Feeding Dairy Cows

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The dairy feeding program affects productivity and profitability more than any other single factor. The effects of good breeding and management programs cannot be fully realized without good feeding programs. Likewise, good management of cows with good genetic potential will result in the most efficient response to good nutrition.

Feeding for high milk production is efficient since the nutrient requirement for maintenance comprises a smaller portion of the total requirement of high-producing cows. This is reflected in Table 1 by higher milk:feed ratios as production increases in DHIA production-tested herds. Therefore, feed cost per hundred weight of milk produced is less in high producing herds.

Table 1. Effects of Production Level on Milk:Feed Ratio

Milk/cow/year (lb)	12,047	15,025	18,857
Grain/cow/year (lb)	6,183	7,273	8,275
Forage dry matter/cow/year (lb)	7,151	7,784	8,096
Milk to Feed ratio	0.90	1.00	1.15

The purpose of this publication, then, is to provide the information needed to develop feeding programs for efficient milk production.

Nutrients Needed

Feeding dairy cows for efficient production involves supplying the five classes of nutrients in proper amounts. These include:

1. ENERGY. The unit of measurement of energy for dairy cows is Net Energy for Lactation (NEL). The Net Energy for Maintenance (NEM) value of feedstuffs for dairy cows is similar to NEL; therefore, the NEL value of feeds is used when calculating rations.

The main sources of energy are provided by carbohydrates and fats. Protein can be metabolized for energy, but it is an expensive source of energy. The carbohydrates of feedstuffs include starch, simple sugars, and cellulose in the crude fiber.

Dairy cows demand a large supply of energy for maintenance, milk production, reproduction, growth, and weight gain. High producing cows usually cannot consume enough feed during early lactation to meet their requirements. The energy deficiency is made-up by converting body fat to energy. However, this loss of body weight should be kept to a minimum to avoid metabolic disturbances.

The crude fiber content of forages is inversely related to energy content. As forages mature, crude fiber becomes more lignified and, thus, less digestible. Acid Detergent Fiber (ADF) is an indicator of lignification. Neutral Detergent Fiber (NDF) is a measure of the amount of cell walls in feeds. The NDF content of a feed is a good indicator of consumption since cows will eat about one pound of NDF/body cwt.

2. PROTEIN. The best sources of protein include legume forages and the oil seed meals. Grain and non-legume forage are somewhat deficient in protein and usually require supplementation for dairy rations.

Protein is required for maintenance, milk production, reproduction, and growth. Unlike energy, protein cannot be mobilized in significant amounts when the requirement is greater than the demand. Therefore, adequate amounts of protein must be supplied daily in order to avoid depressed milk production.

Dairy rations have traditionally been balanced for the Crude Protein (CP) requirements. More recently, some research has shown that the CP of some feeds is converted to ammonia too readily in the rumen and, therefore, is absorbed and wasted in the urine. The CP which is converted to ammonia is designated Degraded Intake Protein (DIP), also known as soluble protein. Since high-producing dairy cows require large amounts of CP, the possibility exists that ammonia is released from certain feeds more rapidly than the rumen microbes can convert it into microbial protein.

The portion of crude protein which is not converted to ammonia in the rumen is termed Undergraded Intake Protein (UIP), also known as by-pass protein. Since the proportion of UIP to DIP varies somewhat in different feeds, the National Research Council's Subcommittee on

Dairy Cattle Nutrition has made recommendations for the UIP and DIP content of rations *(Appendix Table 2)*. However, the UIP content of many feeds has not been determined, or the UIP content of some feeds is based upon a limited number of samples. Therefore, general recommendations for the requirements of UIP and DIP is based upon limited data. It appears that performance will be equal with slightly less CP in the ration using UIP and DIP guidelines. However, precaution should be taken to not feed too much UIP since milk production, DM consumption and milk protein test may be reduced.

3. MINERALS. The major minerals not adequately supplied by most feedstuffs are (1) calcium, (2) phosphorus, and (3) salt. In certain localities, magnesium may need to be supplemented and rations containing extremely large amounts of grain and small amounts of forage may need supplemental potassium.

Calcium and phosphorus are necessary for maintenance, milk production, reproduction, and growth. Most rations will require supplementation with calcium and phosphorus.

Salt is required for metabolic purposes and to maintain osmotic pressure in the body tissues. It is recommended that trace mineralized salt be supplemented to insure adequate supplies of trace minerals.

4. VITAMINS. With the exception of vitamins A and D, the other vitamins needed by dairy cows are generally believed to be present in adequate amounts in normal feedstuffs or are manufactured in adequate quantities by microorganisms in the rumen. Supplementation at the rate of 2,000 I.U. vitamin A and 1,000 I.U. vitamin D per pound of grain mix is adequate.

5. WATER. Although not thought of as a nutrient, large quantities of water are required by dairy cows for normal metabolic functions. Depending upon the temperature and the moisture content of feedstuffs, dairy cows will consume from 3 to 5 pounds of water for each pound of milk produced.

Selecting a Forage Program

Every dairy feeding program should be built around quality forages. The grain mix portion of the ration is fed only to supplement the deficiencies of the forages. Even though grain mixes can be formulated to supplement any forage, the performance of dairy cows will be limited when poor quality forage is fed because the amount of consumption will be reduced.

There is no single best forage program, all have some advantages and disadvantages which include:

	Advantages	Disadvantages
Hay	1. Protein content can be high 2. Some hay is desirable in the ration to maintain rumen function 3. Low equipment and facilities cost	1. High labor requirement 2. Waste may be a problem 3. Greater risk from weather at harvest 4. Tonnage is usually lower than row-crop silage
Haylage	1. Protein content can be high 2. Adapted to automation 3. Less weather risk at harvest 4. Reduced waste	1. Nutrient loss from spoilage can be significant 2. High investment in equipment and facilities 3. Limited market for surplus forage 4. Tonnage is usually lower than row-crop silage
Row-Crop Silage	1. High tonnage 2. Adapted to automation 3. Reduced waste	1. High investment 2. Low protein content 3. Nutrient loss from spoilage can be high 4. Limited market for surplus
Pasture	1. Low harvesting cost 2. Reduces time spent on concrete 3. Manure is spread	1. Not well adapted to large herds or confinement systems 2. Quality varies through the season

The final basis for selecting a forage program should depend on the equipment and facilities available and/or the availability of capital. To a lesser extent, the forage program selected will be affected by the soil type and availability of labor.

Selecting Forages

Alfalfa makes up at least a portion of the ration for most dairies. Although it is not absolutely essential in dairy rations, most producers prefer to include at least six to eight pounds in the ration. Alfalfa is very palatable and can provide a significant part of the protein, energy and mineral requirements, which makes it extremely valuable when protein supplements are expensive. Yet, the quality of alfalfa can be quite variable, depending on the stage of maturity at harvest, and the harvest and spoilage losses.

Alfalfa should be harvested at the bud stage of maturity or when regrowth is starting at the root crown. Waiting longer will reduce protein and increase fiber, resulting in lower quality forage. When making hay, care should be taken to avoid leaf loss, but heat damage to the protein may occur if alfalfa is baled too wet.

The moisture content of alfalfa haylage affects quality. Alfalfa haylage which is too wet will lack palatability due to undesirable fermentations, while haylage which is too dry will heat in the silo, causing reduced protein digestibility as evidenced by brown discoloration. Ideal moisture content is 55 to 65 percent for haylage.

Brome can be a good hay crop for dairy cows, but quality can be quite variable. After the brome plant starts heading, fiber content is increased and protein content is decreased. For best results brome should be cut while in the boot stage of maturity.

