29	1.16	1.27	1.25
Calcium, %	0.25	0.33	0.35	0.68
Phosphorus, %	0.48	0.56	0.49	0.56
Dry matter, %	87.9	88.4	86.7	88.6
Dry matter basis				
Crude protein, %	10.5	15.6	16.0	18.8
TDN, %	85.2	79.2	82.0	82.2
NEm, Mcal/kg	2.13	1.93	2.12	2.05
NEg, Mcal/kg	1.47	1.31	1.46	1.41
Calcium, %	0.28	0.37	0.40	0.77
Phosphorus, %	0.55	0.63	0.56	0.63

[a]Formulations are on an as-fed t-asis. Ration 1 is recommended to be fed with legume hay (14-17% CP). Rations 2 and 3 should be fed with a legume-grass mixed hay (10-13% CP). Ration 4 is recommended to be fed with a grass hay (6-9% CP).
[b]Dairy calves should consume daily: 2.0 to 2.5% of their body weight as dry matter forage and 0.5 to 1.0% as dry matter grain mix.

D. Excess fat? If necessary, limit grain to keep calves from becoming too fat.

1) Excess fat can develop breeding problems.
2) Also, produce less in later life vs. those reared on a more moderate nutrition possibly because of excess fatty tissues in the udder.

2. **From 12 Months of Age to Calving**

A. Should have sufficient rumen capacity to meet their nutrient needs from good quality forages.

1) Should be gaining 1.5 to 1.8 1b per day.
2) Feed grain mix only when/if forages are poor or limited in amount.
3) Summer? - Use pasture and(or) hay, and feed 2 to 8 lb of grain mix if necessary (. . . depending on the body size).
4) Winter? - Use hay and silage, and also feed 2 to 8 lb of grain mix if necessary (. . . depending on body size).
5) Provide minerals free-choice. Include Ca, P, & salt, and trace minerals if feeding poor forages.

B. To breed at 15 mo, heifers should be weighing 550 (Jerseys) to 800 lb (Holstein and Brown Swiss). Should gain about 1.75 lb/day from birth!?
C. Growing heifers use available nutrients in an irreversible order: 1) Daily maintenance, 2) growth, and 3) ovulation and conception.
D. Avoid over-conditioning to prevent impairment of reproductive efficiency and also reduced milk production because of fatty deposits in the udder.
E. Some management techniques for early conception?

1) "Flushing" - Increase the intake of all the nutrients to heifers with appropriate age.
2) "Bypass protein" - Use during the first breeding period?
3) "Proteinated trace minerals" - May improve the breeding efficiency.
4) "Ionophores" - Not only reduce waste caused by methane production (& also acting as coccidiostats?) but also spare intake protein by reducing ruminal ammonia production.

F. Nutrition of bred heifers:

1) Feeding to about 60 days before the expected calving date? Should aim for growth, yet avoid excess fat deposition, especially in the udder.
2) The last 60 days of gestation or transition period? Start feeding a grain mix and increase gradually to adapt heifers to high grain intake, which will be necessary for lactation after calving. By doing so:

a) Can adjust the rumen population to increase microbes that ferment specific feeds in a lactation ration.
b) Can increase nutrient intakes to increase body reserves necessary to support early lactation . . . plus own growth.
c) Can provide for the increased demand for nutrients because of rapidly developing fetus.

3. **Feeding Bulls**

A. Bull calves for breeding purposes?

1) Because of today's widespread use of artificial insemination, only a few dairy bull calves are raised for breeding purposes.

2) Should be fed and handled much the same way as heifers, but bulls grow faster than heifers, thus should receive more feed.

B. Older bulls:

1) Should be kept in thrifty, vigorous condition, but not too fat.
2) Mature bulls can be maintained on forage with about 0.5 lb of grain per 100 lb of body wt, if needed - The same grain ration as the one being fed to lactating cows.

4. **Feeding Dairy Breeds for Beef**

A. In the US, about 4 million Holstein steer calves are produced annually.
B. A small portion for veal, and the rest of calves are fed for the commercial beef market.
C. Calves not developed as replacement heifers or bulls are fed and marketed as beef.
D. Types of programs for finishing Holstein? Some e.g.:

1) Raised in hutches and small group pens, weaned along with replacement heifers, and then put on full feeding program.
2) Weaned calves going through an on-the-farm growing program before being put on a finishing program
3) Weaned calves going to the pasture before finishing.

E. Two most common finishing programs and market wt?

1) High-energy diet/light market wt - Full feed a high-grain diet from about 300 lb to market wt of 800 to 1,000 lb.
2) High-roughage/heavy market wt - Grown on roughages (corn or sorghum stalks, wheat or other excess pasture) to 600 to 800 lb, then feed a high-grain diet during a finishing period in the feedlot. Generally marketed at 1,150 to 1,400 lb.

FEEDING FOR MILK PRODUCTION

1. **General**

A. Milk and milk products:

1) In the American diet? Annual per capita consumption of about 280 kg of dairy products, and they supply about 75% of dietary Ca. Also, an important source of other nutrients, i.e., energy, protein, vitamins, and other minerals.
2) Other countries? Consumption could be 50 to 100% higher than the US in some countries, and world consumption is more than 100 kg per capita . . . even when including those countries with consumption of much less milk products.

B. In the US, about 9.5 million dairy cows, each producing an average of 7,500 kg milk/year.

C. Systems used in the US? The type of system used is partially dependent on the geographic area and availability of feedstuffs.

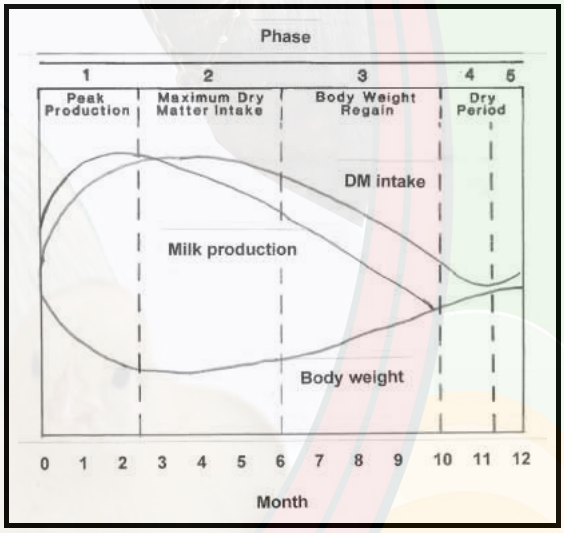
1) Pasture system - Traditional system is continuing in areas of sparse human population.
2) Drylot systems with minimum roughage and higher quantities of less bulky feeds such as concentrates - Being used in areas surrounding some of the larger cities.

D. Dairy cows need to consume a lot of feed/nutrients to achieve today's expected milk production, and feed represents about 50% of the total production costs.

1) Thus, feeding program, more than any other single factor, can determine the productivity of lactating dairy cows & profitability!?.
2) About 75% of the differences in milk production between cows is determined by environmental factors, with feed making up the largest portion.
3) At peak production, may require 3 to 10 times as much as protein & energy vs. late gestation, but the cow's appetite usually lags behind her nutritional needs.

2. **The lactation and Gestation Cycle**

A. The relationships among milk production, DM intake, and body wt changes [See the figure (Schingoethe, 1998)].
B. Milk production? - Increases rapidly and reaches peak 6-8 wk after calving.
C. Feed intake? - Lags behind milk production, i.e., maximum DM intake does not reach until 12 to 15 wk after calving.
D. Body reserves? - Make up the difference in the need & supply by mobilizing body stores. Often loose 90 to 135 kg of body wt!?



3. **Forages**

A. The cow cannot consume enough forage to meet her nutrient needs during lactation, even though they have a considerable capacity!

Forage quality	Daily intake (% BW)
Excellent	3.0
Good	2.5
Average	2.0
Fair	1.5
Poor	1.0

1) Daily intake for forages is estimated based on body wt and forage quality (Table - DM basis).
2) Allowed to consume all the forage at their will? Then, may not have enough room left to consume necessary grains to meet the energy needs of high milk production, thus limit forage intake to 1.75 to 2.0% of boy wt!?
3) Estimated silage intake (as-fed basis)? - 3 lb for each l lb of expected hay intake.

4) Pasture intake? - Usually, higher than silage at the same dry matter percentages.

B. Increase forage intake by feeding several times/day and providing a variety of forages?!

4. **Concentrates**

A. A concentrate mixture contains grains, mill feeds, protein supplements, and minerals (See the table for some examples).

1) The kind of mixture to feed will vary with the kind of forage fed (e.g., a high-protein mix will be needed with a low-protein forage), availability, and cost.

2) The amount of concentrate mix fed will depend on:

   a) The amount of forage consumed.
   b) The amount of milk produced.
   c) The composition (fat %) of the milk produced.

3) Limit % of concentrates to a maximum of about 60% regardless of comparative cost of grains and roughages.

4) Rations with more than 60% of concentrates may result in changes in proportion of ruminal VFA, which in turn can result in the reduction of milk fat.

Suggested concentrate mixtures for lactating dairy cows fed different quality forages[a] (Jurgens, 2002)

	High protein		Medium protein			Low protein	
	1	2	3	4	5	6	7
Ingredient							
Corn, gr.	-	70	-	-	-	50	-
Ground ear corn	92	-	85	74	78	-	61
Oats, gr. or rolled	-	28	-	-	-	-	-
Wheat bran	-	-	-	-	-	23	-
Molasses, liquid	-	-	-	-	-	-	6
Urea (281% CPE)[b]	-	-	1	-	-	-	-
Soybean mea1[c]	6	-	12	-	20	24	30
Soybeans,cracked	-	-	-	24	-	-	-
Dicalcium phosphate[d]	1	1	1	1	1	1	1
Limestone	-	-	-	-	-	1	1
TM salt & vitamin	1	1	1	1	1	1	1
	100	100	100	100	100	100	100
Calculated analysis:							
As-fed basis							
Crude protein, %	9.9	9.5	14.9	15.2	15.2	18.9	18.7
TDN, %	71.4	74.2	70.8	73.5	71.7	71.6	70.5
NEL, Mcal/kg	1.65	1.72	1.63	1.70	1.65	1.66	1.63
Calcium, %	0.29	0.25	0.30	0.34	0.32	0.70	0.76
Phosphorus, %	0.45	0.48	0.47	0.51	0.51	0.76	0.55
Dry matter, %	86.9	88.1	87.3	88.1	87.4	88.6	87.1
Dry matter basis							
Crude protein, %	11.4	10.8	17.1	17.2	17.4	21.3	21.4
TDN, %.	82.2	84.2	81.1	83.4	82.0	80.8	80.9
NEL, Mcal/kg	1.90	1.95	1.87	1.93	1.89	1.87	1.87
Calcium, %	0.33	0.28	0.34	0.38	0.37	0.79	0.87
Phosphorus, %	0.52	0.54	0.54	0.58	0.58	0.86	0.63

[a]Formulations are on an as-fed basis; [b]Urea may be included up to I% of the concentrate mix to supply protein; [c]Other high-protein feeds or commercial supplements can be substituted for soybean meal on a protein basis; [d]Other high Ca-P mineral mixes as steamed bone meal or commercial mixtures can replace dicalcium phosphate.

B. Intake of a concentrate mixture is affected by palatability and the time available to consume concentrates in the barn or milking parlor.

C. Depends, but tend to overfeed the low producer and underfeed the high producer?!

5. **Phase Feeding Program/Feeding Guidelines**

A. Feeding periods/phases can be divided into four or five - See "2. The Lactation and Gestation Cycle."

1) Phase 1 - First 10 wk of lactation. Peak milk production & body stores are being used to make up deficits in the nutrient intake.
2) Phase 2 - 10 to 20 wk or so of lactation. Maximum DM intake, and the intake is in balance with the needs?!
3) Phase 3 - The intake exceed the needs. The main period to restore body reserves for the next lactation.
4) Phases 4 & 5 - Dry period, and can be considered as only one phase, but:

    a) Phase 4 - Most of the dry period, and replete body reserves & regenerate secretory tissues for the next lactation.
    b) Phase 5 - The last 1 to 3 wk of pre-partum. Start increasing grain intake as a means to prepare the rumen for the increased nutritional demands?!

B. Dry period & bred heifers (Phases 4 & 5)

1) Cows need a short dry period as rest to prepare for the next lactation. The optimum dry period would be 6 to 8 wk!

    a) Shorter that 40 d? - Not enough time for udder regeneration, thus may reduce the production rate.
    b) Longer than 60 d? - Do not increase the production, and may result in excess body condition & calving difficulties.

