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FEEDING THE DAIRY HERD

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HISTORY OF BULLETIN 218

Extension Bulletin 218 is a handbook which, in one form or another, the University of Minnesota has been furnishing to dairymen since 1894. Twenty-seven separate editions have been printed, and close to 540,000 copies have been distributed to Minnesota farmers during this time.

The first edition of the bulletin was published in 1894 when Professor T. L. Haecker gave results and suggestions from his feeding experiments with the University dairy herd in both Bulletin 35 and the Station Report for the year. Several other station bulletins by Professor Haecker on this subject appeared between 1900 and 1910.

In 1910 "Feeding Dairy Cows" appeared in popular form as Minnesota Farmers' Library No. 12. This bulletin formed the basis for Professor Haecker's now-famous dairy feeding standards published in a handbook known as Station Bulletin 130, "Feeding Dairy Cows." Bulletin 130 was reprinted as a handbook eight times.

In 1924 the handbook was revised extensively by C. H. Eckles and O. G. Schaefer, and was issued as Minnesota Agricultural Experiment Station Bulletin 218, "Feeding the Dairy Herd." In 1932 the bulletin was revised and reprinted, this time under a single author, C. H. Eckles. In 1938 it was extensively revised with much new material added by the new authors, T. W. Gullickson and J. B. Fitch. Again in 1943 the bulletin was revised, under the authorship of J. B. Fitch, H. R. Searles, E. A. Hanson, and R. D. Leighton. And again in 1952 the bulletin was revised, this time by H. R. Searles, R. W. Wayne, T. W. Gullickson, and R. D. Leighton.

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1. CHANGES IN MINNESOTA DAIRYING

Dairying has long been a main source of farm income in Minnesota.

♦ Dairy products accounted for 22 percent of Minnesota farm income in 1961.

♦ About 40 percent of the beef marketed from Minnesota farms is from dairy cows and calves.

♦ For many years Minnesota has led all states in butter production.

♦ Minnesota ranks second in numbers of dairy cattle and total milk production.

♦ Dairy production in Minnesota changes from decade to decade. Greatest changes have come about since World War II.

Table 1 shows fewer herds, larger herds, and a shift in Minnesota's farm sales from cream to whole milk.

These trends will continue, resulting in fewer but larger herds. Most of the low-producing herds will be forced out of the dairy business by the more efficient units.

Table 1. Changes in Minnesota dairying

Year	Dairy cows	Dairy herds	Average cows per herd	Farm sales (wholesale)		Average milk production	
				Cream	Milk	All cows	DHIA cows
				percent		pounds per cow	
1925	1,311,879	140,763	9.3	90.7	9.3	4,720	6,966
1935	1,717,623	184,065	9.3	88.7	11.3	4,530	7,877
1945	1,627,525	164,463	9.9	46.7	53.3	5,180	8,196
1954	1,344,180	122,416	11.0	32.7	67.3	6,180	9,491
1959	1,215,696	90,518	13.4	12.6	87.4	7,850	10,828
1962	1,237,267*	78,784*	15.7	7.1	92.9	8,130	11,163

* Estimated from State Farm Census.

2. KEYS TO PROFITABLE DAIRYING

Sucessful dairying depends on:

1. The personal interest and ability of the dairyman.
2. High production per cow.
3. The ability to produce—good breeding and inheritance.
4. Proper feeding—enough of the required nutrients.
5. Keeping and using production and breeding records.
6. Good care and management—kind handling, regularity, good milking habits.
7. Maintaining herd health.
8. Regular calving.
9. Providing for quality herd replacements.
10. Producing high quality milk.

1. Personal Interest and Ability of the Dairyman

No one can be successful unless he has an enthusiastic interest in his work. A successful dairyman must like cows and enjoy working with them; dairying must be his hobby as well as his means of livelihood.