Cereal crops such as wheat, oats, rye, and triticale can make good hay or haylage. The protein content is good and fiber is reasonably low if harvested in the boot stage. Quality deteriorates rapidly past the boot stage.

Fescue can be a productive forage crop, but the palatability may limit consumption. For this reason it should not provide a major portion of a forage program, other than for dry cows and heifers.

Sudan and Sorghum-Sudan crosses can be used for summer pasture, green chopping, hay, or haylage. Stage of maturity affects the quality of these crops drastically. For best results, these forages should be harvested when less than 30 inches high. Also, during periods of stress, nitrate and prussic acid may accumulate and be toxic.

Corn Silage is recognized as the choice for row-crop silage. Its high yield of palatable energy-rich forage makes it the choice for row-crop silage where corn can be grown. However, corn silage is deficient in protein, and more expensive feeding programs may result when protein supplements are expensive.

The protein content of corn silage can be increased significantly by the addition of anhydrous ammonia. The moisture content (about 65 percent) and acidity of corn silage makes the utilization of anhydrous ammonia very effective when added at the rate of 7 pounds per ton. On a day matter basis, the protein content can be increased from 2 to 4 percentage points after ammoniation.

Sorghum Silage is used extensively in dairy forage programs, but compared to corn silage, dairy cows utilize only about 80 percent as much of the available energy in sorghum silage. More than likely, the reduced energy value of sorghum silage is due to seed passing through the digestive system undigested. So, sorghum silage production should be limited to areas where corn silage cannot be grown and limited to less than 50 percent of the forage DM intake.

The protein content of sorghum silage is similar to corn silage and is low compared to alfalfa. The use of anhydrous ammonia in sorghum silage is recommended.

Selecting Concentrates

Grains commonly used in dairy rations include: corn, milo, barley, oats, and wheat. Their major function is a source of energy. Barley, oats, and wheat can contribute significantly to the protein content of the ration, but palatability problems may occur when the grain mixture exceeds 40 percent wheat. The main consideration in selecting grains for dairy rations is price.

High moisture corn and milo are used extensively in dairy rations. These feeds are quite palatable but do not offer any nutritional advantages compared to dry grain. It has been shown that high moisture grains are equal to dry grains on a dry matter basis. When formulating rations containing high moisture grain, adjustments should be made to account for their lower dry matter content.

Protein supplement is required in most grain mixtures for dairy cows. Because the dairy cow is a ruminant, there are a variety of protein supplements which can be fed with good results.

Soybean meal is fed extensively in Kansas, mainly due to price. Other oil seed meals, such as cottonseed meal and linseed meal, may be fed with good results when favorably priced.

Occasionally, soybeans are competitive, price-wise, with other protein supplements and are a good supplement when a few restrictions are considered. First, the high oil content of soybeans (18 percent) causes a laxative effect when more than 20 percent of the grain mix is soybeans. The high oil content does increase the energy content about 20 percent above soybean meal, while the protein content is reduced from 44 percent in soybean meal down to 38 percent in soybeans. Second, soybeans need to be ground fresh (about every week) to avoid rancidity in the oil. Third, urea should not be mixed with raw soybeans since it will be converted to ammonia due to the urease contained in raw soybeans and will cause palatability problems.

Commercial protein supplements are used extensively in dairy rations. They are usually made from soybean meal and other by-product feeds. Most commercial supplements will be supplemented with vitamins and minerals, which can be convenient for on-the-farm mixing.

Some commercial supplements contain urea and therefore will have less energy. The urea content of commercial supplements can be estimated by dividing the "equivalent crude protein from non-protein nitrogen (NPN)" by 2.81. *Example:* The feed tag shows the equivalent crude protein from NPN as not more than 12 percent, then the urea percentage is: 12 divided by 2.81 = 4.2 percent urea.

Urea is a source of NPN which can be added to grain mixes as a source of protein. Although urea does not add protein as such, it furnishes ammonia which can be incorporated into the building blocks of protein—amino acids—by the microorganisms in the rumen. Urea contains no energy, therefore, carbohydrates from other ingredients in the ration must furnish carbon for the formation of amino acids. Urea is unpalatable in grain mixes and may result in poor consumption, particularly when fed in the milking parlor. The amount of urea fed should be limited to about 0.25 pound per cow daily. For best results, urea should be incorporated with silage to mask the palatability problem and to allow the cows to consume it at a slower rate.

By-product feeds are common ingredients in commercial feeds and are being fed as individual ingredients in many dairy rations. Many by-products can be good sources of energy and/or protein at reasonable cost if freight is not too expensive.

- Brewers dried grains is a medium protein feed with a relatively high UIP value. It has about 75 percent as much energy as corn due to its relatively high fiber content. Brewers dried grains tends to be bulky and dusty and palatability may be a problem when included in grain mixtures at rates higher than 25 percent or nine pounds/cow daily.

- Corn gluten feed is a medium protein by-product which contains about the same energy as milo. It can be unpalatable when included in grain mixtures at levels higher than 25 percent or when fed at rates higher than nine pounds/day.

- Corn gluten meal is a concentrated source of relatively high UIP protein. It is usually not included in grain mixtures at levels greater than 15 percent or fed at a rate greater than five pounds/day due to poor palatability. Also, the requirement for UIP may be exceeded when fed at high levels.

- Whole cottonseed is an excellent source of protein, energy and fiber. Due to its lint, cottonseed contains about 22 percent crude fiber or 31 percent ADF (as fed) making it desirable to feed in high-energy rations which are low in fiber. Since cottonseed contains 22 percent oil, the amount fed should be limited to about six pounds/cow daily.

- Cottonseed hulls is a by-product which is low in protein and energy and high in fiber. Sometimes it is included in high-energy rations to increase the fiber content.

- Distillers dried grains is a good energy source and medium in protein with relatively high UIP. Its nutrient content will vary depending on the original grain source. Distillers dried grains is a palatable feedstuff and can be fed in large amounts.

- Hominy feed is slightly higher than corn in energy and protein content. The fat content can be variable depending on the manufacturing process, so the fat content should be guaranteed by the supplier. Hominy feed is palatable, but it may not flow well through automated feeding systems.

- Soy hulls is a by-product which is similar to milo in nutrient content. It may make up 45 percent of grain mixtures or be fed up to 12 pounds/cow daily.

- Wheat bran is higher in protein, phosphorus and fiber than grains but is lower in energy. It is bulky and, therefore, will not flow through feeding systems unless mixed with other grains. Wheat bran is palatable, but should be limited to 25 percent of the grain mixture or 7 pounds/cow daily due to its laxative nature.

- Wheat mids is higher in protein and lower in energy than most grains: It is palatable and can be fed in large amounts if dustiness is not a problem.

Feed Additives

Minerals requiring supplementation in dairy rations include: (1) calcium, (2) phosphorus, and (3) salt (sodium and chlorine). Large quantities of calcium and phosphorus are needed for milk production. Many mineral supplements are available for supplementing calcium and phosphorus, and the basis for selecting a supplement should depend on the content of these elements in the supplement in relation to their requirements for supplementation. Salt is required for supplementing sodium and chlorine. Rations which include sodium bicarbonate may not require supplemental sodium; however, salt should be force fed at the rate of 0.5 percent of the grain mix to prevent a chlorine deficiency.

Trace Minerals are usually considered available in adequate amounts in most Kansas grown feeds. However, a trace mineral premix or trace mineralized salt is recommended to ensure that adequate amounts of trace minerals are fed.

Antibiotics have been added to dairy rations to reduce stress. However, considering the level permissible in dairy rations (70 mg/day), it is doubtful that the addition of antibiotics in rations for lactating dairy cows is beneficial. Antibiotics fed in excess can be secreted in milk.