2) Bred heifers

    a) Nutrient needs are slightly higher vs. dry cows of similar size - Still growing!
    b) Good-quality hay can provide all the nutrient needs during the early gestation.
    c) Need some grains along with forages during the last 3 to 4 mo of gestation to support growth & provide nutrients for fetus.
    d) As with dry cows, should be in good condition but not too fat at calving.

3) Quality of forage may not be as critical during the dry period, but cows need sufficient feed to support both the unborn calf and to meet body reserves not replaced in the previous period.
4) Nutrient needs can be met with only forages and no grain, but may be fed up to 4 to 6 lb of grain per day (0.5% of body wt) depending on the condition. (DM intake is approximately 2% of body wt!)
5) "Fat cow syndrome" - Feeding high levels of corn silage or grains may cause excess fat deposits in the liver area:

    a) Characterized by high blood lipids & fatty livers.
    b) May result in calving difficulties, displaced abomasum, ketosis, and others.
    c) Less likely to have problems with hay and(or) haylage vs. corn silage.

6) About 2 wk before calving, increase grain feeding, so cows are consuming 12 to 16 lb grain/day at calving (1% of body weight).

a) Helps cows get accustomed to high grain intake needed after calving, and can reduce the occurrence of ketosis during lactation.
b) Best to increase the amount of grains gradually, which may minimize the chance for milk fever. Most grain mixes have a more desirable Ca to P ratio?
c) Feed a low-Ca ration (< 0.20%, reduce Ca intake to 14 to 18 g/d) 2 wk before parturition to those with milk fever problems may be beneficial?!
d) Also, feed a diet with a negative dietary electrolyte balance (-10 to -15 mEQ/100 g DM) may alleviate milk fever problems!?

C. Peak milk production (Phase 1)

1) Cows should be brought into peak milk production as soon as possible after calving. Can be done by feeding slightly more grain than recommended until there is no increase in production & then adjusting the amount of grain accordingly.
2) Milk production increases rapidly, peaking at 6 to 8 wk after calving.
3) The most critical period for a dairy cow is "from parturition until peak milk production:"

a) Objective for this phase? - To increase feed intake as rapidly as possible!
b) Increase grain intake 1 to 2 lb per day after calving to meet the energy needs.
c) May want to avoid excessive grain (> 65% total DM) and maintain 17 to 19% acid detergent fiber in diet to reduce rumen disorders.
d) Extra dietary protein permits more efficient use of body fat for milk production because cows are usually losing body weight.
e) More ruminally undegradable protein source (i.e., bypass protein) might be recommended for high-producing cows in early lactation.

- The protein need of cows producing up to 5 kg/100 kg body wt can be met by rumen microbial protein, plus normal amount of bypass protein, but cows producing more would benefit form additional bypass protein.

f) Limit urea to 0.2 to 0.4 lb/day. Some research indicates urea is utilized less efficiently when total ration protein level is high.
g) Increasing the energy density of the ration may help cows meet the energy requirement. Feed 1 to 1.5 lb of added fat per day may increase energy intake while maintaining adequate fiber intake.
h) Buffers, such as Na bicarbonate alone or in combination with Mg oxide, may be beneficial during the early lactation - May aid in maintaining ruminal pH, which minimizes acidosis, reduce digestive upsets, and result in increased DM intake.

D. Peak dry matter intake (Phase 2)

1) To maintain peak milk production, should achieve maximum DM intake as early in lactation as possible. Usually, reached at 12 to 14 wk
2) With maximum DM intake:

    a) Can minimize the negative nutrient balance experienced during the early lactation.
    b) A conception rate is greater for ones in positive energy balance, which is an important consideration because cows are usually being bred during this phase.

3) Maximum DM intake will likely to reach 3.5 to 4% of body wt for most cows, but some variations. (Some may consume as much as 5% of body wt?)

    a) Grain intake may reach 2½% of cow's body wt, and forage intake (DM) should be at least 1-1¼% of cow's body wt to maintain rumen function and milk-fat test.
    b) Should feed forages and grain several times daily.
    c) High-producing cows (i.e., > 70 lb 4% FCM) should be fed only natural protein and not urea!?
    d) Protein?

        (1) Percent protein needed may be lower than the early lactation possibly because of the absolute amount of protein being consumed?
        (2) Less beneficial effect of bypass protein? - Increased microbial protein synthesis can be stimulated by the increased DM intake?! Still, should try to maintain a balance between ruminally degradable & undegradable protein.

E. Mid to late lactation (Phase 3)

1) Perhaps, the easiest phase to manage because milk production is declining and the nutrient intake exceeds the needs. (The cow is pregnant at this phase though.)
2) Should keep in mind that young cows are still growing, i.e., the nutrient requirements for growth are 20% of the maintenance requirements for 2-yr-olds and 10% maintenance for 3-yr-olds.
3) Match grain intake to milk production, and avoid wasteful grain feeding to low producers - Perhaps, an opportunity to minimize feed costs during this phase?
4) The NPN may be well utilized, thus can use urea (0.4 to 0.5 lb/cow/day) if needed to, again, reduce feed costs.
5) Feed extra nutrients, if needed, to replace any body tissue lost during the early lactation. Cows are more efficient in replacing body tissue while lactating than during the dry period, but avoid over-conditioning.

6. **Some Considerations in Feeding for Milk Production?**

A. Optimizing feed intake during lactation

1) Water content of feed:

a) Important consideration when using ensiled or fresh forages, or other high-moisture feedstuffs such as high-moisture corn, wet brewers grains, liquid whey.
b) The effect on DM intake is less when water is present in the form of fresh forages than it is in the form of silage or other fermented feeds - e.g., DM intake can be reduced when the moisture content exceeds 50% from ensiled feeds, perhaps, partially caused by chemicals in the feed rather than by moisture per se?

2) Frequency of feeding:

a) A minimum of four daily feedings? - Alternating between forages and concentrates might be the best to increase intake.
b) Total mixed ration? - Feeding frequency may not increase DM intake, but may help to stabilize rumen fermentation though!

3) High-producing cows? Obviously, necessary to maximize feed intake:

a) Should have access to feeds for at least 18 to 20 hr/d? May consume their daily intake in 12 to 22 meals & increase the intake!
b) Consuming more than 4.5 kg of concentrate mix/meal at once can cause acidosis.
c) Many electronic grain feeders are programmed to limit the amount of concentrate consumed by a cow within a short period of time, which would be helpful in alleviating acidosis problem.

B. Feed young growing cows enough to allow for growth, as well as for maintenance and milk production. Best to group cows by production as a means of challenge feeding.
C. In general, more cows are underfed energy than protein. [Most lactation rations will contain 13 to 17% CP and 60 to 70% TDN (0.6 to 0.8 Mcal/lb NEl).]
D. Finely ground or pelleted forages or grains should not be fed alone to lactating cattle because it can lower milk fat test.
E. Best to feed some hay when using silage.
F. Cows in full production will consume 3 to 5 lb of water (including water in feed) for each l lb of milk produced. Have water available at all times and warm water during winter?
G. Give considerations to the relationship of feeds & milk flavor, e.g., cows must be removed from wheat pasture several hours before milking to prevent an off-flavor problem.
H Added Fat

1) High-producing cows during the first 12 to 16 wk of lactation will benefit most. Cows under heat stress may also benefit.
2) Lactating cows can be fed 1 to 1.5 lb of added fat per day to increase the energy density:

    a) Can be blended into the concentrate mix up to 8% or up to 4% to the total ration. Higher percentages may reduce feed intake, reduce fiber digestibility, and cause digestive upsets, especially with unsaturated fatty acids?
    b) Whole or processed oilseeds may be fed as a source of added fat.

        (1) Oilseeds contain polyunsaturated fatty acids, but they are slowly digested and the oil is gradually released into the rumen, thus allowing for saturation of the fatty acids and less chance of reduced fiber digestibility or milk fat depression.
        (2) Oilseeds also provide some protein and fiber. Perhaps, feed 5 to 7 lb oilseeds (whole or rolled) per head daily.
        (3) Heat-treated soybeans may have greater protein bypass properties than unheated soybeans.

3) When feeding fat, increase the dietary Ca to 0.9% +, Mg to 0.3%, acid detergent fiber to 20%, and also increase the CP content by 1 or 2%.

I. Protein

1) The need for protein increases even more dramatically at the onset of lactation than the increase in energy needs because milk solids contain about 27% CP.
2) Achieving optimal protein utilization?

    a) Supply sufficient amounts of ruminally degradable protein & fermentable energy for maximum microbial protein synthesis.
    b) Supply the remainder of the protein needs with high-quality ruminally undegradable protein.
    c) Relative proportion in a typical ration? - 60% ruminally degradable protein & 40% ruminally undegradable protein.
    d) Supplementing with ruminally protected amino acids can be another means to increase the amount of amino acids presented to the GI tract. But, must supplemet with the most limiting amino acid, which might be difficult to determine.
    e) Microbial protein synthesis:

        (1) The amount of microbial protein varies with many factors, but perhaps, limited to 2 to 3 kg/d?
        (2) High-producing cows (> 5 kg milk/100 kg BW) will likely to benefit form more bypass protein.

J. Bovine somatotropin (BST):

1) Has been approved for use in lactating cows to increase milk production. Expected increase milk production by 8 to 10 + lbs milk per day.
2) It is marketed as "Posilac," a 14-day prolonged-release BST, and the dose is 500 mg BST injected every 14 days (36 mg/cow per day).
3) Should be given to healthy cows from 9th wk of lactation until drying off.
4) Has no effect on basal metabolism and maintenance or digestion of feeds:

    a) Directs nutrients away from other body tissues towards the mammary gland.
    b) The efficiency of nutrient utilization is not altered, thus increased milk production, and results in a greater requirement for energy and nutrients.
    c) Feed intake of BST cows increases within 3-6 wk to support the increase in milk production, thus cows will lose body condition initially.

5) When using BST, dairy producers should score cows for body condition to reduce the incidence of lowered reproductive performance.

NUTRIENT REQUIREMENT TABLES FOR NON-LACTATING DAIRY ANIMALS

(Based on NRC, 2001)

1. Table 1. Daily Energy and Protein Requirements of Young Replacement Calves Fed Only Milk or Milk Replacer[a] [NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; DE = digestible energy; ADP = apparent digestible protien; CP = crude protein]

Live Weight (kg)	Gain (g)	Dry Matter Intake (kg)	NEm (Mcal)	NEg (Mcal)	ME (Mcal)	DE (Mcal)	ADP (g)	CP (g)	Vitamin A (IU)
25	0	0.24	0.96	0	1.12	1.17	18	20	2,750
	200	0.32	0.96	0.26	1.50	1.56	65	70	2,750
	400	0.42	0.96	0.60	2.00	2.08	113	121	2,750
30	0	0.27	1.10	0	1.28	1.34	21	23	3,300
	200	0.36	1.10	0.28	1.69	1.76	68	73	3,300
	400	0.47	1.10	0.65	2.22	2.31	115	124	3,300
40	0	0.34	1.37	0	1.59	1.66	26	28	4,400
	200	0.43	1.37	0.31	2.04	2.13	73	79	4,400
	400	0.55	1.37	0.72	2.63	2.74	120	129	4,400
	600	0.69	1.37	1.16	3.28	3.41	168	180	4,400
45	0	0.37	1.49	0	1.74	1.81	28	30	4,950
	200	0.46	1.49	0.32	2.21	2.30	76	81	4,950
	400	0.59	1.49	0.75	2.82	2.94	123	132	4,950
	600	0.74	1.49	1.21	3.50	3.64	170	183	4,950
50	0	0.40	1.62	0	1.88	1.96	31	33	5,500
	200	0.45	1.62	0.34	2.37	2.47	78	84	5,500
	400	0.63	1.62	0.77	3.00	3.13	125	135	5,500
	600	0.78	1.62	1.26	3.70	3.86	173	185	5,500

[a]**Dry Matter Intake** = necessary to meet ME requirements for calves fed milk replacer composed primarily of milk proteins and containing ME at 4.75 Mcal/kg of dry matter; NEm (Mcal) = 0.086 $LW^{0.75}$, where LW is live weight in kilograms; **NEg** (Mcal) = (0.84 $LW^{0.355}$ x $LWG^{1.2}$) x 0.69, where LW and LWG (live weight gain) are in kilograms; **ME** (Mcal) = 0.1 $LW^{0.75}$ + (0.84 $LW^{0.355}$ x $LWG^{1.2}$), where LW and LWG are in kilograms; **DE** (Mcal) = ME/0.96; **ADP**(g/d) = 6.25 [l/BV(E + G + M x D) - M x D]. BV (biologic value) is assumed to be 0.8. E (endogenous urinary nitrogen) is 0.2 $LW^{0.75}$/d, where LW is in kilograms. M (metabolic fecal nitrogen) is 1.9 g/kg of dry matter intake (D). G (nitrogen in live weight gain) is 30 g/kg of LWG; **CP** = ADP/0.93. The digestibility of undenatured milk proteins is assumed to be 93 percent; **Vitamin A** (IU) = 110 IU/kg of LW.