2. High Production Per Cow

Although a farmer cannot control prices, he can help himself to larger profits through good feeding and management of his cattle. Many maintenance costs such as feed, shelter, taxes, insurance, interest on investment, and labor are practically the same for low producers as for high producers. The extra feed above that required for maintenance is used mainly to produce milk. So the net return from a 400-pound cow is far more than twice that from a 200-pound producer.

Table 2. As milk production increases the percentage of the feed used for production also increases

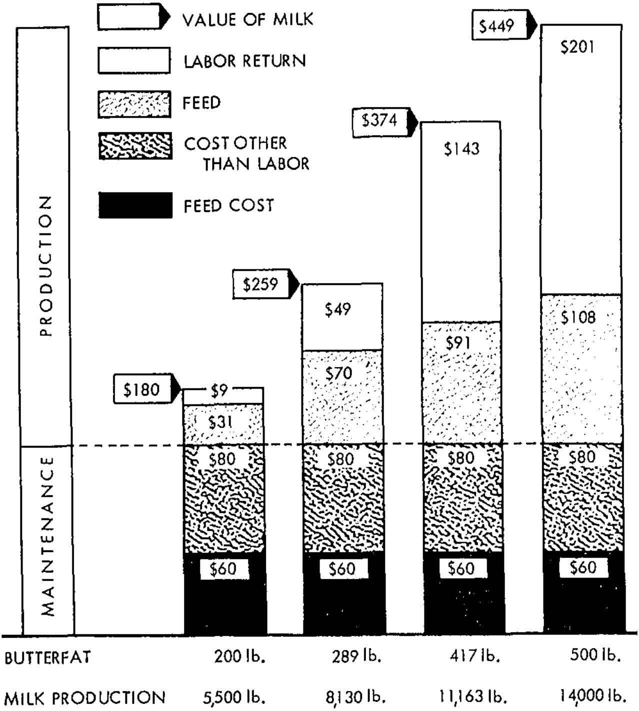
Level of production, pounds of milk	Percentage of feed consumed which is: Used for milk production	Used for maintenance
5,000	33.3	66.7
8,000	44.3	55.7
12,000	54.5	45.5
15,000	59.9	40.1
18,000	64.2	35.8

These differences occur because there is a base feed maintenance and overhead cost per cow regardless of how much or little she produces.

The average production of all Minnesota milk cows in 1962 was 289 pounds of butterfat with an annual

Table 3. Number of cows and production level per cow needed to return $5,000 annually for labor at different levels of production

Average production, pounds of fat	Cows needed	Total production, pounds of fat
600	19	11,400
500	25	12,500
417	35	14,595
289	85	24,565
200	555	111,000



labor return of $49. Cows enrolled in DHIA averaged 417 pounds of butterfat and gave a $143 labor return.

Higher production per cow with fewer cows clearly results in greater returns and less total production on the market.

3. The Ability of the Cow to Produce

Breeding is the first limiting factor affecting the level of production in dairy cattle. A cow can produce no more than the production level she inherited—the capacity of her tools for producing milk.

Dairy cattle vary tremendously in their ability to produce, as countless records show. Under the same feeding and management conditions, heifers assembled from Minnesota farms for research studies by the University of Minnesota have varied in annual production from 5 to 487 pounds of butterfat, due mainly to their inherited production levels.

There is a great need for increasing the inherited level for production in low-producing herds. This can be done most quickly and surely by using sires who have proven themselves through the production of their daughters.

In most areas of Minnesota artificial breeding associations now make the services of outstanding proved sires available. But artificial breeding is only as good as the sire used. The performance of daughters of each sire, whether owned by an individual or a breeding association, must be analyzed. And other inherited traits—such as type, size, breeding efficiency, longevity, and ease of milking of the daughters—also must be considered. The influence of the environment in which records are made also must be considered in passing final judgment on performance records.

4. Proper Feeding

Feeding is important to profitable dairying and is treated in detail later in this publication.