Fats and oils are considered as additives for supplementing energy since the caloric content is 2.25 times that of carbohydrates. Addition of fat or oil can increase the energy concentration of a grain mixture significantly, but should only be considered when it is not feasible to feed more grain to high producing cows. The rate of supplementing fat or oil to grain mixes should be limited to 1 lb/cow daily.

Molasses can be added to control dustiness and improve palatability of grain mixes, especially for parlor feeding. There is no need for molasses in grain mixtures to be fed outside because palatability is usually not a problem. Molasses is a readily available source of carbohydrates but is not a concentrated source of energy. The addition of molasses should be limited to less than 5 percent of the grain mix since digestibility of other carbohydrates may be depressed.

Buffers are needed in high energy rations to control the acidity of the rumen. Depressed milk fat tests and digestive upsets may occur if the ration is not buffered properly. Sodium bicarbonate fed at the rate of 1.5 percent of the grain mix is effective for this purpose. Magnesium oxide, although not a true buffer of the rumen, can improve milk fat tests when fed at the rate of 0.75 percent of the grain mix in combination with 1.5 percent sodium bicarbonate. Sodium bentonite, a clay mineral, fed at the rate of 5 percent of the grain mix, has improved milk fat tests somewhat, although not as effectively as a sodium bicarbonate-magnesium oxide combination. Calcium carbonate has been referred to as a buffer, but it is not soluble in the rumen and therefore will only buffer the small intestine. Its need has not been well demonstrated.

Feeding Systems

The goal of any feeding system on a modern dairy farm should be to deliver the correct amount of nutrients needed to meet the individual cow's requirements. This means the system can provide more nutrients to high producers and can restrict nutrient intake to lower-producing cows. Therefore, in one fashion or another, a good feeding system splits cows into production groups and provides nutrients according to production requirements.

Although the split herd system is not the most common feeding system in Kansas, it offers several advantages over a one-group feeding system. Most herds are not split into production groups because of limited herd size or because the existing facilities do not adapt well to the split herd system. If the herd size is large enough, four production groups (high, medium and low) are recommended, plus a group of first lactation heifers. Of course, an additional group for dry cows is always recommended whether the split herd system is used or not.

Herds split according to production can be managed more efficiently at milking time, and heat detection and breeding can be handled more efficiently. Cows grouped by production milk-out at a uniform rate, smaller groups mean less time in the holding pen, and most of the postpartum reproductive exams, heat detection, and pregnancy exams can be done in the high-production group.

Feeding can be done efficiently with the split herd system, thus reducing the problem of underfeeding some cows and overfeeding others. Also, in some situations, the quality of the forage can be selected according to production. A disadvantage of the split herd system is that cows have to go through some adjustments when moved from one group to another.

The following are some feeding systems that may adapt to a split herd or non-split herd system.

SPLIT HERD

1. Hay and Grain

A. Magnet or computer feeder can be used.
B. One forage program eliminates selective feeding.
C. Buffer needed only for high producers.
D. Only one forage harvesting system needed.
E. Inexpensive storage.

2. Hay, Silage and Grain

A. Magnet or computer feeder can be used.
B. Selective feeding can be a problem.
C. Buffer needed only for high producers.
D. More investment in forage harvesting equipment.
E. More expensive storage in permanent structures.
F. More automation.
G. More feed produced/acre.

3. Total Mixed Ration (TMR)

A. Eliminates selective feeding.
B. Grain consumed at slower rate.
C. Magnet or computer feeder can be used.
D. More automation.
E. Best adapted to silage program.
F. Requires additional equipment.
G. Buffer needed only for high producers.

NON-SPLIT HERD

1. Hay and Grain

A. Magnet or computer feeder should be used.
B. One forage program eliminates selective feeding.
C. Buffer needed for all cows.
D. Only one forage harvesting system needed.
E. Inexpensive storage.

2. Hay, Silage and Grain

A. Magnet or computer feeder should be used.
B. Selective feeding can be a problem.
C. Buffer needed for all cows
D. More investment in forage harvesting equipment.
E. More expensive storage in permanent structures.
F. More automation.
G. More feed produced/acre.

3. Total Mixed Ration (TMR)

A. Eliminates selective feeding.
B. Grain consumed at slower rate.
C. Magnet or computer feeder should be used.
D. More automation.
E. Best adapted to silage program.
F. Requires additional equipment.
G. Buffer needed for all cows.

Throughout this discussion parlor feeding has not been mentioned. It is felt that parlor feeding only complicates a feeding program. There can be little control over amounts consumed in the parlor, and most high-producing cows need additional grain mix. Therefore, it is difficult to feed the correct amounts of additional nutrients outside. One of the most common reasons for feeding in the parlor is to encourage the cows to come into the parlor. However, cows that are coming into the parlor because they are hungry have been hungry too long!

Computerized Feeders

Computerized feeding systems provide a means of feeding cows individually. Herds which are not split according to production face the problem of overfeeding low producers and underfeeding high producers–both are expensive. The magnet feeding system can eliminate the problem of underfeeding, but in most cases, some cows are overfed. The economic advantage of a computerized feeding system would be due to increased production and/or reduced grain cost. Other advantages include:

- Feeding additional supplements to fresh cows with dual ration systems.
- Starting cows on feed in rapid step-wise fashion.
- Reducing grain consumption gradually as production decreases.
- Detecting abnormal conditions of cows by monitoring grain consumption.

To evaluate the potential economic advantage of a computerized feeding system, a producer needs to estimate how much grain could be saved by feeding the low-producing cows less and how much production could be increased by feeding the high producers more. This evaluation can be made by comparing the amount of grain fed versus grain needed for each cow on the DHIA-200 report. An example herd shows the following:

	No.	lbs grain	Expected Change in Milk
Cows overfed	27	96	
Cows underfed	29	-66	+132
Cows no change	12	—	—
	68	-30 lb	+132

In this herd the average grain consumption was about equal to the amount of grain needed. However, there were 27 cows being overfed and 29 cows being underfed. Assuming a 2-lb increase in milk production for each additional pound of grain, there could be 132 lb extra milk produced daily by feeding 66 lb more grain to the underfed cows. Additional savings could be realized by feeding 96 lb less grain to the overfed cows. Hence, the economic advantage of a computerized feeding system can be substantial, depending on the price of milk and grain.

Balancing Dairy Rations

The summit milk yield and stage of lactation profile of a herd *(Figure 1)* can be a reflection of the feeding program. High-producing herds establish a higher summit milk yield after freshening than lower producing herds, probably due to nutrition. After the summit milk yield has been established, the stage of lactation profile indicates that higher production is maintained throughout all stages of lactation. Therefore production in lower producing herds seems to be limited by nutrition early in lactation. Since the rate of decline of the stage of lactation profile is similar regardless of production level, it is absolutely essential to obtain high summit milk yields in order to obtain high total lactation yields. Therefore, feeding balanced rations is needed for high production.

Dairy rations are balanced by calculating the amount of grain mix needed to supplement the requirements for energy, protein, calcium, and phosphorus which are not supplied by forages. It is not feasible to balance a ration for each cow in the herd, and it is not recommended to balance one ration for an entire herd. Instead, rations should be balanced for production groups in order to avoid underfeeding the high-producing cows and overfeeding the low producers.

The following procedures are suggested for balancing the ration for a herd split into two production groups with average body weights of 1,300 lb which are producing 60 lb of 3.5 percent milk fat and 40 lb of 4.0 percent milk fat. The calculations for balancing the ration for the higher producing group are shown in *Table 3.* Similar calculations would be made for the lower producing group.

■ **Step 1. Determining Nutrient Requirements.** Nutrient requirements are affected by (1) maintenance (body size), (2) milk and milk fat production, and (3) body weight gain. The nutrient allowance for pregnancy is not significant until the last two months of gestation when cows are normally dry.