2. Table 2. Daily Energy and Protein Requirements of Calves Fed Milk and Starter or Milk Replacer and Starter[a] [NEm = net energy for maintenance; NEg = netenergy for gain; ME = metabolizable energy; DE = digestible energy; ADP = apparent digestible protien; CP = crude protein]

Live Weight (kg)	Gain (g)	Dry Matter Intake (kg)	NEm (Mcal)	NEg (Mcal)	ME (Mcal)	DE (Mcal)	ADP (g)	CP (g)	Vitamin A (IU)
30	0	0.32	1.10	0	1.34	1.43	23	26	3,300
	200	0.42	1.10	0.28	1.77	1.89	72	84	3,300
	400	0.56	1.10	0.65	2.33	2.49	122	141	3,300
35	0	0.36	1.24	0	1.50	1.61	25	29	3,850
	200	0.47	1.24	0.30	1.96	2.09	75	87	3,850
	400	0.61	1.24	0.68	2.55	2.73	125	145	3,850
40	0	0.40	1.37	0	1.66	1.78	25	33	4,400
	200	0.51	1.37	0.31	2.14	2.29	78	90	4,400
	400	0.66	1.37	0.72	2.76	2.95	128	148	4,400
	600	0.83	1.37	1.16	3.44	3.68	178	205	4,400
45	0	0.44	1.49	0	1.81	1.94	31	36	4,950
	200	0.56	1.49	0.32	2.31	2.47	80	93	4,950
	400	0.71	1.49	0.75	2.96	3.16	130	151	4,950
	600	0.88	1.49	1.21	3.67	3.93	180	209	4,950
50	0	0.47	1.62	0	1.96	2.10	33	38	5,500
	200	0.60	1.62	0.34	2.48	2.65	83	96	5,500
	400	0.76	1.62	0.77	3.15	3.37	133	154	5,500
	600	0.94	1.62	1.26	3.89	4.17	183	212	5,500
	800	1.13	1.62	1.78	4.69	5.02	233	270	5,500
55	0	0.51	1.74	0	2.11	2.25	36	41	6,050
	200	0.63	1.74	0.35	2.64	2.83	85	99	6,050
	400	0.80	1.74	0.80	3.33	3.57	135	157	6,050
	600	0.99	1.74	1.30	4.10	4.39	185	215	6,050
	800	1.18	1.74	1.84	4.93	5.27	236	273	6,050
60	0	0.54	1.85	0	2.25	2.41	38	44	6,600
	200	0.67	1.85	0.36	2.80	3.00	88	102	6,600
	400	0.84	1.85	0.83	3.51	3.76	138	159	6,600
	600	1.04	1.85	1.34	4.31	4.61	188	217	6,600
	800	1.24	1.85	1.90	5.16	5.52	238	275	6,600

[a]These data apply to calves fed milk replacer (MR) plus starter. MR contains ME at 4.75 Mca/kg of DM and starter ME at 3.28 McaVkg. It is assumed that MR provided 60 percent and starter 40 percent of dry matter intake; thus, dry matter consumed contained ME at 4.16 Mca/kg. The DMI here is the total necessary to meet ME requirements and is not intended to predict voluntary intake; **NEm** (Mcal) = 0.086 $LW^{0.75}$, where LW is live weight in kilograms; **NEg** (Mcal) = (0.84 $LW^{0.355}$ x $LWG^{1.2}$) x 0.69, where LW and LW gain (LWG) are in kilograms; ME (Mcal) was computed as follows: **ME** (maintenance) = NEm/0.825. Efficiency of use of ME for maintenance (0.825) was computed as average of efficiencies of 0.86 for MR and 0.75 for starter, weighted according to proportions of ME supplied by each feed. ME (gain) = NEg/0.652. Efficiency of use of ME for gain (0.652) was computed as weighted average of efficiencies of 0.69 and 0.57 for MR and starter, respectively; **DE** (Mcal) = ME/0.934. Efficiency of conversion of DE to ME is assumed to be 0.96 for MR and 0.88 for starter; **ADP** (g/d) = 6.25 [1/BV(E + G + M x D) - M x D]. BV (biologic value) = 0.764 (weighted average of MR = 0.8 and starter = 0.70). E (endogenous urinary nitrogen, 9) = 0.2$LW^{0.75}$. G (nitrogen content of gain, g) = 30 g/kg gain. M (metabolic fecal nitrogen, g/d) = 2.46 x dry matter intake, D, kg). Metabolic fecal nitrogen for MR assumed to be 1.9 g/kg of DMI and for starter 3.3 g/kg of DMI.; **CP** (g) = ADP/0.8645. Digestibility of protein was assumed to be weighted average of 93 percent for MR and 75 percent for starter; MR was assumed to contain 21 percent CP and starter 18 percent CP; **Vitamin A** (IU) = 110 IU/kg of LW.

3. Table 3. Daily Energy and Protein Requirements of Veal Calves Fed Only Milk or Milk Replacer[a] [NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; DE = digestible energy; ADP = apparent digestible protien; CP = crude protein]

Live Weight (kg)	Gain (g)	Dry Matter Intake (kg)	NEm (Mcal)	NEg (Mcal)	ME (Mcal)	DE (Mcal)	ADP (g)	CP (g)	Vitamin A (IU)
40	0	0.34	1.37	0	1.59	1.66	26	28	4,400
	300	0.49	1.37	0.51	2.32	2.42	97	104	4,400
	600	0.69	1.37	1.16	3.28	3.41	168	180	4,400
50	0	0.40	1.62	0	1.88	1.96	31	33	5,500
	300	0.56	1.62	0.55	2.67	2.79	102	109	5,500
	600	0.78	1.62	1.26	3.71	3.86	172	185	5,500
	900	1.02	1.62	2.05	4.85	5.05	244	262	5,500
60	0	0.45	1.85	0	2.16	2.25	35	38	6,600
	300	0.63	1.85	0.58	3.00	3.13	106	114	6,600
	600	0.86	1.85	1.34	4.10	4.27	177	190	6,600
	900	1.12	1.85	2.18	5.32	5.54	248	267	6,600
70	0	0.51	2.08	0	2.42	2.52	39	42	7,700
	300	0.70	2.08	0.62	3.32	3.45	110	119	7,700
	600	1.94	2.08	1.42	4.48	4.66	181	195	7,700
	900	1.21	2.08	2.31	5.76	6.01	253	272	7,700
	1,200	1.50	2.08	3.26	7.14	7.44	324	348	7,700
80	0	0.56	2.30	0	2.68	2.79	44	47	8,800
	300	0.76	2.30	0.65	3.61	3.76	115	123	8,800
	600	1.02	2.30	1.49	4.83	5.03	186	200	8,800
	900	1.30	2.30	2.42	6.18	6.44	257	276	8,800
	1,200	1.61	2.30	3.42	7.63	7.95	328	353	8,800
90	0	0.62	2.51	0	2.92	3.04	48	51	9,900
	300	0.82	2.51	0.68	3.90	4.06	119	128	9,900
	600	1.09	2.51	1.55	5.17	5.39	190	204	9,900
	900	1.38	2.51	2.55	6.62	6.85	263	283	9,900
	1,200	1.70	2.51	3.56	8.09	8.42	332	357	9,900
100	0	0.67	2.72	0	3.16	3.29	52	55	11,000
	300	0.88	2.72	0.70	4.18	4.35	122	132	11,000
	600	1.16	2.72	1.61	5.50	5.72	194	208	11,000
	900	1.46	2.72	2.62	6.96	7.25	265	285	11,000
	1,200	1.80	2.72	3.70	8.52	8.88	336	362	11,000
	1,500	2.14	2.72	4.84	10.17	10.59	408	438	11,000
110	0	0.72	2.92	0	3.40	3.54	55	60	12,100
	300	0.94	2.92	0.72	4.45	4.63	126	136	12,100
	600	1.22	2.92	1.66	5.81	6.05	198	212	12,100
	900	1.54	2.92	2.71	7.32	7.63	269	289	12,100
	1,200	1.88	2.92	3.83	8.94	9.32	340	366	12,100
	1,500	2.24	2.92	5.00	10.65	11.09	412	443	12,100
120	0	0.76	3.12	0	3.63	3.78	59	64	13,200
	300	0.99	3.12	0.75	4.71	4.91	130	140	13,200
	600	1.29	3.12	1.72	6.12	6.39	201	217	13,200
	900	1.62	3.12	2.80	7.68	8.00	273	293	13,200
	1,200	1.97	3.12	3.69	9.34	9.74	329	353	13,200
	1,500	2.34	3.12	5.16	11.10	11.56	416	447	13,200
130	0	0.81	3.31	0	3.85	4.01	63	67	14,300
	300	1.05	3.31	0.77	4.97	5.17	134	144	14,300
	600	1.35	3.31	1.77	6.41	6.68	205	220	14,300
	900	1.69	3.31	2.88	8.02	8.35	276	297	14,300
	1,200	2.05	3.31	4.06	9.74	10.14	348	374	14,300
	1,500	2.43	3.31	5.31	11.54	12.02	420	451	14,300
140	0	0.86	3.50	0	4.07	4.24	66	71	15,400
	300	1.10	3.50	0.79	5.22	5.43	137	148	15,400
	600	1.41	3.50	1.82	6.70	6.98	209	224	15,400
	900	1.76	3.50	2.95	8.35	8.70	280	301	15,400
	1,200	2.13	3.50	4.17	10.11	10.53	352	378	15,400
	1,500	2.52	3.50	5.45	11.97	12.45	423	455	15,400
150	0	0.90	3.69	0	4.29	4.46	70	75	16,500
	300	1.15	3.69	0.81	5.46	5.69	141	152	16,500
	600	1.47	3.69	1.86	6.98	7.27	212	228	16,500
	900	1.82	3.69	3.02	8.67	9.03	284	305	16,500
	1,200	2.21	3.69	4.27	10.48	10.91	355	382	16,500
	1,500	2.61	3.69	5.58	12.38	12.90	427	459	16,500

[a]**Dry Matter Intake** = necessary to meet ME requirements when veal calves are fed milk replacer containing ME at 4.75 Mcal/kg of DM; **NEm** (Mcal) = 0.086 $LW^{0.75}$, where LW is live wt in kg; **NEg** (Mcal) = (0.84 $LW^{0.355}$ x $LWG^{1.2}$) x 0.69, where LW and LWG (live wt gain) are in kg; **ME** (Mcal) = 0.1 $LW^{0.75}$ + (0.84 $LW^{0.355}$ x $LWG^{1.2}$), where LW and LWG are in kg; **DE** (Mcal) = ME/0.93; **ADP** (g/d) = 6.25 [I/BV(E + G + M x D) - M x D]. BV (biologic value) is assumed to be 0.8. E (endogenous urinary nitrogen) is 0.2 $LW^{0.75}$/d, where LW is in kg. M (metabolic fecal nitrogen) is 1.9 g/kg of dry matter intake (D). G (nitrogen in live wt gain) is 30 g/kg of LWG; **CP** = ADP/0.93. The digestibility of undenatured milk proteins is assumed to be 93%; **Vitamin A** (IU) = 110 IU/kg of LW.