5. Keeping and Using Production and Breeding Records

Good records are necessary in a successful business. More than 5,800 of Minnesota's top dairymen are members of Dairy Herd Improvement Associations. Through these associations they employ a qualified person to keep complete records on their herds.

Thousands of other dairymen would gain greater profits through keeping similar records.

DHIA records form the basis for all other activities within the dairy herd. They provide complete individual cow records of production, feed consumed, feed costs, returns over feed costs, calving records, breeding and identification, and records of progeny. Dairymen use these records as a guide for feeding, for locating and culling out the least profitable cows, and for maintaining a permanent, detailed record of each cow.

DHIA lactation records are used in all proved sire analysis work. In fact, the entire proved sire program is built on DHIA records. Every dairyman using artificial breeding thus benefits directly from this use of DHIA records, though he may not be a DHIA member. The fact that Minnesota's 5,800 DHIA members pay over $1 million annually for this service shows that they appreciate the value of these records.

6. Good Care and Management

The successful dairyman must know how to get the most from his herd. This requires gentle handling, close observation, provision for comfort of the animal, quick detection and treatment of sick animals, regular feeding and milking, and knowledge of the detail characteristics of each cow and how she responds to her environment. It's the cowmanship part of his job.

The successful dairyman must organize his operation to most efficiently utilize feed, labor, and his investment in farm and equipment. To save labor, dairymen have installed additional equipment and adopted labor-conserving practices. Although these often result in additional investment they are essential in an efficient dairy operation.

7. Maintaining Herd Health

Good herd health is essential for regular calving and high production. With bovine tuberculosis and brucellosis practically eliminated, mastitis and reproductive disease are of most concern at present. While several drugs are effective treatments, the prevention of cattle diseases is enhanced by good management, close observation, and an understanding of the different diseases.

8. Regular Calving

The annual production of the dairy herd is greatly affected by the interval between calvings. For best production, the calving interval should be as near 12 months as possible. Regularity of calving is affected by the general health of the herd, by the closeness with which the dairyman watches his cattle for evidence of heat, and the time of service. The ration fed apparently has little effect on breeding efficiency. Heifers should be grown to reach breeding size by 15 months of age and should calve when 24 to 26 months old.

9. Providing for Good Herd Replacements

Even with good management a certain number of cows leave the herd each year for various reasons, and must be replaced. The summary of Minnesota DHIA records shows that in addition to cows sold for dairy purposes 23.4 percent of all DHIA cows leave the herd annually for: (1) death, 1.1 percent; (2) disease, 3.9 percent; (3) low production, 11.4 percent; (4) sterility, 4.1 percent; and (5) other causes, 2.9 percent.

10. Producing High Quality Milk

Full returns from a dairy herd are realized only when that herd produces milk of high quality. Markets are becoming more and more insistent on high quality milk. Only the dairyman who meets this demand will be successful.

3. HOW A COW DIGESTS AND USES FEED

The digestive tract of the cow consists of the esophagus (throat), rumen (paunch), reticulum (honeycomb), omasum (manyplies), abomasum (true stomach), small intestine, and large intestine.

Except in very young calves, the feed swallowed by dairy cattle enters the rumen. The rumen and reticulum (R-R) occupy the greatest space of any organ in the body; in an adult cow it may weigh over 200 pounds when filled with feed and water. The R-R contains several blind sacs and is very muscular. Contraction waves move the feed from one area to another. The reticulum is most concerned with belching out gas and with rumination. It also collects foreign materials, and because of peculiar pocketlike structures on its surface it may direct sharp objects through its surface toward the heart, causing what is commonly termed hardware disease.

From the R-R the partly digested feed goes to the omasum. In this organ many leaflike structures lie parallel to the path of the feed. The feed then goes to the true stomach and the small and large intestines, as in other animals.

To be useful to animals, nutrients must enter the bloodstream for transport to various parts of the body. The process whereby the animal releases feed nutrients from feed is termed digestion. As commonly used, this process also includes absorption of food from the digestive tract into the bloodstream. Most of the unused portion of the feed is eliminated in feces although a considerable portion is also given off as gas through the mouth and nose.