When determining the requirements for milk production, always balance for a higher level of production than the group is averaging. If the herd is grouped by production, the level of production of the high group should be estimated about 15 pounds more than the

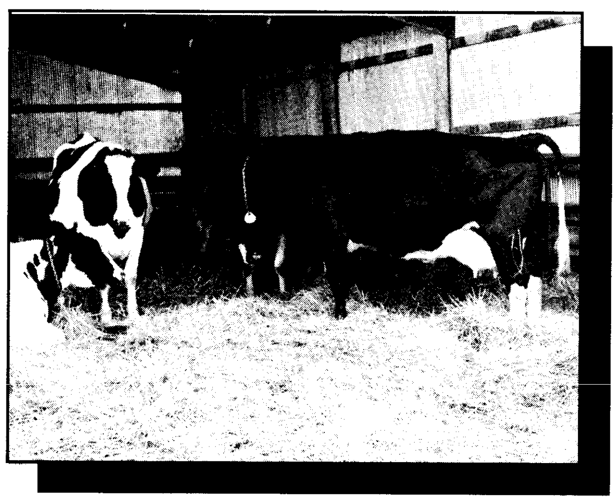
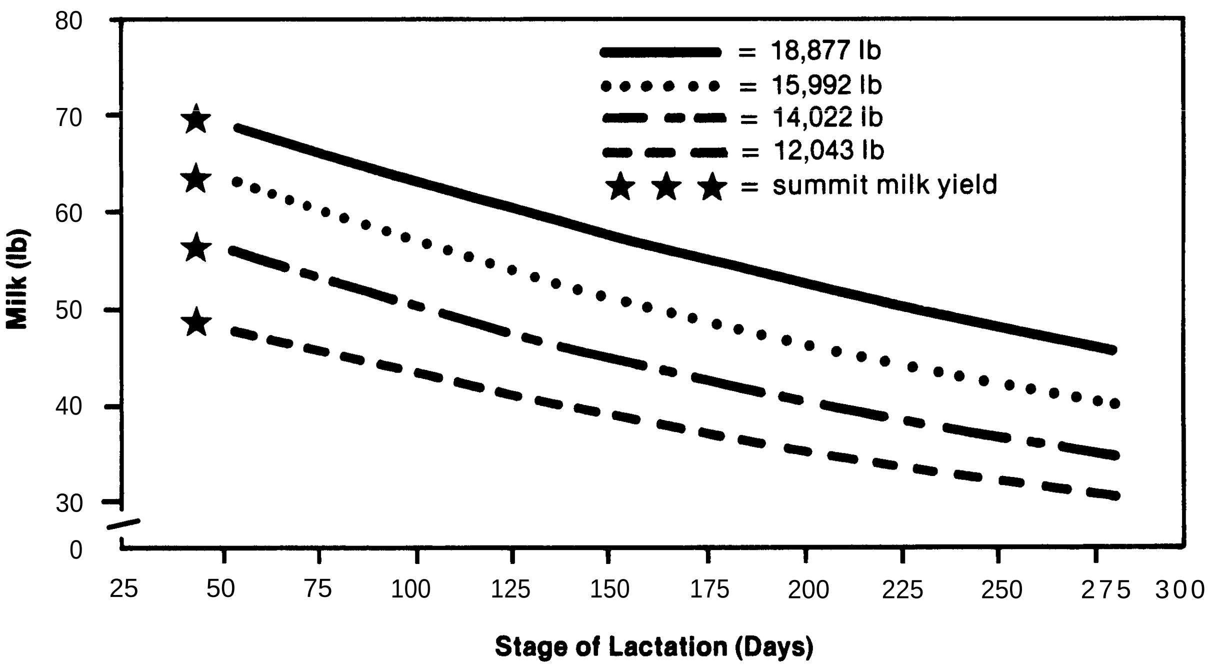


Figure 1. Comparison of Rolling Herd Average (RHA), summit milk yield, and stage of lactation profile of DHIA herds.



group average. The requirements for production should be about 5 pounds above average for the low-producing group. If the herd is not grouped, then the production requirements should be estimated at about 30 percent above the average production. Growth requirements can be estimated by increasing the nutrient allowances for maintenance by 20 percent for first lactation cows and 10 percent for second. A typical herd will need about 15 percent added to the maintenance allowance for growth.

Nutrient requirements for maintenance, maintenance plus pregnancy, milk production at various milk fat percentages and weight gain are shown in *Appendix Table 1.* To determine the requirement, select the maintenance requirement which corresponds to the average body size of the cows and the production requirement corresponding to the milk fat percentage of the group. The production requirement is then multiplied by the pounds of milk. In this example, the production requirements would be multiplied by 75 pounds (15 pounds above group average.)

■ **Step 2. Determining Forage Intake.** Dairy cows should be fed all the forage they will consume. However, there are limits as to how much forage dairy cows can eat. Normally, the maximum consumption of high quality forage dry matter will be about 2 1/2 percent of body weight when no grain is fed. Somewhat less consumption can be expected from lower quality forages. An average herd will consume about 1.8 percent of body weight as forage dry matter when enough grain is fed to meet requirements. When a herd is split, the high-producing cows will probably consume about 1.6 percent of their body weight as forage dry matter and the lower producing cows will consume about 2 percent of body weight. This means a group of high-producing cows weighing 1,300 pounds would eat 20.8 pounds of dry matter from forage while the lower producers would average 26 pounds.

■ **Step 3. Calculate Nutrients from Forages.** The values for energy, protein, calcium, and phosphorus are shown in *Appendix Table 2* on a dry matter basis. Calculate the nutrients supplied by the forages by multiplying the pounds of forage by the content of nutrients shown in the table, or better yet, from a forage analysis.

■ **Step 4. Determine Nutrients Required in Grain Mix.** Subtract the nutrients supplied by the forages (Step 3) from the nutrient requirements (Step 1).

■ **Step 5. Determine the Pounds of Grain Mix Needed.** Divide the energy required from the grain mix by its energy content. Most grain mixes will contain about 0.76 Mcal/lb of NEL on an as-fed basis.

■ **Step 6. Determine Protein Percentage of Grain Mix.** Divide the pounds of protein needed in the grain mix by the pounds of grain mix required.

■ **Step 7. Determine Calcium Percentage of Grain Mix.** Divide pounds of calcium required in grain mix by the pounds of grain mix required.

■ **Step 8. Determine Phosphorus Percentage of Grain Mix.** Divide pounds of phosphorus required in grain mix by the pounds of grain mix required.

Table 3. BALANCING DAIRY RATIONS. Group of 1,300 lb cows producing 75 lbs with 3.5% milk fat and consuming 10 lb average quality alfalfa hay and 36 lb of corn silage.