4. Table 4. Daily Energy and Protein Requirements of Weaned (Ruminant) Calves[a] [NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; DE = digestible energy; ADP = apparent digestible protien; CP = crude protein]

Live Weight (kg)	Gain (g)	Dry Matter Intake (kg)	NEm (Mcal)	NEg (Mcal)	ME (Mcal)	DE (Mcal)	ADP (g)	CP (g)	Vitamin A (IU)
50	0	0.70	1.62	0	2.16	2.58	40	53	5,500
	400	1.13	1.62	0.77	3.51	3.92	151	201	5,500
	500	1.27	1.62	1.01	3.93	4.35	179	238	5,500
	600	1.86	1.62	1.26	4.36	4.77	207	276	5,500
60	0	0.80	1.85	0	2.47	2.89	46	61	6,600
	400	1.26	1.85	0.83	3.92	4.33	156	209	6,600
	500	1.41	1.85	1.08	4.36	4.77	185	246	6,600
	600	1.56	1.85	1.34	4.83	5.23	213	284	6,600
	700	1.71	1.85	1.62	5.31	5.70	241	322	6,600
	800	1.87	1.85	1.90	5.80	6.19	269	359	6,600
70	0	0.90	2.08	0	2.77	3.19	51	68	7,700
	400	1.39	2.08	0.87	4.31	4.71	163	217	7,700
	500	1.54	2.08	1.14	4.77	5.17	191	254	7,700
	600	1.70	2.08	1.42	5.26	5.66	219	292	7,700
	700	1.86	2.08	1.71	5.77	6.16	247	330	7,700
	800	2.03	2.08	2.00	6.29	6.67	275	367	7,700
80	0	0.99	2.30	0	3.07	3.48	57	75	8,800
	400	1.51	2.30	0.92	4.67	5.07	168	224	8,800
	500	1.66	2.30	1.20	5.16	5.56	196	262	8,800
	600	1.83	2.30	1.49	5.68	6.07	225	300	8,800
	700	2.00	2.30	1.79	6.21	6.59	253	337	8,800
	800	2.18	2.30	2.10	6.75	7.13	281	375	8,800
90	0	1.16	2.51	0	3.35	3.76	62	82	9,900
	600	2.09	2.51	1.55	6.07	6.46	231	309	9,900
	700	2.28	2.51	1.87	6.62	7.00	260	346	9,900
	800	2.48	2.51	2.19	7.19	7.57	288	385	9,900
	900	2.68	2.51	2.52	7.78	8.15	317	423	9,900
100	0	1.25	2.72	0	3.63	4.04	68	90	11,000
	600	2.22	2.72	1.61	6.45	6.83	237	316	11,000
	700	2.42	2.72	1.94	7.02	7.40	265	354	11,000
	800	2.63	2.72	2.27	7.62	7.99	294	392	11,000
	900	2.84	2.72	2.62	8.22	8.59	323	430	11,000

[a]These data apply to small-breed female calves from 50 to 80 kg gairung 0.4 to 0.5 kg/d and large-breed calves from 60 to 100 kg gaining from 0.6 to 0.9 kg/d; **NEm** (Mcal) = 0.086 $LW^{0.75}$ (NRC 1989), where LW is live weight in kilograms; **NEg** (Mcal) = (0.84 $LW^{0.75}$ x $LWG^{1.2}$) x 0.69, where LW and LW gain (LWG) are in kilograms; **ME**, maintenance (Mcal) = NEm/0.75. ME values of diets (Mcal/kg of DM) are 3.10 for calves weighing 60, 10, and 80 kg and 2.90 for calves weighing 90 and 100 kg. ME, gain (Mcal) = NEg/0.57. Sum of ME values for maintenance plus gain equals total ME requirement; **DE** (Mcal) = (ME + 0.45) /1.01; **ADP** (g/d) as follows: ADP (g/d) = 6.25 [l/BV(E + G + M x D) - M x D] where BV is biologic value set at 0.10. E (endogenous urinary rutrogen) = 0.2$LW^{0.75}$. G is rutrogen content of gain, assuming 30 g/kg of gain. M is metabolic fecal rutrogen computed as 3.3 g/kg of dry matter consumed (D); **CP** calculated as ADP/0.75; **Vitamin A** (IU) = 110 IU/kg of LW.

5. **Table 5. Daily Nutrient Requirements (DM basis) of Small Breed (Mature Weight = 450 kg) Non-Bred Heifers**[a] [BW = body weight; ADG = average daily gain; DMI = dry matter intake; TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

BW kg	ADG kg/d	DMI kg/d	TDN %	NEm Mcal/d	NEg Mcal/d	ME Mcal/d	RDP g/d	RUP g/d	RDP %	RUP %	CP %	Ca g/d	P g/d
100	0.3	3.0	56.5	2.64	0.47	6.0	255	110	8.6	3.7	12.4	14	7
	0.4	3.0	58.6	2.64	0.64	6.4	270	143	9.0	4.7	13.7	18	8
	0.5	3.1	60.7	2.64	0.82	6.7	284	175	9.3	5.7	15.0	21	10
	0.6	3.1	62.9	2.64	1.00	7.0	298	207	9.6	6.7	16.3	25	11
	0.7	3.1	65.2	2.64	1.19	7.3	310	239	10.0	7.7	17.7	28	12
	0.8	3.1	67.7	2.64	1.37	7.6	323	270	10.4	8.7	19.0	31	13
150	0.3	4.0	56.5	3.57	0.63	8.2	346	95	8.6	2.4	11.0	15	8
	0.4	4.1	58.6	3.57	0.87	8.7	366	124	9.0	3.0	12.0	19	10
	0.5	4.1	60.7	3.57	1.11	9.1	385	152	9.3	3.7	12.9	22	11
	0.6	4.2	62.9	3.57	1.36	9.5	403	180	9.6	4.3	13.9	25	12
	0.7	4.2	65.3	3.51	1.61	9.9	421	207	10.0	4.9	14.9	28	13
	0.8	4.2	67.7	3.57	1.86	10.3	437	234	10.4	5.5	15.9	31	14
200	0.3	5.0	56.5	4.44	0.79	10.2	429	81	8.6	1.6	10.3	17	10
	0.4	5.1	58.6	4.44	1.08	10.7	454	106	9.0	2.1	11.1	20	11
	0.5	5.1	60.7	4.44	1.38	11.3	478	131	9.3	2.6	11.8	23	12
	0.6	5.2	62.9	4.44	1.68	11.8	500	156	9.6	3.0	12.6	26	13
	0.7	5.2	65.3	4.44	1.99	12.3	522	179	10.0	3.4	13.4	29	14
	0.8	5.2	67.7	4.44	2.31	12.8	543	202	10.4	3.9	14.2	32	15
250	0.3	5.9	56.5	5.24	0.93	12.0	508	69	8.6	1.2	9.8	19	11
	0.4	6.0	58.6	5.24	1.28	12.7	537	91	9.0	1.5	10.5	21	12
	0.5	6.1	60.7	5.24	1.63	13.4	565	113	9.3	1.9	11.1	24	13
	0.6	6.1	62.9	5.24	1.99	14.0	592	135	9.6	2.2	11.8	27	14
	0.7	6.2	65.3	5.24	2.36	14.6	617	155	10.0	2.5	12.5	30	15
	0.8	6.2	67.7	5.24	2.73	15.2	642	175	10.4	2.8	13.2	32	16
300	0.3	6.7	56.5	6.01	1.07	13.8	582	58	8.6	0.9	9.5	20	12
	0.4	6.9	58.6	6.01	1.46	14.6	616	79	9.0	1.1	10.1	23	13
	0.5	7.0	60.7	6.01	1.87	15.3	648	98	9.3	1.4	10.7	26	14
	0.6	7.0	62.9	6.01	2.28	16.0	678	117	9.6	1.7	11.3	28	15
	0.7	7.1	65.3	6.01	2.70	16.7	707	135	10.0	1.9	11.9	31	16
	0.8	7.1	67.7	6.01	3.13	17.4	736	151	10.4	2.1	12.5	34	17

[a]Crude protein required on1y if ration is perfectly balanced for RDP and RUP.

6. **Table 6. Daily Nutrient Requirements (DM basis) of Large Breed (Mature Weight = 650 kg) Non-Bred Heifers**[a] [BW = body weight; ADG = average daily gain; DMI = dry matter intake; TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

BW kg	ADG kg/d	DMI kg/d	TDN %	NEm Mcal/d	NEg Mcal/d	ME Mcal/d	RDP g/d	RUP g/d	RDP %	RUP %	CP %	Ca g/d	P g/d
150	0.5	4.1	58.4	3.57	0.84	8.6	364	167	8.9	4.1	13.0	23	11
	0.6	4.1	60.0	3.57	1.03	9.0	379	199	9.2	4.8	14.0	26	12
	0.7	4.2	61.7	3.57	1.22	9.3	393	230	9.4	5.5	14.9	30	13
	0.8	4.2	63.4	3.57	1.41	9.6	407	261	9.7	6.2	15.9	33	15
	0.9	4.2	65.3	3.57	1.61	9.9	421	292	10.0	6.9	16.9	37	16
	1.0	4.2	67.2	3.57	1.80	10.3	434	322	10.3	7.6	17.9	40	17
	1.1	4.2	69.2	3.57	2.00	10.6	446	352	10.6	8.3	18.9	43	18
200	0.5	5.1	58.4	4.44	1.05	10.7	452	148	8.9	2.9	11.9	24	12
	0.6	5.1	60.0	4.44	1.28	11.1	470	177	9.2	3.4	12.6	27	13
	0.7	5.2	61.7	4.44	1.51	11.5	488	205	9.4	4.0	13.4	30	14
	0.8	5.2	63.4	4.44	1.75	11.9	505	233	9.7	4.5	14.2	34	15
	0.9	5.2	65.3	4.44	1.99	12.3	522	260	10.0	5.0	15.0	37	17
	1.0	5.2	67.2	4.44	2.24	12.7	538	287	10.3	5.5	15.8	40	18
	1.1	5.2	69.2	4.44	2.49	13.1	554	314	10.6	6.0	16.6	43	19
250	0.5	6.0	58.4	5.24	1.24	12.6	534	131	8.9	2.2	11.1	25	13
	0.6	6.1	60.0	5.24	1.51	13.1	556	156	9.2	2.6	11.8	28	14
	0.7	6.1	61.7	5.24	1.79	13.6	577	182	9.4	3.0	12.4	31	15
	0.8	6.2	63.4	5.24	2.07	14.1	597	207	9.7	3.4	13.1	34	16
	0.9	6.2	65.3	5.24	2.36	14.6	617	232	10.0	3.7	13.7	37	17
	1.0	6.2	67.2	5.24	2.65	15.0	636	256	10.3	4.1	14.4	40	18
	11.1	6.2	69.2	5.24	2.94	15.5	655	280	10.6	4.5	15.1	43	19
300	0.5	6.9	58.4	6.01	1.42	14.5	612	114	8.9	1.7	10.6	27	14
	0.6	6.9	60.0	6.01	1.73	15.1	637	138	9.2	2.0	11.2	30	15
	0.7	7.0	61.7	6.01	2.05	15.6	661	161	9.4	2.3	11.7	33	16
	0.8	7.1	63.4	6.01	2.38	16.2	685	183	9.7	2.6	12.3	35	17
	0.9	7.1	65.3	6.01	2.70	16.7	707	205	10.0	2.9	12.9	38	18
	1.0	7.1	67.2	6.01	3.03	17.2	729	227	10.3	3.2	13.5	41	19
	1.1	7.1	69.2	6.01	3.37	17.7	751	248	10.6	3.5	14.1	44	20
350	0.5	7.7	58.4	6.75	1.59	16.2	687	99	8.9	1.3	10.2	28	15
	0.6	7.8	60.0	6.75	1.94	16.9	715	121	9.2	1.5	10.7	31	16
	0.7	7.9	61.7	6.75	2.30	17.6	742	141	9.4	1.8	11.2	34	17
	0.8	7.9	63.4	6.75	2.67	18.2	769	162	9.7	2.0	11.7	37	18
	0.9	8.0	65.3	6.75	3.03	18.8	794	181	10.0	2.3	12.3	40	19
	1.0	8.0	67.2	6.75	3.41	19.4	819	200	10.3	2.5	12.8	42	20
	1.1	8.0	69.2	6.75	3.78	19.9	843	218	10.6	2.7	13.3	45	21
400	0.5	8.5	58.4	7.46	1.76	18.0	760	86	8.9	1.0	9.9	30	16
	0.6	8.6	60.0	7.46	2.15	18.7	791	105	9.2	1.2	10.4	33	17
	0.7	8.7	61.7	7.46	2.55	19.4	821	124	9.4	1.4	10.9	35	18
	0.8	8.8	63.4	7.46	2.95	20.1	850	142	9.7	1.6	11.3	38	19
	0.9	8.8	65.3	7.46	3.35	20.7	878	159	10.0	1.8	11.8	41	20
	1.0	8.8	67.2	7.46	3.76	21.4	905	176	10.3	2.0	12.3	44	21
	1.1	8.8	69.2	7.46	4.18	22.0	931	192	10.6	2.2	12.8	46	22

[a]CP = crude protein required only if ration is perfectly balanced for RDP and RUP.