A great deal of bacterial fermentation or digestion takes place in the R-R. A considerable part of all roughage is fiber, a complex form of carbohydrate not digested by simple-stomached animals, but effectively utilized by cattle.

Bacteria in the rumen break down proteins and other nitrogenous compounds into simple components (ammonia and amino acids). These are then recombined into essential protein in the form of bacteria which are then digestible. Certain portions of ammonia are lost during absorption into the bloodstream and are eliminated in the urine. Portions of simple nonprotein materials, such as urea, may be changed into high quality protein.

Certain plant fats are changed in the rumen so that the fat in the ration has much less influence on the characteristics of body or milk fat than it does in other species.

All of the B-complex vitamins are synthesized in the rumen by bacteria.

Under certain conditions gases generated in the rumen form a stable froth, and the animal bloats. Bloat is a very serious and costly disease of ruminants fed predominantly on legumes.

Because bacterial digestion is carried out to a high degree in ruminants, the proportion of nutrients absorbed from different sections of the digestive tract differs considerably. Animals with simple stomachs absorb most nutrients from their small intestines. Ruminants absorb approximately half of what is absorbed through the wall of the R-R. Once nutrients are absorbed into the bloodstream all animals use them in practically the same way.

Measuring the Value of Feeds

Feeding trials have resulted in the compilation of two types of data needed for feeding standards: (1) tables giving the requirements of nutrients for the several classes of animals, and (2) tables giving the nutrient content of the various feedstuffs used in feeding animals.

In feeding standards, nutrients in feeds which supply energy for dairy cattle usually are expressed as: (1) total digestible nutrients (TDN), or (2) estimated net energy (ENE).

Feed energy entering the animal body is partitioned as follows:

Energy in feed	→	Digestion in cow, or TDN	— Loss in	Gas Urine Heat	= ENE available for animal use

"Animal use" means the incorporation of energy- and nonenergy-containing nutrients into such things as growth and maintenance in the animal itself (meat, fat, etc.), milk production, and development of the unborn calf.

Either of two methods, both difficult and expensive, may be used to accurately and directly determine net energy of rations:

1. Slaughter and analysis of representative animals before and after feeding a given ration fed at one or (preferably) more than one level.
2. Use of respiration chambers or respiration calorimeters designed to measure the uses a cow makes of her feed.

The net energy value of a given feed is influenced by such variables as health, size, age and condition of the animal, level of feeding, and weather.

Because of the great expense involved in determining true net energy values, ENE is now commonly used. Compared to TDN, ENE is a more accurate way to estimate a cow's response to feeds in her ration.

TDN is based on the digestion coefficient, or the percentage of the feed digested: It is determined by multiplying digested fat by 2.25 and adding the digested carbohydrate and protein on a weight basis. ENE is expressed in heat units or therms (1,000 calories). Feeds high in fiber have a relatively lower percentage of ENE as compared to TDN because of the energy required to digest the fiber.

Table 4 illustrates the advantage of using the ENE system in evaluating 100 pounds of feed for livestock:

Table 4. TDN compared to ENE in evaluating 100 pounds of feed for livestock

Feed	Fiber	TDN	ENE
	percent	pound	therms
Corn, No. 2	2	80	80
Alfalfa hay	29	50	41
Wheat straw	37	41	11

It is evident that a pound of corn TDN is equal to a therm (a unit for measuring energy) of net energy while for the roughages a pound of TDN ranges between 0.8 and 0.25 therms, decreasing rapidly as the fiber content increases.

The tables in this bulletin are the best guides available for calculating dairy rations. When evaluating feeds consideration must be given to such things as moisture in soft corn, weight of oats, stage of growth in hay and hay-crop silage, and the amount of corn grain in corn silage. A dairyman must not overestimate the nutritive value of his forage supply or the roughage portion of his ration.