Step 1		**lbs**	**NEL (Mcal)**	**Protein (lbs)**	**Calcium (lbs)**	**Phosphorus (lbs)**
Maintenance*		1,300	11.04	1.47	0.061	0.043
Production		75(3.5%)	23.25	5.93	0.225	0.135
Weight Gain			2.32	0.32	—	—
Total Requirements			36.61	7.72	0.286	0.178
Step 2 and 3						
Nutrients from Forages	**lb**	**lb D.M.**	**NEL (Mcal)**	**Protein (lb)**	**Calcium (lb)**	**Phosphorus (lb)**
Alfalfa	10.0	9.0	5.58	1.53	0,068**	0.021
Corn Silage	36.0	11.8	8.50	.94	0.032	0.024
Total	46.0	20.8	14.08	2.47	0.100	0.045
Average			0.68Mcal	1 1.9%	0.48%	0.21%
Step 4 (Step 1 -Step 3)						
Nutrients Required in Grain Mix			22.53Mcal NEL	5.25lb Protein	0.186lb Calcium	0.133lb Phosphorus

Step 5
Grain needed for Energy = 22.53 Mcal ÷ by 0.76 Mcal/lb = 29.6 lb grain

Step 6
Percent Protein Required in Grain = 5.25 lb ÷ by 29.6 lb X 100 = 17.7% protein

Step 7
Percent Calcium Required in Grain = 0.186 lb ÷ by 29.6 lb X 100 = 0.63% calcium

Step 8
Percent Phosphorus Required in Grain = 0.133 lb ÷ by 29.6 lb X 100 = 0.45% phosphorus

**The maintenance requirement has been increased by 15% for growth of young cows.*
***The calcium content of alfalfa has been reduced by 40% due to low availability.*

Ration Formulation

After determining the protein, calcium and phosphorus percentages needed *(Table 3)*, the grain mixture can be formulated by using Pearson's Square as follows:

Step 1. Write the desired percentage of the nutrient in the center of the square.

Step 2. Write the percentage of the nutrient in the grain and the supplement in the upper and lower left corners of the square respectively.

Step 3. Subtract diagonally across the square the smaller value from the larger and place the results at the right corner diagonally across from the left corner. The values at the upper right corner corresponds to the parts of the ingredient at the upper left corner and likewise for the lower figures. In the first examples, 26.3 parts of shelled corn and 8.7 parts of soybean meal will result in a mixture containing 17.7 percent protein.

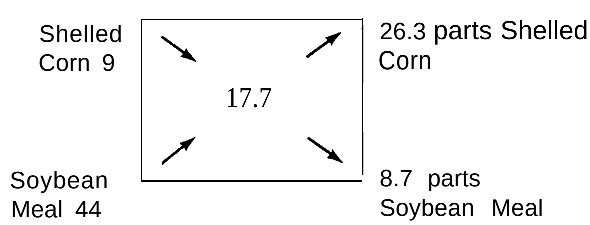
Step 4. To convert to percentage, divide the parts of the ingredient by the total parts of both ingredients and multiply by 100.

Example: 8.7 ÷ (26.3 + 8.7) X 100 = 24.9% soybean meal.

Step 5. Multiply the percentage of the ingredient by the size of the batch to obtain the total pounds of that ingredient in the batch.

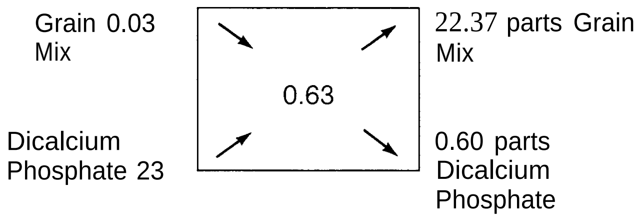
Example: 24.9% x 2,000 lb = 498 lb soybean meal.

Example Calculations
Protein percent = 17.7



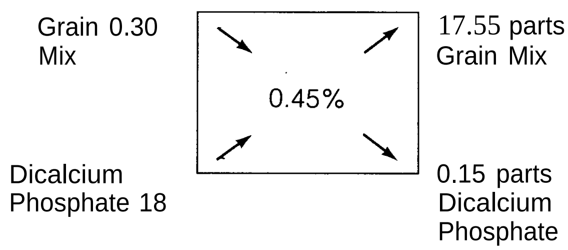
Soybean meal = 8.7 ÷ (26.3 + 8.7) X 100 = 24.9% soybean meal

Calcium percent = 0.63



Dicalcium Phosphate % = .60 ÷ (22.37 + 0.60) X 100 = 2.6%
Dicalcium Phosphate

Phosphorus percent = 0.45



Dicalcium Phosphate percent = 0.15 ÷ (17.55 + 0.15) X 100 = 0.8%

In this example, dicalcium phosphate would be added at the rate of 2.6 percent of the grain mix in order to meet the requirement for calcium. A less expensive ration could be formulated by adding 0.8 percent dicalcium phosphate for the phosphorus requirement and adding limestone for the remainder of the calcium supplement as follows:

2,000 X 0.8% dicalcium phosphate = 16 lb/ton

16 lb dicalcium phosphate X 23% calcium = 3.7 lb calcium supplied by dicalcium phosphate.

Calcium required = 52 lb dicalcium phosphate x 23% = 12.0 lb

Limestone required = (12.0 lb -3.7 lb) ÷ .38 = 23 lb limestone/ton.

A 2,000 lb batch of grain mix would include:

		percent
Shelled Corn	1,424lb	71.2
Soybean Meal	498 lb	24.9
Dicalcium Phosphate	16 lb	0.8
Limestone	22 lb	1.1
Sodium Bicarbonate *	30 lb	1.5
Trace Mineralized Salt **	10 lb	0.5
Vitamin A ***	4,000,000 units	2,000/lb
Vitamin D ****	2,000,000 units	1,000/lb

*Sodium Bicarbonate should be added to the grain mix at the rate of 1.5 percent when feeding more than 25 lb grain/cow daily.
**Trace mineralized salt is recommended for all grain mixes at 0.5 percent.
***Vitamin A is recommended at 4,000,000 units/ton.
****Vitamin D is recommended at 2,000,000 units/ton.

Balancing Total Mixed Rations

Similar procedures would be used as in the above example to formulate a total mixed ration (TMR). The rate of grain feeding was determined to be 29.6 pounds/day, so the amount of each ingredient would be determined by its percentage in the grain mix. The TMR for the above example would be as follows:

	Per Cow Daily
Alfalfa Hay	10.0 lb
Corn Silage	36.0 lb
Shelled Corn (29.6 X 71.2%)	21.1 lb
Soybean Meal (29.6 X 24.9%)	7.4 lb
Dicalcium Phosphate (29.6 X 0.8%) x 16	3.8 oz
Limestone (29.6 x 1.1%) X 16	5.2 oz
Sodium Bicarbonate (29.6 X 1.5%) x 16	7.1 oz
Trace Mineralized Salt (29.6 X 0.5%) X 16	2.4 oz
Vitamin A (29.6 X 2,000 U)	59,200 U
Vitamin D (29.6 X 1,000 U)	29,600 U

Another procedure for balancing a TMR is to formulate the TMR based upon the nutrient concentration required in the DM. *Appendix Table 2* shows the total dry matter intake (DMI) and forage DMI along with the nutrient concentrations required in the DM. The following steps are used to formulate a TMR for early lactation cows.

Step 1. Determine total and forage DMI. If the group average body weight is 1300 pounds, and the rate of total DMI and forage DMI is 3.8 and 1.5 percent *(Appendix Table 2)* respectively, then the cows would be expected to consume 49.4 pounds DM and 19.5 pounds forage DM. Therefore, the amount of grain mix DMI would be 29.9 pounds (49.4 lb -19.5 lb). If the grain mix contains 88 percent DM, then 34 pounds of grain mix would be needed (29.9 ÷ 0.88).

Step 2. Calculate nutrient content of forages.

	lb	DM lb	NEL Mcal	Protein lb	Calcium lb	Phosphorus lb
Alfalfa Hay	10	9.0	5.58	1.53	0.068	0.021
Corn Silage	30	10.5	7.56	.84	0.028	0.021
Total	40	19.5	13.14	2.37	0.096	0.042
Average		48.8%	0.67	12.2%	0.49%	0.22%

Step 3. Calculate nutrients required in grain mix.