7. **Table 7. Daily Nutrient Requirements (DM basis) of Small Breed (Mature Weight = 450 kg) Bred Heifers**[a] [BW = body weight; ADG = average daily gain; DMI = dry matter intake; TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

BW kg	ADG kg/d	DMI kg/d	TDN %	NEm Mcal/d	NEg Mcal/d	ME Mcal/d	RDP g/d	RUP g/d	RDP %	RUP %	CP %	Ca g/d	P g/d
300	0.3	7.7	56.5	5.42	0.96	15.7	663	291	8.6	3.8	12.4	36	19
	0.4	7.7	58.6	5.42	1.32	16.4	693	310	9.0	4.0	13.0	39	20
	0.5	7.7	60.8	5.42	1.68	17.0	721	329	9.3	4.2	13.5	41	21
	0.6	7.7	63.1	5.42	2.06	17.7	748	346	9.7	4.5	14.1	44	22
	0.7	7.7	65.5	5.42	2.44	18.3	774	364	10.0	4.7	14.7	47	23
	0.8	7.7	68.1	5.42	2.82	18.9	798	380	10.4	5.0	15.4	49	24
	0.9	7.6	70.9	5.42	3.21	19.4	822	395	10.8	5.2	16.1	52	24
350	0.3	8.6	56.2	6.18	1.10	17.5	739	282	8.6	3.3	11.9	38	20
	0.4	8.7	58.3	6.18	1.50	18.3	773	299	8.9	3.4	12.4	40	21
	0.5	8.7	60.5	6.18	1.92	19.0	805	315	9.3	3.6	12.9	43	22
	0.6	8.7	62.8	6.18	2.35	19.8	836	330	9.6	3.8	13.4	46	23
	0.7	8.7	65.3	6.18	2.78	20.4	865	345	10.0	4.0	14.0	48	24
	0.8	8.6	67.8	6.18	3.22	21.1	893	358	10.4	4.2	14.5	51	25
	0.9	8.5	70.6	6.18	3.66	21.8	921	371	10.8	4.3	15.1	53	25
400	0.3	9.5	56.0	6.91	1.23	19.2	813	275	8.6	2.9	11.5	40	21
	0.4	9.6	58.1	6.91	1.68	20.1	851	291	8.9	3.0	11.9	42	22
	0.5	9.6	60.3	6.91	2.15	21.0	887	305	9.2	3.2	12.4	45	23
	0.6	9.6	62.6	6.91	2.62	21.8	921	319	9.6	3.3	12.9	47	24
	0.7	9.6	65.0	6.91	3.11	22.5	953	331	9.9	3.5	13.4	50	25
	0.8	9.5	67.6	6.91	3.60	23.3	985	342	10.3	3.6	13.9	52	26
	0.9	9.4	70.3	6.91	4.09	24.0	1,015	352	10.8	3.7	14.5	55	26
450	0.3	10.4	55.8	7.62	1.35	20.9	884	273	8.5	2.6	11.2	41	22
	0.4	10.5	57.9	7.62	1.85	21.9	926	288	8.9	2.8	11.6	44	23
	0.5	10.5	60.1	7.62	2.37	22.8	965	301	9.2	2.9	12.1	46	24
	0.6	10.5	62.4	7.62	2.89	23.7	1,003	313	9.5	3.0	12.5	49	25
	0.7	10.5	64.8	7.62	3.42	24.5	1,038	324	9.9	3.1	13.0	51	26
	0.8	10.4	67.4	7.62	3.96	25.4	1,073	333	10.3	3.2	13.5	54	27
	0.9	10.3	70.1	7.62	4.51	26.1	1,106	341	10.7	3.3	14.0	56	28

[a]240 days pregnant (Conceptus weight of 39 kg and ADG of 0.4 kg/day); CP = crude protein required only if ration is perfectly balanced for RDP and RUP.

8. **Table 8. Daily Nutrient Requirements (DM basis) of Large Breed (Mature Weight = 650 kg) Bred Heifers**[a] [BW = body weight; ADG = average daily gain; DMI = dry matter intake; TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; ME = metabolizable energy; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

BW kg	ADG kg/d	DMI kg/d	TDN %	NEm Mcal/d	NEg Mcal/d	ME Mcal/d	RDP g/d	RUP g/d	RDP %	RUP %	CP %	Ca g/d	P g/d
450	0.5	10.5	59.3	7.49	1.77	22.5	951	402	9.1	3.8	12.9	47	25
	0.6	10.5	61.1	7.49	2.16	23.2	981	418	9.3	4.0	13.3	50	25
	0.7	10.5	62.9	7.49	2.55	23.9	1,010	433	9.6	4.1	13.7	53	26
	0.8	10.5	64.8	7.49	2.96	24.5	1,038	448	9.9	4.3	14.2	55	27
	0.9	10.4	66.8	7.49	3.37	25.2	1,066	462	10.2	4.4	14.7	58	28
	1.0	10.4	68.9	7.49	3.78	25.8	1,092	475	10.5	4.6	15.1	61	29
	1.1	10.3	71.2	7.49	4.19	26.4	1,118	488	10.9	4.8	15.6	63	30
500	0.5	11.3	59.0	8.17	1.93	24.2	1,024	391	9.0	3.4	12.5	49	26
	0.6	11.4	60.8	8.17	2.36	25.0	1,057	405	9.3	3.6	12.9	52	27
	0.7	11.4	62.6	8.17	2.79	25.7	1,088	419	9.6	3.7	13.3	54	27
	0.8	11.3	64.5	8.17	3.23	26.4	1,119	432	9.9	3.8	13.7	57	28
	0.9	11.3	66.5	8.17	3.67	27.2	1,149	444	10.2	3.9	14.1	59	29
	1.0	11.2	68.6	8.17	4.13	27.8	1,177	455	10.5	4.1	14.5	62	30
	1.1	11.1	70.8	8.17	4.58	28.5	1,206	465	10.8	4.2	15.0	65	31
550	0.5	12.2	58.8	8.84	2.09	25.9	1,094	382	9.0	3.1	12.1	51	27
	0.6	12.2	60.5	8.84	2.55	26.7	1,130	395	9.3	3.2	12.5	53	28
	0.7	12.2	62.3	8.84	3.02	27.5	1,164	407	9.5	3.3	12.9	56	29
	0.8	12.2	64.2	8.84	3.49	28.3	1,197	418	9.8	3.4	13.3	58	29
	0.9	12.1	66.2	8.84	3.98	29.1	1,229	428	10.1	3.5	13.7	61	30
	1.0	12.1	68.3	8.84	4.46	29.8	1,260	437	10.4	3.6	14.1	64	31
	1.1	12.0	70.5	8.84	4.95	30.5	1,291	445	10.8	3.7	14.5	66	32
600	0.5	13.0	58.6	9.50	2.24	27.5	1,163	375	9.0	2.9	11.8	53	28
	0.6	13.0	60.3	9.50	2.74	28.4	1,202	387	9.2	3.0	12.2	55	29
	0.7	13.0	62.1	9.50	3.24	29.3	1,238	397	9.5	3.0	12.5	58	30
	0.8	13.0	64.0	9.50	3.75	30.1	1,274	407	9.8	3.1	12.9	60	30
	0.9	13.0	66.0	9.50	4.27	30.9	1,308	416	10.1	3.2	13.3	63	31
	1.0	12.9	68.0	9.50	4.79	31.7	1,342	423	10.4	3.3	13.7	65	32
	1.1	12.8	70.2	9.50	5.32	32.5	1,374	430	10.7	3.4	14.1	68	33
650	0.5	13.8	58.4	10.14	2.39	29.1	1,231	371	8.9	2.7	11.6	54	29
	0.6	13.8	60.1	10.14	2.92	30.1	1,272	382	9.2	2.8	12.0	57	30
	0.7	13.8	61.9	10.14	3.46	31.0	1,311	392	9.5	2.8	12.3	59	31
	0.8	13.8	63.8	10.14	4.00	31.9	1,349	400	9.8	2.9	12.7	62	31
	0.9	13.8	65.8	10.14	4.56	32.7	1,385	408	10.1	3.0	13.0	64	32
	1.0	13.7	67.8	10.14	5.11	33.6	1,421	414	10.4	3.0	13.4	67	33
	1.1	13.6	70.0	10.14	5.68	34.4	1,456	418	10.7	3.1	13.8	69	34

[a]240 days pregnant (Conceptus weight of 48 kg and ADG of 0.6 kg/day); CP = crude protein required only if ration is perfectly balanced for RDP and RUP.

9. **Table 9. Nutrient Requirements of Growing Holstein Heifers Using Model to Predict Target Average Daily Gain Needed to Attain a Mature Body Weight of 680 Kg** [BCS = body condition score; ME = metabolizable energy; MP = metabolizable protein; RDP = rumen degradable protein; RUP = rumen undegradable protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; TDN = total digestible nutrients]

Month (& weight):	6 (200 kg)	12 (300 kg)	18 (450 kg)
BCS to calve at 24 mo. of age:	3.0	3.0	3.0
Dry matter intake predicted by model, kg	5.2	7.1	11.3
Energy			
ME, Mcal/d	10.6	16.2	20.3
ME, Mcal/kg	2.04	2.28	1.79
Protein			
Metabolizable protein, g/d	415	550	635
Diet % MP	8.0	7.7	5.6
Rumen degradable protein, g/d	481	667	970
Diet % RDP	9.3	9.4	8.6
Rumen undegradable protein, g/d	176	209	88
Diet % RUP	3.4	2.9	0.8
% RDP + % RUP (crude protein)[a]	12.7	12.3	9.4
Fiber and carbohydrate[b]			
NDF, min %	30-33	30-33	30-33
ADF, min %	20-21	20-21	20-21
NFC, max %	34-38	34-38	34-38
Minerals			
Absorbable calcium, g/d	11.3	15.0	13.0
Dietary Ca, %	0.41	0.41	0.37
Absorbable phosphorus, g/d	9.1	10.6	13.0
Dietary P, %	0.28	0.23	0.18
Mg[c], %	0.11	0.11	0.08
Cl, %	0.11	0.12	0.10
K, %	0.47	0.48	0.46
Na, %	0.08	0.08	0.07
S, %	0.2	0.2	0.2
Co, mg/kg	0.11	0.11	0.11
Cu, mg/kg[d]	10	10	9
I, mg/kg[e]	0.27	0.30	0.30
Fe, mg/kg	43	31	13
Mn, mg/kg	22	20	14
Se, mg/kg	0.3	0.3	0.3
Zn, mg/kg	32	27	18
Vitamin A, IU/d	16,000	24,000	36,000
Vitamin D, IU/d	6,000	9,000	13,500
Vitamin E, IU/d	160	240	360
Vitamin A, IU/kg	3,076	3,380	3,185
Vitamin D, IU/kg	1,154	1,268	1,195
Vitamin E, IU/kg	31	34	32
Sample Diets used in model to generate tables:			
Ingredient, kg/d			
Corn silage, normal	2.90	4.08	1.51
Soybean meal, solv. 48% CP	0.30	0.41	0
Grass silage, C-3, mid-mat	1.68	2.29	9.52
Limestone	0.03	0.02	0
Vitamin premix	0.30	0.27	0.30
Diet ME, Mcal/kg	2.24	2.29	2.08
Diet undiscounted TDN, %	61	62	56
Target ADG without conceptus, kg	0.65	0.87	0.59
Target ADG with conceptus, kg	0.65	0.87	0.59
ME allowable ADG without conceptus of diet	0.82	0.87	0.86
ME allowable ADG with conceptus of diet	0.82	0.87	0.86
MP allowable ADG without conceptus of diet	0.76	1.09	1.30
MP allowable ADG with conceptus of diet	0.76	1.09	1.30

[a]Equivalent to crude protein requirement only if RDP and RUP are perfectly balanced; [b]These are the miuimum fiber (or maximum NFC) concentrations needed to maintain rumen health. Actual concentrations may need to be higher (or lower for NFC) depending on energy requirements of the heifer; [c]Assumes that active transport of magnesium across the rumen wall is intact. High dietary potassium and excess non-protein nitrogen often interfere with Mg absorption. Under these conditions dietary Mg should be increased; [d]High dietary Mo, sulfur, and Fe can interfere with Cu absorption increasing the requirement; [e]Diets high in goitrogenic substances increase the iodine requirement.

10. **Table 10. Nutrient Requirements and Diet Concentrations Needed to Meet Requirements for Dry Cows as Determined Using Example Diets** (Holstein Cow - Mature Body Weight Without Conceptus = 680 kg; Body Condition Score (BCS) = 3.3; Calf Weight = 45 kg; Gaining 0.67 kg/day with conceptus) [NEl = net energy for lactation; MP = metabolizable protein; RDP = rumen degradable protein; RUP = rumen undegradable protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; NFC = nonfibrous carbohydrate; TDN = total digestible nutrients; DMI = dry matter intake]

Days pregnant	240	270	279
Current body wt (with conceptus), kg	730	751	757
Age (months)	57	58	58
Dry matter intake, kg/d	14.4	13.7	10.1
Energy			
NEl (Mcal/d required)	14.0	14.4	14.5
NEl (Mcal/kg required)	0.97	1.05	1.44
Protein			
Metabolizable protein, g/d	871	901	810
Diet % MP	6.0	6.6	8.0
Rumen degradable protein, g/d	1,114	1,197	965
Diet % RDP	7.7	8.7	9.6
Rumen undegradable protein, g/d	317	292	286[a]
Diet % RUP	2.2	2.1	2.8[a]
% RDP+ % RUP (crude protein)[b]	9.9	10.8	12.4
Fiber and carbohydrate[c]			
Minimum % NDF	33	33	33
Minimum % ADF	21	21	21
Maximum % NFC	42	42	42
Minerals			
Absorbable calcium, g/d	18.1	21.5	22.5
Dietary Ca, %	0.44	0.45	0.48
Absorbable phosphorus, g/d	19.9	20.3	16.9
Dietary P, %	0.22	0.23	0.26
Mg[d], %	0.11	0.12	0.16
Cl, %	0.13	0.15	0.20
K, %	0.51	0.52	0.62
Na, %	0.10	0.10	0.14
S, %	0.2	0.2	0.2
Co, mg/kg	0.11	0.11	0.11
Cu, mg/kg[e]	12	13	18
I, mg/kg	0.4	0.4	0.5
Fe, mg/kg	13	13	18
Mn, mg/kg	16	18	24
Se, mg/kg	0.3	0.3	0.3
Zn, mg/kg	21	22	30
Vitamin A, IU/d	80,300	82,610	83,270
Vitamin D, IU/d	21,900	21,530	22,710
Vitamin E, IU/d	1,168	1,202	1,211
Vitamin A, IU/kg	5,576	6,030	8,244
Vitamin D, IU/kg	1,520	1,645	2,249
Vitamin E, IU/kg	81	88	120
Sample diets used in model to generate tables			
Ingredient, kg DM			
Corn silage, normal	-	4.32	4.03
Soybean meal, solv. 48% CP	-	-	0.27
Grass silage, C-3, mid-mat	8.1	7.35	3.73
Corn grain, ground hi moist	-	-	0.31
Beet sugar pulp, dried	-	-	1.42
Wheat straw	5.79	1.56	-
Sodium chloride	0.02	0.02	0.02
Vitamin and mineral premix	0.46	0.41	0.31
Calcium carbonate	-	-	-
Monosodium phosphate (1 H_2O)	-	-	-
Magnesium oxide	-	-	-
Calcium phosphate (Di-)	-	-	-
Sample dry cow diet evaluation			
NDF, %	62.2	53.9	46.5
Forage NDF, %	62.2	53.9	39.5
ADF, %	39.7	33.5	27.8
NFC, %	19.6	27.2	34.7

Undiscounted TDN, %	51	57	63
Diet NEl (Mcal/kg), dependent on DMI	1.12	1.33	1.49
NEl (Mcal/d supplied by example diet)	16.1	18.1	15

[a]RUP corrected from model prediction to provide actual RUP requirement if diet had been formulated to meet RDP requirement. Protein in many cases will not be balanced for RDP before the metabolizable protein requirement of the dry cow is met. when this occurs the RUP requirement determined by the model increases to compensate for the lost microbial protein. When RDP is inadequate the energy derived from the diet may be less than predicted by model due to incomplete digestion as a result of reduced bacterial activity in the rumen; [b]% RUP + % RDP = Crude protein required only if ration is perfectly balanced for RDP and RUP. Rumen function may require that the crude protein content of the dry cow ration be 12%, despite the needs of the cow being met at lower CP levels; [c]These are the minimum fiber (or maximum NFC) concentrations needed to maintain rumen health and milk fat test. Actual concentrations may need to be higher (or lower for NFC) depending on energy requirements of the cow. For transition and early lactation cows, diets should meet these minimum and maximum constraints and be formulated to contain 1.60 Mcal/kg of NEl; [d]High dietary potassium and excess non-protein nitrogen can interfere with Mg absorption; [e]High dietary molybdenum, sulfur, and iron can interfere with copper absorption increasing the requirement; [f]Diets high in goitrogenic substances increase the iodine requirement.

NUTRIENT REQUIREMENT TABLES FOR LACTATING DAIRY ANIMALS

(Based on NRC, 2001)

1. Table 11. Daily Nutrient Requirements of Small Breed Cows (Live Weight = 454 kg) in *Early Lactation* - 11 Days in Milk (Values are Appropriate for the *Diet Below With 78% TDN*)[a] [DMI = dry matter intake; LW = live weight; NEl = net energy for lactation; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

Milk (kg)	Fat (%)	TrueProtein (%)	DMI (kg)	LW change (kg)	NEl (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
15	4.0	3.0	9.4	-0.3	19.0	1,060	500	11.3	5.3	16.6
15	4.0	3.5	9.4	-0.3	19.4	1,060	630	11.3	6.7	18.0
15	4.0	4.0	9.4	-0.4	19.8	1,060	760	11.3	8.1	19.4
15	4.5	3.0	9.7	-0.3	19.7	1,090	490	11.2	5.1	16.3
15	4.5	3.5	9.7	-0.4	20.1	1,090	620	11.2	6.4	17.6
15	4.5	4.0	9.7	-0.5	20.5	1,090	750	11.2	7.7	18.9
15	5.0	3.0	9.9	-0.4	20.4	1,110	480	11.2	4.8	16.0
15	5.0	3.5	9.9	-0.5	20.8	1,110	610	11.2	6.2	17.4
15	5.0	4.0	9.9	-0.5	21.2	1,110	740	11.2	7.5	18.7
30	4.0	3.0	12.9	-1.4	30.1	1,410	1,170	10.9	9.1	20.0
30	4.0	3.5	12.9	-1.6	30.9	1,410	1,430	10.9	11.1	22.0
30	4.0	4.0	12.9	-1.7	31.8	1,410	1,690	10.9	13.1	24.0
30	4.5	3.0	13.5	-1.5	31.5	1,460	1,150	10.8	8.5	19.3
30	4.5	3.5	13.5	-1.7	32.3	1,460	1,410	10.8	10.4	21.2
30	4.5	4.0	13.5	-1.9	33.2	1,460	1,670	10.8	12.4	23.2
30	5.0	3.0	14.0	-1.6	32.8	1,510	1,140	10.8	8.1	18.9
30	5.0	3.5	14.0	-1.8	33.7	1,510	1,400	10.8	10.0	20.8
30	5.0	4.0	14.0	-2.0	34.6	1,510	1,660	10.8	11.9	22.7

[a]Diet used for tlris table consisted of 15% immature legume silage, 33% normal corn silage, 34% ground lrigh moisture shelled corn, 12% soybean meal (48% crude protein), 2.5% tallow, 1.5% menhaden fish meal, and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for Jive weight change. Live weight change is based on assumed NEl intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

2. **Table 12. Daily Nutrient Requirements of Small Breed Cows (Live Weight = 454 kg) in *Midlactation - 90 Days in Milk*** (Values Are Appropriate for the ***Diet Below with 78% TDN***)[a] [DMI = dry matter intake; LW = live weight; NEl = net energy for lactation; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

Milk (kg)	Fat (%)	TrueProtein (%)	DMI (kg)	LW change (kg)	NEl (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
20	4.0	3.0	16.0	1.0	22.7	1,680	560	10.5	3.5	14.0
20	4.0	3.5	16.0	0.8	23.2	1,680	740	10.5	4.6	15.1
20	4.0	4.0	16.0	0.7	23.8	1,680	910	10.5	5.7	16.2
20	4.5	3.0	16.5	0.9	23.6	1,730	550	10.5	3.3	13.8
20	4.5	3.5	16.5	0.8	24.2	1,730	720	10.5	4.4	14.9
20	4.5	4.0	16.5	0.7	24.8	1,730	900	10.5	5.5	16.0
20	5.0	3.0	17.0	0.9	24.5	1,770	540	10.4	3.2	13.6
20	5.0	3.5	17.0	0.8	25.1	1,770	710	10.4	4.2	14.6
20	5.0	4.0	17.0	0.6	25.7	1,770	880	10.4	5.2	15.6
30	4.0	3.0	19.5	0.4	30.1	1,980	1,010	10.2	5.2	15.4
30	4.0	3.5	19.5	0.2	30.9	1,980	1,270	10.2	6.5	16.7
30	4.0	4.0	19.5	0	31.8	1,980	1,530	10.2	7.8	18.0
30	4.5	3.0	20.3	0.3	31.5	2,040	990	10.0	4.9	14.9
30	4.5	3.5	20.3	0.1	32.3	2,040	1,250	10.0	6.2	16.2
30	4.5	4.0	20.3	-0.1	33.2	2,040	1,510	10.0	7.4	17.4
30	5.0	3.0	21.1	0.2	32.8	2,100	980	10.0	4.6	14.6
30	5.0	3.5	21.1	0	33.7	2,100	1,240	10.0	5.9	15.9
30	5.0	4.0	21.1	-0.2	34.6	2,100	1,500	10.0	7.1	17.1
40	4.0	3.0	23.1	-0.3	37.5	2,240	1,470	9.7	6.4	16.1
40	4.0	3.5	23.1	-0.6	38.6	2,240	1,820	9.7	7.9	17.6
40	4.0	4.0	23.1	-0.8	39.8	2,240	2,160	9.7	9.4	19.1
40	4.5	3.0	24.2	-0.5	39.3	2,310	1,460	9.5	6.0	15.5
40	4.5	3.5	24.2	-0.7	40.5	2,310	1,800	9.5	7.4	16.9
40	4.5	4.0	24.2	-1.0	41.7	2,310	2,150	9.5	8.9	18.4
40	5.0	3.0	25.2	-0.7	41.2	2,390	1,450	9.5	5.8	15.3
40	5.0	3.5	25.2	-0.9	42.3	2,390	1,790	9.5	7.1	16.6
40	5.0	4.0	25.2	-1.1	43.5	2,390	2,140	9.5	8.5	18.0

[a]Diet used for this table consisted of 15% immature legume silage, 33% normal corn silage, 34% ground high moisture shelled corn, 12% soybean meal (48% crude protein), 2.5% tallow, 1.5% menhaden fish meal, and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NEl intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

3. **Table 13. Daily Nutrient Requirements of Small Breed Cows (Live Weight = 454 kg) in *Midlactation* - 90 Days in Milk** (Values are Appropriate for the ***Diet Below with 68% TDN***)[a] [DMI = dry matter intake; LW = live weight; NEl = net energy for lactation; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

Milk (kg)	Fat (%)	TrueProtein (%)	DMI (kg)	LW change (kg)	NEl (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
10	4.0	3.0	12.4	0.9	15.3	1,240	230	10.0	1.9	11.9
10	4.0	3.5	12.4	0.8	15.6	1,240	320	10.0	2.6	12.6
10	4.0	4.0	12.4	0.8	15.9	1,240	420	10.0	3.4	13.4
10	4.5	3.0	12.7	0.9	15.7	1,270	230	10.0	1.8	11.8
10	4.5	3.5	12.7	0.8	16.0	1,270	320	10.0	2.5	12.5
10	4.5	4.0	12.7	0.8	16.3	1,270	410	10.0	3.2	13.2
10	5.0	3.0	12.9	0.9	16.2	1,290	220	10.0	1.7	11.7
10	5.0	3.5	12.9	0.8	16.5	1,290	310	10.0	2.4	12.4
10	5.0	4.0	12.9	0.8	16.8	1,290	400	10.0	3.1	13.1
20	4.0	3.0	16.0	0.4	22.7	1,560	680	9.8	4.3	14.1
20	4.0	3.5	16.0	0.3	23.2	1,560	860	9.8	5.4	15.2
20	4.0	4.0	16.0	0.2	23.8	1,560	1,040	9.8	6.5	16.3
20	4.5	3.0	16.5	0.4	23.6	1,610	660	9.8	4.0	13.8
20	4.5	3.5	16.5	0.3	24.2	1,610	840	9.8	5.1	14.9
20	4.5	4.0	16.5	0.2	24.8	1,610	1,030	9.8	6.2	16.0
20	5.0	3.0	17.0	0.4	24.5	1,660	650	9.8	3.8	13.6
20	5.0	3.5	17.0	0.2	25.1	1,660	830	9.8	4.9	14.7
20	5.0	4.0	17.0	0.1	25.7	1,660	1,010	9.8	5.9	15.7
30	4.0	3.0	19.5	-0.1	30.1	1,870	1,130	9.6	5.8	15.4
30	4.0	3.5	19.5	-0.3	30.9	1,870	1,400	9.6	7.2	16.8
30	4.0	4.0	19.5	-0.4	31.8	1,870	1,670	9.6	8.6	18.2
30	4.5	3.0	20.3	-0.2	31.5	1,940	1,110	9.6	5.5	15.1
30	4.5	3.5	20.3	-0.3	32.3	1,940	1,380	9.6	6.8	16.4
30	4.5	4.0	20.3	-0.5	33.2	1,940	1,650	9.6	8.1	17.7
30	5.0	3.0	21.1	-0.2	32.8	2,000	1,090	9.5	5.2	14.7
30	5.0	3.5	21.1	-0.4	33.7	2,000	1,360	9.5	6.4	15.9
30	5.0	4.0	21.1	-0.6	34.6	2,000	1,630	9.5	7.7	17.2