A. Total Protein (lb) = Total lb DM X % Protein Required = 49.4 lb DM X 18% Protein = 8.89 lb Protein

B. Grain Mix Protein (lb) = Total Protein - Forage Protein = 8.89 lb -2.37 = 6.52 lb Protein

C. Grain Mix Protein (%) = (6.52 lb ÷ 34 lb) X 100 = 19.2% Protein

D. Total Calcium (lb) = Total DM X % Calcium Required = 49.4 lb X 0.70% = 0.346 lb Calcium

E. Grain Mix Calcium (lb) = Total Calcium - Forage Calcium = 0.346 - 0.096 = 0.25 lb Calcium

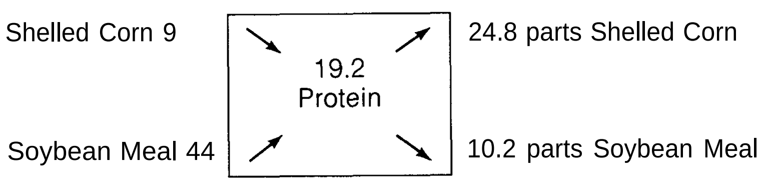
F. Grain Mix Calcium (%) = (0.25 lb ÷ 34 lb) X 100 = 0.74% Calcium

G. Total Phosphorus (lb) = Total DM X % Phosphorus Required = 49.4 X 0.45% = 0.222 lb Phosphorus

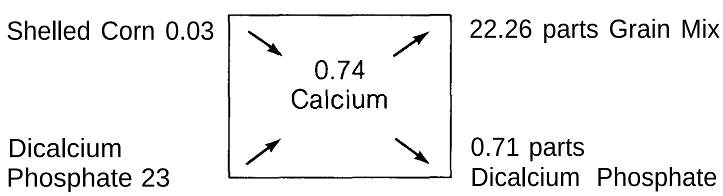
H. Grain Mix Phosphorus (lb) = Total Phosphorus - Forage Phosphorus = 0.222 lb - 0.042 lb = 0.018 lb Phosphorus

1. Grain Mix Phosphorus (%) = (0.18 lb ÷ 34 lb) X 100 = 0.53% Phosphorus

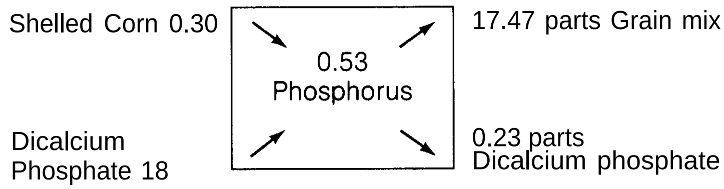
Step 4. **Determine amounts of supplement and grain required using Pearson's Square.**



Soybean Meal % = 10.2 ÷ (10.2 + 24.8) X 100 = 29.1%



Dicalcium Phosphate % = 0.71 ÷ (22.26 + 0.71) X 100 = 3.1% Dicalcium Phosphate



Dicalcium Phosphate % = 0.23 ÷ (17.47 + 0.23) X 100 = 1.3%
Dicalcium Phosphate

Step 5. Grain mix formulation

	Pounds	%	Per Cow Daily
Shelled Corn	1,316	65.8	22.4 lbs.
Soybean Meal	582	29.1	9.9 lbs.
Dicalcium Phosphate	62	3.1	16.0 oz.
Sodium Bicarbonate	30	1.5	8.0 oz.
Trace Mineralized Salt	10	0.5	2.7 oz.
Vitamin A (IU)	4,300,000		73,100 IU
Vitamin D (IU)	1,400,000		23,800 IU
Vitamin E (IU)	20,750		352 IU

Managing Feeding Programs

Cows should be fed and managed according to the production cycle—early, mid, and late lactation and two stages of the dry period. The nutritient requirements are shown in Appendix Table 2.

1. Early lactation
   - A. Cows should be fed for production.
   - B. Cows should be challenged with a high energy ration soon after calving. Waiting longer than a few days may cause digestive upsets.
   - co Feed additional protein *(Appendix Table 2)* to stimulate summit milk yield.
   - D. Fresh cows should be milked out completely.
2. Mid lactation
   - A. Cows should be fed **according** to production.
   - B. Cows should be gaining weight and bred by this time.
3. Late lactation
   - A. Cows should be fed **according** to body condition.
   - B. Cows should gain enough body condition to be well covered with fat at dry-off.
4. Dry period
   - A. Cows should be fed **according** to body condition.
   - B. Cows should be well covered with fat without developing fat pads over the pin bones.
   - C. Thin cows should be fed additional grain mix (up to one percent of body weight).
   - D. Grass hay or pasture is the preferred forage.
5. Prepartum period
   - A. Cows should be **adjusted** to the lactating ration two weeks before calving *(Appendix Table 2).*
   - B. If the lactating cows are fed silage, include silage in the ration.
   - C. Prepartum milking is recommended when excessive udder edema or mastitis develops.

Nutritional and Metabolic Disorders

DESCRIPTION	PREVENTION
Acidosis (Indigestion, founder)	
Lactic acid is produced in the rumen at accelerated rates as the pH drops when highly fermentable carbohydrates are fed. Cows go off feed, may kick at their belly and may exhibit varying degrees of diarrhea.	Avoid sudden changes to high levels of grain feeding. Include 1½% sodium bicarbonate in grain mix when feeding more than 25 lb/cow/day.
Bloat	
Frothy-type gases accumulate in the rumen and cause distention of the abdominal cavity, especially on the left side. Breathing becomes labored and death may result from suffocation due to crowding of the heart and lungs.	Feed bloat preventing drugs when pasturing legumes.
Displaced Abomasum	
The abomasum shifts positions and may twist which prevents passage of digesta. Usually occurs in recently fresh cows fed large amounts of corn silage during the dry period or large amounts of grain and ensiled forages after freshening.	Feed long, dry grass hay during dry period. Include at least 5 lb dry forage after freshening and avoid finely chopped forages.
Fat Cow Syndrome	
Cows over-conditioned when dry tend to have enlarged, fatty livers. Soon after calving, such symptoms as loss of appetite, retained placenta, milk fever, displaced abomasum, and ketosis may occur.	Feed balanced ration during dry period. Dry grass hay is preferred to ensiled feeds, especially corn silage, and avoid fattening during the dry period.
Grass Tetany	
Associated with pasturing lush grass or cereal crop pastures, Animals become nervous, lose control of their limbs, exhibit convulsions, and may die. Sometimes confused with milk fever in lactating cows on magnesium deficient rations.	Supplement 2 oz of magnesium oxide daily to grazing cattle on lush pastures. Include 0.5% magnesium oxide in grain mixes in problem herds.
Hardware Disease	
Occurs when sharp pieces of metal puncture the reticulum. Animals lose appetite, become gaunt, are reluctant to walk, and develop a fever.	Avoid making hay or silage from fields where wire has been discarded. Give magnets to cows in problem herds.
Ketosis	
Usually occurs during the first 6 to 8 weeks of lactation when body weight loss is greatest, especially in herds with restricted grain consumption. May occur anytime when appetite is depressed. Breath of affected cows smells like acetone.	Avoid over-conditioned dry cows. Lead feed last 2 to 3 weeks of dry period. Increase grain consumption with buffers early in lactation to reduce weight loss. Treat with propylene glycol or sodium propionate.

Nutritional and Metabolic Disorders

DESCRIPTION	PREVENTION

Low Fat Test

Associated with restricted forage consumption due to high grain intake, forages chopped or ground to fine, or pelleted feeds.

Avoid finely ground or chopped forages, encourage forage consumption by feeding more times/day, add 1½% sodium bicarbonate plus 3/4% magnesium oxide to grain mix.

Milk Fever

Usually occurs just prior to or shortly after calving, but can occur later in lactation. Caused by low blood calcium. Early symptoms include quivering of muscles then staggering, then the cow goes down and usually turns head toward flank. Delayed treatment can result in death.