[a]Diet used for this table consisted of 40% mid-maturity legume bay, 27% normal corn silage, 23% cracked dry shelled corn, 8% soybean meal (48% crude protein), and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NEl intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

4. **Table 14. Daily Nutrient Requirements Of Large Breed Cows (Live Weight = 680 kg) In *Early Lactation* - 11 Days in Milk** (Values Are Appropriate For The ***Diet Below With 78% TDN***)[a] [DMI = dry matter intake; LW = live weight; NEl = net energy for lactation; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

Milk (kg)	Fat (%)	TrueProtein (%)	DMI (kg)	LW change (kg)	NEl (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
20	3.0	2.5	12.0	0	23.0	1,360	500	11.3	4.2	15.5
20	3.0	3.0	12.0	-0.2	23.6	1,360	670	11.3	5.6	16.9
20	3.0	3.5	12.0	-0.3	24.2	1,360	850	11.3	7.1	18.4
20	3.5	2.5	12.4	-0.1	23.9	1,400	480	11.3	3.9	15.2
20	3.5	3.0	12.4	-0.2	24.5	1,400	660	11.3	5.3	16.6
20	3.5	3.5	12.4	-0.4	25.1	1,400	840	11.3	6.8	18.1
20	4.0	2.5	12.7	-0.2	24.9	1,440	470	11.3	3.7	15.0
20	4.0	3.0	12.7	-0.3	25.4	1,440	650	11.3	5.1	16.5
20	4.0	3.5	12.7	-0.4	26.0	1,440	820	11.3	6.5	17.8
30	3.0	2.5	14.0	-0.6	29.2	1,570	860	11.2	6.1	17.4
30	3.0	3.0	14.0	-0.8	30.1	1,570	1,130	11.2	8.1	19.3
30	3.0	3.5	14.0	-1.0	30.9	1,570	1,390	11.2	9.9	21.1
30	3.5	2.5	14.5	-0.7	30.6	1,620	850	11.2	5.9	17.0
30	3.5	3.0	14.5	-0.9	31.4	1,620	l,110	11.2	7.7	18.8
30	3.5	3.5	14.5	-1.1	32.3	1,620	1,370	11.2	9.4	20.6
30	4.0	2.5	15.1	-0.9	32.0	1,670	830	11.1	5.5	16.6
30	4.0	3.0	15.1	-1.0	32.8	1,670	1,090	11.1	7.2	18.3
30	4.0	3.5	15.1	-1.2	33.7	1,670	1,350	11.1	8.9	20.0
40	3.0	2.5	16.0	-1.2	35.3	1,760	1,230	11.0	7.7	18.7
40	3.0	3.0	16.0	-1.5	36.5	1,760	1,580	11.0	9.9	20.9
40	3.0	3.5	16.0	-1.7	37.7	1,760	1,930	11.0	12.1	23.1
40	3.5	2.5	16.7	-1.4	37.2	1,830	1,210	11.0	7.2	18.2
40	3.5	3.0	16.7	-1.6	38.4	1,830	1,560	-11.0	9.3	20.3
40	3.5	3.5	16.7	-1.9	39.6	1,830	1,910	11.0	11.4	22.4
40	4.0	2.5	17.4	-1.6	39.1	1,900	1,190	10.9	6.8	17.8
40	4.0	3.0	17.4	-1.8	40.2	1,900	1,540	10.9	8.9	19.8
40	4.0	3.5	17.4	-2.0	41.4	1,900	1,890	10.9	10.9	21.8

[a]Diet used for this table consisted of 15% immature legume silage, 33% normal corn silage, 34% ground high moisture shelled corn, 12% soybean meal (48% crude protein), 2.5% tallow, 1.5% Menbaden fish meal, and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NEl intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

5. **Table 15. Daily Nutrient Requirements Of Large Breed Cows (Live Weight = 680 kg) In *Midlactation* - 90 Days in Milk** (Values Are Appropriate For The ***Diet Below With 78% TDN***)[a] [DMI = dry matter intake; LW = live weight; NEl = net energy for lactation; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

Milk (kg)	Fat (%)	TrueProtein (%)	DMI (kg)	LW change (kg)	NEl (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
35	3.0	2.5	22.7	1.3	32.2	2,370	820	10.4	3.6	14.1
35	3.0	3.0	22.7	1.1	33.2	2,370	1,130	10.4	5.0	15.4
35	3.0	3.5	22.7	0.9	34.2	2,370	1,430	10.4	6.3	16.7
35	3.5	2.5	23.6	1.2	33.8	2,450	800	10.4	3.4	13.8
35	3.5	3.0	23.6	1.0	34.8	2,450	1,110	10.4	4.7	15.1
35	3.5	3.5	23.6	0.8	35.9	2,450	1,410	10.4	6.0	16.4
35	4.0	2.5	24.5	1.1	35.4	2,520	780	10.3	3.2	13.5
35	4.0	3.0	24.5	0.9	36.5	2,520	1,090	10.3	4.4	14.7
35	4.0	3.5	24.5	0.7	37.5	2,520	1,390	10.3	5.7	16.0
45	3.0	2.5	25.7	0.8	38.3	2,620	1,190	10.2	4.6	14.8
45	3.0	3.0	25.7	0.5	39.7	2,620	1,580	10.2	6.1	16.3
45	3.0	3.5	25.7	0.3	41.0	2,620	1,970	10.2	7.7	17.9
45	3.5	2.5	26.9	0.7	40.4	2,710	1,170	10.1	4.3	14.4
45	3.5	3.0	26.9	0.4	41.8	2,710	1,560	10.1	5.8	15.9
45	3.5	3.5	26.9	0.2	43.1	2,710	1,950	10.1	7.2	17.3
45	4.0	2.5	28.1	0.5	42.5	2,800	1,150	10.0	4.1	14.1
45	4.0	3.0	28.1	0.3	43.8	2,800	1,540	10.0	5.5	15.4
45	4.0	3.5	28.1	0	45.2	2,800	1,930	10.0	6.9	16.8
55	3.0	2.5	28.7	0.3	44.5	2,850	1,570	9.9	5.5	15.4
55	3.0	3.0	28.7	0	46.1	2,850	2,060	9.9	7.2	17.1
55	3.0	3.5	28.7	-0.4	47.7	2,850	2,540	9.9	8.9	18.8
55	3.5	2.5	30.2	0.1	47.1	2,960	1,560	9.8	5.2	15.0
55	3.5	3.0	30.2	-0.2	48.7	2,960	2,040	9.8	6.8	16.6
55	3.5	3.5	30.2	-0.6	50.7	2,960	2,510	9.8	8.3	18.1
55	4.0	2.5	31.7	-0.1	49.6	3,060	1,540	9.7	4.9	14.5
55	4.0	3.0	31.7	-0.5	51.2	3,060	2,020	9.7	6.4	16.0
55	4.0	3.5	31.7	-0.8	52.8	3,060	2,490	9.7	7.9	17.5

[a]Diet used for this table consisted of 15% immature legume silage. 33% normal corn silage, 34% ground high moisture shelled corn, 12% soybean meal (48% crude protein), 2.5% tallow, 1.5% menhaden fish meal, and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NEl intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

+ =Milk Booster

6. **Table 16. Daily Nutrient Requirements Of Large Breed Cows (Live Weight = 680 kg) In *Midlactation* - 90 Days in Milk** (Values Are Appropriate For The ***Diet Below With 68% TDN***)[a] [DMI = dry matter intake; LW = live weight; NEl = net energy for lactation; RDP = rumen degradable protein; RUP = rumen undegradable protein; CP = crude protein]

Milk (kg)	Fat (%)	TrueProtein (%)	DMI (kg)	LW change (kg)	NEl (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
25	3.0	2.5	19.6	1.0	26.0	1,940	620	9.9	3.2	13.1
25	3.0	3.0	19.6	0.8	26.8	1,940	840	9.9	4.3	14.2
25	3.0	3.5	19.6	0.7	27.5	1,940	1,070	9.9	5.5	15.4
25	3.5	2.5	20.3	0.9	27.2	2,000	600	9.9	3.0	12.9
25	3.5	3.0	20.3	0.8	27.9	2,000	820	9.9	4.0	13.9
25	3.5	3.5	20.3	0.6	28.7	2,000	1,050	9.9	5.2	15.1
25	4.0	2.5	21.0	0.9	28.4	2,060	580	9.8	2.8	12.6
25	4.0	3.0	21.0	0.7	29.1	2,060	810	9.8	3.9	13.7
25	4.0	3.5	21.0	0.6	29.8	2,060	1,030	9.8	4.9	14.7
35	3.0	2.5	22.7	0.6	32.2	2,210	990	9.7	4.4	14.1
35	3.0	3.0	22.7	0.4	33.2	2,210	1,300	9.7	5.7	15.4
35	3.0	3.5	22.7	0.2	34.2	2,210	1,620	9.7	7.1	16.8
35	3.5	2.5	23.6	0.5	33.8	2,290	960	9.7	4.1	13.8
35	3.5	3.0	23.6	0.3	34.8	2,290	1,280	9.7	5.4	15.1
35	3.5	3.5	23.6	0.1	35.9	2,290	1,600	9.7	6.7	16.4
35	4.0	2.5	24.5	0.4	35.4	2,370	940	9.7	3.8	13.5
35	4.0	3.0	24.5	0.2	36.5	2,370	1,260	9.7	5.1	14.8
35	4.0	3.5	24.5	0	37.5	2,370	1,570	9.7	6.4	16.1
45	3.0	2.5	25.7	0.1	28.3	2,470	1,370	9.6	5.3	14.9
45	3.0	3.0	25.7	-0.1	39.7	2,470	1,780	9.6	6.9	16.5
45	3.0	3.5	25.7	-0.4	41.0	2,470	2,180	9.6	8.5	18.1
45	3.5	2.5	26.9	0	40.4	2,570	1,340	9.6	5.0	14.6
45	3.5	3.0	26.9	-0.2	41.8	2,570	1,750	9.6	6.5	16.1
45	3.5	3.5	26.9	-0.5	43.1	2,570	2,160	9.6	8.0	17.6
45	4.0	2.5	28.1	-0.1	42.5	2,670	1,310	9.5	4.7	14.2
45	4.0	3.0	28.1	-0.3	43.8	2,670	1,720	9.5	6.1	15.6
45	4.0	3.5	28.1	-0.6	45.2	2,670	2,130	9.5	7.6	17.1

[a]Diet used for this table consisted of 40% mid-maturity legume hay, 27% normal com silage, 23% cracked dry shelled com. 8% soybean meal (48% crude protein), and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NEl intake minus NEl requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

7. **Table 17. Nutrient Requirements and Required Diet Nutrient Concentrations for *Fresh Cows* Fed an Example Fresh-Cow Ration** [BW = body weight; BCS = body condition score; NEl = net energy for lactation; MP = metabolizable protein; RDP = rumen degradable protein; RUP = rumen undegradable protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; NFC = nonfibrous carbohydrate; TDN = total digestible nutrient]