Restrict alfalfa intake to 5 lb or less during dry period. Grass hay is preferred. Calcium deficient rations can be fed last one or two weeks before calving.

Nitrate Poisoning

Excessive nitrate intake results in restricted oxygen-carrying capacity of the hemoglobin due to the conversion of nitrate to nitrite. Symptoms include labored breathing, brownish-colored blood, occasional abortions, depression, and death in severe cases.

Stressed crops due to drought or frost may accumulate nitrate. Levels above 5,000 ppm KNO_3, 3,000 ppm NO_3, or 1,500 ppm Nitrate N are dangerous. Test forages if nitrate problems are suspected.

Prussic Acid Poisoning

Drought or frost-stressed sorghum crops are the most dangerous, especially when grazed. Symptoms include labored breathing, depression, staggering, convulsions and death. Blood remains bright red.

Avoid grazing susceptible crops. Making silage or hay usually minimizes risk.

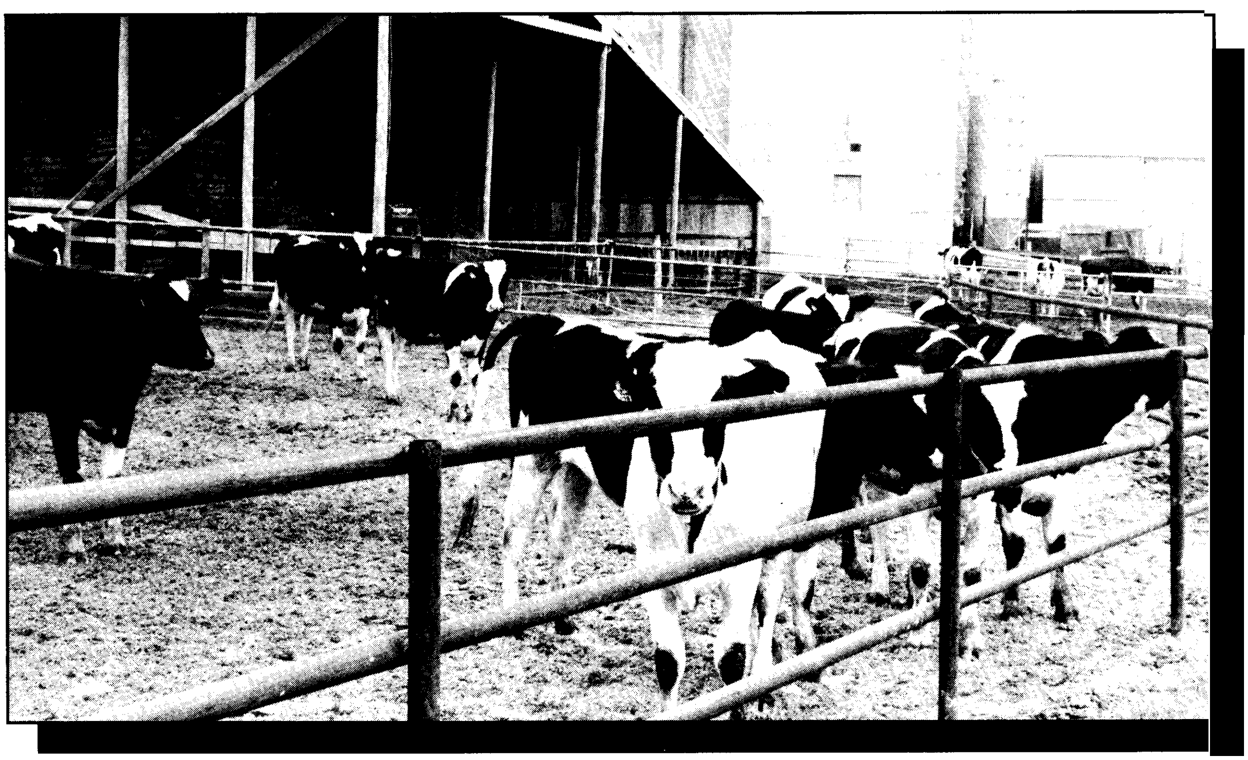
APPENDIX TABLE 1. Daily Nutrients Requirements of Dairy Cows (NCR–1988).

Body Weight lb	Protein lb	NEL Mcal.	Calcium lb	Phosphorus lb	Vitamin A 1,000 IU	Vitamin D 1,000 IU
Maintenance Mature Lactating Cows*						
700	0.67	6.02	0.028	0.020	24	10
800	0.77	6.65	0.032	0.023	28	11
900	0.88	7.27	0.036	0.026	31	12
1,000	0.92	7.86	0.041	0.029	34	14
1,100	1.08	8.45	0.045	0.031	38	15
1,200	1.18	9.02	0.049	0.034	41	16
1,300	1.28	9.57	0.053	0.037	45	18
1,400	1.37	10.12	0.057	0.040	48	19
1,500	1.46	10.66	0.061	0.043	52	20
1,600	1.55	11.19	0.065	0.046	55	22
1,700	1.64	11.71	0.069	0.049	59	23
Maintenance Plus Last 2 Months Gestation of Mature Dry Cows						
700	1.39	7.82	0.046	0.028	24	10
800	1.46	8.65	0.053	0.032	28	11
900	1.54	9.45	0.059	0.036	31	12
1,000	1.61	10.22	0.066	0.040	34	14
1,100	1.75	10.98	0.072	0.044	38	15
1,200	1.90	11.72	0.079	0.048	41	16
1,300	2.03	12.45	0.086	0.052	45	18
1,400	2.17	13.16	0.092	0.056	48	19
1,500	2.31	13.86	0.099	0.060	52	20
1,600	2.44	14.54	0.105	0.064	55	22
1,700	2.57	15.22	0.112	0.068	59	23
Milk Production— Nutrients Per Pound of Milk of Different Milk Fat Percentages						
Milk Fat %						
2.5	0.072	0.27	0.0024	0.0017	—	—
3.0	0.073	0.29	0.0027	0.0017	—	—
3.5	0.079	0.31	0.0030	0.0018	—	—
4.0	0.086	0.33	0.0032	0.0020	—	—
4.5	0.092	0.36	0.0035	0.0021	—	—
5.0	0.100	0.38	0.0037	0.0023	—	—
5.5	0.105	0.40	0.0039	0.0024	—	—
6.0	0.108	0.42	0.0041	0.0026	—	—
Weight Gain—Nutrients Required to Re-gain Body Weight Loss						
	0.32	2.32				

*To allow for growth of young lactating cows, increase the maintenance allowances for all nutrients except vitamins A and D by 20 percent during the first lactation and 10 percent during the second lactation.

APPENDIX TABLE 2. Recommended Nutrient Content of Ration Dry Matter for Dairy Cows (NCR—1988).

	Early Lactation	Mid Lactation	Late Lactation	Dry Period 1st 6wk	Dry Period Last 2wk
DMI, % Body Weight	3.8	3.4	3.0	2.0	2.2
Forage DMI, % Body Weight	1.5	1.7	2.0	1.6	1.6
NEL, Mcal/lb	0.76	0.73	0.70	0.57	0.65
Protein					
CP%	18	16	14	12	14
UIP%	6.3	5.7	5.0		
DIP%	10.4	9.7	8.4		
Fiber (minimum)					
CF,%	12	15	18	22	20
ADF,%	15	18	21	25	23
NDF,%	27	33	39	45	40
Minerals (minimum)					
Ca,%	0.70	0.60	0.55	0.40	0.40
P,%	0.45	0.40	0.36	0.25	0.25
Mg,%	0.25	0.20	0.20	0.16	0.16
K,%	1.00	0.90	0.90	0.65	0.65
Trace Mineral Salt	0.25	0.25	0.25	0.25	0.25
Buffer	0.75	0.75			
Vitamins					
A,IU/lb	1,450	1,450	1,450	1,800	1,800
D,IU/lb	450	450	450	540	540
E,IU/lb	7	7	7	7	7



APPENDIX TABLE 3. Nutrient Content of Common Feeds.