Breed, mature BW, and BW:	Holstein, 680 kg, and 680 kg				Jersey, 454 kg, and 454 kg	
BCS at 58 mo. of age:	3.3				3.3	
Milk fat, true protein, and lactose:	3.5, 30.0, and 4.8%, respectively				4.2, 3.6, and 4.8%, respectively	
Day in milk:	11	11	11	11	11	11
Dry matter intake input:	Model Predicted	Model Predicted + 20%	Model Predicted	Model Predicted + 20%	Model Predicted	Model Predicted + 20%
Milk production (kg)	25	25	35	35	25	25
Dry matter intake (kg)	13.5	16.1	15.6	18.8	11.9	14.3
Daily wt change (kg)	-0.9	0	-1.6	-0.6	-1.4	-0.7
Days to gain one condition score						
Days to lose one condition score	99	4,886	55	143	41	83
Energy[a]						
NEl (Mcal/day)	27.9	27.9	34.8	34.8	27.7	27.7
NEl (Mcal/kg)	2.06	1.73	2.23	1.85	2.33	1.93
Protein[b]						
Metabolizable protein (g/d)	1,643	1,725	2,157	2,254	1,801	1,875
Diet % MP	12.2	10.7	13.8	12.0	15.1	13.1
Rumen degradable protein (g/d)	1,421	1,683	1,634	1,931	1,244	1,469
Diet % RDP	10.5	10.5	10.5	10.3	10.5	10.3
Rumen undegradable protein (g/d)	949	863	1,405	1,045	1,265	1,202
Diet % RUP	7.0	5.4	9.0	5.6	10.6	8.4
% RDP+ % RUP (crude protein)[c]	17.5	15.9	19.5	15.9	21.1	18.7
Fiber and carbohydrate[d]						
NDF, min %	25-33	25-33	25-33	25-33	25-33	25-33
ADF, min %	17-21	17-21	17-21	17-21	17-21	17-21
NFC, max %	36-44	36-44	36-44	36-44	36-44	36-44
Minerals						
Absorbable calcium (g/day)	52.1	52.1	64.0	64.0	51.0	51.0
Dietary Ca, %	0.74	0.65	0.79	0.68	0.80	0.70
Absorbable phosphorus (g/day)	37.3	40.0	49.0	52.0	35.0	37.7
Dietary P, %	0.38	0.34	0.42	0.37	0.40	0.36
Mg[e], %	0.27	0.23	0.29	0.24	0.27	0.22
Cl, %	0.36	0.30	0.40	0.33	0.36	0.30
K[f], %	1.19	1.11	1.24	1.14	1.19	1.10
Na, %	0.34	0.29	0.34	0.28	0.31	0.26
S, %	0.2	0.2	0.2	0.2	0.2	0.2
Co, mg/kg	0.11	0.11	0.11	0.11	0.11	0.11
Cu, mg/kg[g]	16	13	16	13	15	12
I, mg/kg[h]	0.88	0.74	0.77	0.64	0.67	0.56
Fe, mg/kg	19	16	22	19	21	17
Mn, mg/kg	21	17	21	17	19	15
Se, mg/kg	0.3	0.3	0.3	0.3	0.3	0.3
Zn, mg/kg	65	54	73	60	67	56
Vitamin A (IU/day)	75,000	75,000	75,000	75,000	49,900	49,900
Vitarnin D (IU/day)	21,000	21,000	21,000	21,000	13,600	13,600
Vitamin E (IU/day)	545	545	545	545	363	363
Vitamin A (IU/kg)	5,540	4,646	4,795	3,978	4,193	3,490
Vitamin D (IU/kg)	1,511	1,267	1,308	1,085	1,143	951
Vitamin E (IU/kg)	40	34	35	29	31	25

Sample diet used in model to generate tables. Ingredients listed as % DM

Corn silage, normal	36.44
Corn grain, steam flaked 18.29	
Soybean meal, expellers	7.65
Soybean meal, solv. 48% CP	2.53
Legume forage hay, immature	20.17
Cottonseed, whole with lint	8.41
Calcium soaps of fatty acids	0.65
Blood meal, ring dried	1.02
Calcium carbonate	0.56
Monosodium phosphate (1 H20)	0.4
Sodium chloride	0.7
Vitamin and mineral premix	3.18

Sample "fresh cow" diet evaluation

NDF, %	31.6					
Forage NDF, %	23.7					
ADF, %	21					
NFC, %	41.4					
Undiscounted TDN, %	71					
Diet NEl (Mcal/kg), dependent on DMI	1.75	1.73	1.73	1.70	1.72	1.69
Crude protein, %	17.4					

[a] Recommended energy content of early lactation rations must be limited to prevent rumen acidosis. Cow must therefore be expected to utilize body reserves to meet energy and protein requirements of early lactation. See fiber and NFC restrictions; [b]It will be nearly impossible to meet the metabolizable protein needs of the high producing fresh cow due to low dry matter intake and the difficulty formUlating rations with such high RUP; [c]Equivalent to crude protein requirement only if RDP and RUP are perfectly balanced; [d]These are the minimum fiber (or maximum NFC) concentrations needed to maintain rumen health and milk fat test; [e]Assumes that active transport of magnesium across the rumen wall is intact. High dietary potassium and excess non-protein nitrogen often interfere with Mg absorption. Under these conditions dietary Mg should be increased to 0.3%-0.35%; [f]Heat stress may increase the need for potassium; [g]High dietary molybdenum, sulfur, and iron can interfere with copper absorption increasing the requirement; [h]Diets high in goitrogenic substances increase the iodine requirement.

8. Table 18. Nutrient Requirements of Lactating Dairy Cows as Determined Using Sample Diets [BW = body weight; BCS = body condition score; NEl = net energy for lactation; MP = metabolizable protein; RDP = rumen degradable protein; RUP = rumen undegradable protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; NFC = nonfibrous carbohydrate; TDN = total digestible nutrient]

Breed, mature BW, and BW:	Holstein, 680 kg, and 680 kg				Jersey, 454 kg, and 454 kg					
BCS at 65 mo. of age:	3.0				3.0					
Milk fat, true protein, and lactose:	3.5, 3.0, and 4.8%, respectively				4.2, 3.6, and 4.8%, respectively					
Day in milk:	90	90	90	90	90	90	90	50	120	90
Dry matter intake input:	Model Predicted	Model Predicted	Model Predicted	Model Predicted	Model Predicted	Model Predicted[a]	Model Predicted	Model Predicted[a]	Model Predicted[a]	Model Predicted + 5%[a]
Milk production (kg)	25	35	45	54.4	25	35	40	35	35	35
Dry matter intake (kg)	20.3	23.6	26.9	30	18	21.7	23.5	19.8	22.2	22.7
Daily wt change (kg)	0.5	0.3	0.1	-0.2	0	-0.2	-0.5	-0.7	-0.1	0
Days to gain one condition score	221	316	1166		3777					4247
Days to lose one condition score				544		241	110	80	532	
Energy[b]										
NEl (Mcal/day)	27.9	34.8	41.8	48.3	27.7	35.6	39.5	35.6	35.6	35.6
NEl (Mca1/ kg)	1.37	1.47	1.55	1.61	1.54	1.64	1.68	1.8	1.6	1.57
Protein										
Metabolizable protein (g/d)	1,862	2,407	2,954	3,476	1,991	2,639	2,965	2,579	2,656	2,672
Diet % MP	9.2	10.2	11	l1.6	11.1	12.2	12.6	13.0	12.0	11.8
Rumen degradable protein (g/d)	1,937	2,298	2,636	2,947	1,747	2,125	2,288	1,971	2,167	2,206
Diet % RDP	9.5	9.7	9.8	9.8	9.7	9.8	9.7	10.0	9.8	9.7
Rumen undegradable protein (g/d)	933	1,291	1,677	2,089	1,151	1,632	1,865	1,670	1,619	1,6l1
Diet% RUP	4.6	5.5	6.2	6.9	6.4	7.5	7.9	8.4	7.3	7.1
% RDP+ % RUP (crude protein)[c]	14.1	15.2	16.0	16.7	16.1	17.3	17.6	18.4	17.1	16.8
Fiber and carbohydrate[d]										
NDF, min %	25-33	25-33	25-33	25-33	25-33	25-33	25-33	25-33	25-33	25-33
ADF, min %	17-21	17-21	17-21	17-21	17-21	17-21	17-21	17-21	17-21	17-21
NFC, max %	36-44	36-44	36-44	36-44	36-44	36-44	36-44	36-44	36-44	36-44
Minerals										
Absorbable calcium (g/day)	52.1	65.0	76.5	88.0	50.7	65.2	72.4	65.2	65.2	65.2
Dietary Ca, %	0.62	0.61	0.67	0.60	0.57	0.57	0.63	0.66	0.54	0.53
Absorbable phosphorus (g/day)	44.2	56.5	68.8	80.3	41.4	54.1	60.4	52.2	54.6	55.1
Dietary P, %	0.32	0.35	0.36	0.38	0.33	0.37	0.36	0.44	0.35	0.34
Mg[e], %	0.18	0.19	0.20	0.21	0.18	0.19	0.20	0.21	0.19	0.19
Cl, %	0.24	0.26	0.28	0.29	0.24	0.26	0.27	0.28	0.25	0.25
K[f], %	1.00	1.04	1.06	1.07	1.02	1.03	1.04	1.07	1.03	1.02
Na, %	0.22	0.23	0.22	0.22	0.20	0.20	0.20	0.22	0.20	0.19
S, %	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Co, mg/kg	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Cu, mg/kg[g]	11	11	11	11	10	10	10	11	10	9
I, mg/kg[h]	0.60	0.50	0.44	0.40	0.44	0.40	0.34	0.40	0.36	0.35
Fe, mg/kg	12.3	15	17	18	14	16	17	18	16	15
Mn, mg/kg	14	14	13	13	12	12	12	13	12	12
Se, mg/kg	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Zn, mg/kg	43	48	52	55	45	49	51	54	48	47
Vitamin A (IU/day)	75,000	75,000	75,000	75,000	49,500	49,500	49,500	49,500	49,500	49,500
Vitamin D (IU/day)	21,000	21,000	21,000	21,000	13,500	13,500	13,500	13,500	13,500	13,500
Vitamin E (IU/day)	545	545	545	545	360	360	360	360	360	360
Vitamin A (IU/kg)	3,665	3,169	2,780	2,500	2,772	2,300	2,123	2,520	2,247	2,198
Vitamin D (IU/kg)	1,004	864	758	680	755	621	579	687	613	600
Vitamin E (IU/kg)	27	23	20	18	20	17	16	18	16	16
Sample diets used in model to generate tables. Ingredients listed as kg /day DM										
Corn silage, normal	8.48	8.21	5.61	12.02	8.96	7.77	7.39	7.10	7.96	8.15
Soybean meal, solv. 48% CP	1.01	1.62	1.41	2.39	2.16	2.78	1.67	2.54	2.85	2.91
Legume forage silage, mid-maturity	3.85	4.57	-	-	2.67	3.10	-	2.83	3.18	3.25
Corn grain, steam flaked	1.80	4.33	7.08	6.35	2.6	4.91	5.88	4.48	5.03	5.15
Calcium carbonate	0.04	0.07	0.09	0.02	0.06	0.04	0.03	0.04	0.04	0.04
Monosodium phosphate (1 H2O)	0.02	0.02	0.04	0.06	0.01	0.01	0.03	0.01	0.01	0.01
Soybean meal, expellers	-	-	-	-	-	-	l.16	-	-	-
Legume forage hay, immature			6.16	5.42			4.59			
Sodium chloride	0.12	0.01	0.12	0.14	0.10	0.10	0.12	0.09	0.10	0.1
Grass hay, c-3, mid-mat	4.47	3.21	0.98	0.93	0.85	0.95	0.97	-	-	-
Vitamin and mineral premix	0.54	0.49	0.51	0.49	0.50	0.50	0.50	0.45	0.51	0.52
Bermudagrass hay, coastal	-	-	0.87	-	-	-	-	-	-	-
Cottonseed. whole with lint	-	-	2.53	2.24	-	1.02	1.64	0.94	1.05	1.07
Tallow	-	-	-	0.29	-	0.24	0.21	0.22	0.24	0.25
Calcium soaps of fatty acids	-	-	-	0.29	-	0.18	0.21	0.17	0.19	0.19
Blood meal, ring dried	-	-	0.23	0.31	-	0.11	0.10	0.10	0.11	0.12
Sorghum, sudan type. silage	-	-	2.26	-	-	-	-	-	-	-

Sample diet evaluation

NEl (Mcal/kg)	1.49	1.55	1.57	1.58	1.54	1.59	1.57	1.62	1.58	1.57
Undiscounted TDN, %	65	69	71	74	69	73	75	73	73	73

[a]Diet composition is the same in all four cases of the Jersey cow producing 35 kg milk. Amount of dry matter consumed varies with days in milk and the use of predicted vs. actual dry matter intake in the model; [b]Recommended energy content of early lactation rations must be limited to prevent rumen acidosis. Cow must therefore be expected to utilize body reserves to meet energy needs at highest levels of milk production. See fiber and NFC restrictions; [c]Equivalent to crude protein requirement only if RDP and RUP are perfectly balanced; [d]These are the minimum fiber (or maximum NFC) concentrations needed to maintain rumen health and milk fat test; [e]Assumes that active transport of magnesium across the rumen wall is intact. High dietary potassium and excess non-protein nitrogen often interfere with Mg absorption. Under these conditions dietary Mg should be increased to 0.3%-0.35%; [f]Heat stress may increase the need for potassium; [g]High dietary molybdenum. sulfur. and iron can interfere with copper absorption increasing the requirement; [h]Diets high in goitrogenic substances increase the iodine requirement.

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