	Crude Protein %	UIP %	NEL Mcal/lb	Crude Fiber %	ADF %	NDF %	Calcium %	Phosphorus %
FORAGES	----------100% Dry Matter----------							
Alfalfa								
Bud	20.0	28.0	0.60	24.0	29.0	40.0	1.35	0.30
1/10 Bloom	17.0	28.0	0.58	26.0	31.0	42.0	1.25	0.25
1/2 Bloom	16.0	28.0	0.56	28.0	33.0	46.0	1.25	0.25
Full Bloom	14.0	28.0	0.54	30.0	35.0	50.0	1.25	0.25
Barley								
Boot	13.0	27.0	0.58	27.0	31.0		0.25	0.30
Bloom	9.8	27.0	0.55	30.0	40.0		0.22	0.30
Dough	9.8	27.0	0.54	33.0	38.0		0.21	0.26
Brome								
Boot	12.0	44.0	0.56	30.0	35.0	65.0	0.32	0.37
Bloom	10.0	44.0	0.51	37.0	43.0	68.0	0.30	0.35
Mature	8.0	44.0	0.46	42.0	51.0	70.0	0.28	0.33
Clover, Red								
Early Bloom	16.0	31.0	0.56	26.1	35.0	43.0	1.53	0.27
Full Bloom	14.6	31.0	0.50	28.8	36.0	46.0	1.31	0.25
Clover, Sweet								
Early Bloom	15.0		0.50	33.4	40.0		1.30	0.20
Full Bloom	11.0		0.43	41.9	51.2		1.25	0.17
Corn Silage								
Well-Eared	8.4	31.0	0.72	23.7	28.0	51.0	0.27	0.22
Few Ears	8.1	31.0	0.64	32.3	30.0	53.0	0.34	0.19
Fescue								
Boot	10.5		0.55	33.0	43.0	63.0	0.60	0.40
Bloom	8.5		0.51	42.0	51.3	67.0	0.50	0.40
Mature	6.0		0.47	46.0	56.7	70.0	0.48	0.35
Milo Silage								
Dough	8.3		0.60	26.0	33.0	45.0	0.32	0.18
Oats								
Boot	13.0		0.58	29.0	35.0	58.0	0.25	0.30
Bloom	9.8		0.55	32.0	39.0	62.0	0.22	0.30
Dough	8.0		0.54	27.0	34.0	56.0	0.21	0.30
Prairie								
Early	10.0		0.48	38.8	47.1		0.32	0.07
Late	7.0		0.40	46.6	57.5		0.29	0.07

APPENDIX 3 CONTINUED. Nutrient Content of Common Feeds.

	Crude Protein %	UIP %	NEL Mcal/lb	Crude Fiber %	ADF %	NDF %	Calcium %	Phosphorus %
Rye								
Boot	12.8		0.58	34.0	40.7		0.39	0.32
Bloom	9.0		0.54	38.9	47.2		0.35	0.32
Dough	7.0		0.50	36.0	46.0		0.32	0.32
Sorghum Silage								
Milk	7.5		0.56	28.5	33.3		0.35	0.20
Dough	7.0		0.58	27.0	31.3		0.30	0.22
Sorghum-Sudan								
Immature	13.0		0.57	30.0	40.0	65.0	0.43	0.36
Headed	8.0		0.48	36.0	42.0	68.0	0.55	0.30
Soybeans								
Bloom	17.0		0.54	29.8	40.0		1.26	0.27
Dough	16.8		0.63	28.5	39.0		1.29	0.33
Sunflowers								
Bloom	11.0		0.63	33.5	42.0	45.0	0.80	0.30
Triticale								
Boot	13.5		0.58	28.0	34.0		0.25	0.30
Bloom	10.0		0.55	32.0	38.0		0.22	0.30
Dough	8.0		0.54	30.0	36.0		0.21	0.30
Wheat								
Boot	13.0		0.58	29.0	34.0		0.27	0.27
Bloom	10.3		0.55	32.0	38.0		0.26	0.27
Dough	8.0		0.54	28.0	36.0		0.25	0.27

APPENDIX 3 CONTINUED. Nutrient Content of Common Feeds.

	Crude Protein %	UIP %	NEL Mcal/lb	Crude Fiber %	ADF %	NDF %	Calcium %	Phosphorus %
GRAINS, BYPRODUCTS & PROTEIN SUPPLEMENTS								
Barley	13.5	27.0	0.88	5.7	7.0	19.0	0.05	0.38
Beef Pulp	9.7	45.0	0.81	19.8	33.0	54.0	0.69	0.10
Brewers Grains	25.4	49.0	0.68	14.9	24.0	46.0	0.33	0.55
Corn, Shelled	10.0	52.0	0.92	2.6	3.0	9.0	0.03	0.29
Corn & Cob Meal	9.0		0.87	9.4	11.0	28.0	0.07	0.27
Corn Distillers Grains	23.0	54.0	0.90	12.1	17.04	3.0	0.11	0.43
Corn Gluten Feed	25.6	25.0	0.87	9.7	12.0	45.0	0.36	0.82
Corn Gluten Meal	67.2	55.0	0.94	4.8	9.0	37.0	0.16	0.50
Corn Hominy Feed	11.5		0.91	6.7	13.0	55.0	0.05	0.57
Cottonseed Meal	44.3	43.0	0.81	12.8	20.0	28.0	0.21	1.16
Cottonseed Hulls	4.1		0.45	47.8	73.0	90.0	0.15	0.09
Cottonseed, Whole	23.0		1.01	24.0	34.0	44.0	0.21	0.64
Fat, Animal			2.65					
Linseed Meal	38.3	35.0	0.81	10.1	19.1	25.0	0.43	0.89
Milo	9.7	54.0	0.84	2.0	9.0	18.0	0.04	0.34
Milo Head Chop	9.0		0.75	13.0			0.16	0.29
Molasses	5.8		0.75				1.00	0.11
Oats	13.3	17.0	0.80	12.1	16.0	32.0	0.07	0.38
Rye	13.8	19.0	0.88	2.5			0.07	0.37
Soybeans	42.8	26.0	0.96	5.8	10.0		0.27	0.65
Soybean Meal, Expeller	47.7	35.0	0.89	6.6			0.29	0.68
Soybean Meal, Solvent	49.9	35.0	0.88	7.0	10.0		0.30	0.68
Soybean Meal, De-hulled	55.1	35.0	0.91	3.7	6.0	8.0	0.29	0.70
Soy Hulls	12.1		0.80	40.1	50.0	67.0	0.49	0.21
Sunflower Meal	49.8	26.0	0.67	12.2			0.44	0.98
Wheat, Hard	14.4	22.0	0.93	2.8	4.0		0.05	0.43
Wheat, Soft	13.0	22.0	0.94	2.4			0.05	0.43
Wheat, Bran	17.1	29.0	0.73	11.3	15.0	51.0	0.13	1.38
Wheat, Mids	18.4	21.0	0.71	8.2	10.0	37.0	0.13	0.99
CALCIUM AND PHOSPHORUS SUPPLEMENTS								
Bone Meal	13.2						30.17	12.86
Dicalcium Phosphate							23.00	19.30
Limestone							39.39	
Monocalcium Phosphate							16.40	21.60
Monosodium Phosphate								22.50

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