Roughage quality is best estimated from the cutting date, appearance, and a chemical analysis.

The main factors contributing to protein content are species involved, stage of maturity when harvested, and level of nitrogen fertilizer used.

Table 5. The range of values in crude protein content of several forage samples

Feed	Range in crude protein*	Number of samples
	percent	
Corn silage	6-16	336
All hays	5-21	915
First cutting hay	5-21	580
Hay crop silage	6-27	460

* Dry matter basis.

4. FEED CONSTITUENTS

The Nutrients Needed

The first consideration in any feeding program is to determine the need for nutrients. A nutrient is any substance that aids in the support of life. Dairy cattle require nutrients for:

1. **Growth**—nutrient need is great when the animal is young. A progressively smaller portion of the feed intake is required for growth as the animal approaches maturity.

2. **Body maintenance**—This is a continual requirement to rebuild worn tissues, maintain body temperature, provide energy for muscular activities, and keep vital organs functioning.

3. **Pregnancy**—the requirements are greatest during the last 3 months of pregnancy.

4. **Milk production**—nutrient need varies with the amount of milk produced and its composition.

Nutrient needs for growth, body maintenance, and pregnancy generally are provided for before milk production can take place in quantity. For this reason it does not pay to underfeed. The cow produces most economically when worked near full capacity.

In computing rations the main considerations are for body maintenance and milk production needs.

Classes of Nutrients

Feeds are made up of nutrients which include proteins, carbohydrates, fats, water, minerals, and vitamins. Each performs specific functions in the body. Cows vary in their requirements for nutrients and feeds differ in nutrients that they contain.

Protein is essential for growth and for the maintenance of life. Proteins are made up of various combinations of amino acids and help form skin, hair, muscles, blood, bones, horns, and milk. Animals with simple stomachs must be supplied with all of the essential amino acids through their diet. In cattle, however, micro-organisms in the rumen build up most of the amino acids needed. For this reason the kind and quality of protein in the ruminant diet are not too important.

When more protein is fed than is needed for growth, maintenance, and milk production, it is used as a source of energy. Because protein concentrates are more expensive than carbohydrate feeds, it usually is more economical to feed only the amount of protein needed.

Carbohydrates are composed largely of starches and sugars. They are used for energy to maintain body temperature, for muscular activity, and for milk production. Surplus carbohydrates are converted and stored in the body as fat.

Fats are largely interchangeable with carbohydrates but are more concentrated. Compared to carbohydrates, fats are worth 2¼ times as much per pound in heat and energy.

Water is cheapest of all the nutrients. It forms over half the weight of a cow and about 87 percent of her milk. In the blood and lymph it carries food nutrients to different parts of the body and takes waste products away. It helps control body temperature. A cow requires 3 to 5 pounds of water for each pound of milk she produces.

Minerals make up approximately 5 percent of the weight of a dairy cow. This is mostly calcium and phosphrous, found chiefly in the skeleton. Minerals are also needed in cell activity, digestion, milk production, and development of the unborn calf. Cattle need a dozen or more minerals. Most rations commonly fed provide ample amounts of all except chlorine, which may be supplied in common salt.

Much of the soil in Minnesota is low in iodine. Soils low in phosphorus are found chiefly in the western and northwestern part of the state. A few scattered areas low in cobalt have been found.

Most of the essential minerals are needed in very small (trace) amounts. The addition of 1 percent trace mineralized salt to the grain mixture provides adequate insurance against the possibility of rare mineral deficiencies. When possible, use free-choice feeding of salt and either bone meal or dicalcium phosphate.

Vitamins are feed constituents which are required in minute amounts and are essential to the life and well-being of all animals.

Of the known vitamins, only A and D are likely to be lacking in the average dairy ration. Vitamin K and the B complex vitamins are synthesized by body tissue. Vitamin E is abundant in most feeds.

Vitamin A deficiency is most likely to occur in late winter following a period when only poor quality forages have been fed. Lack of vitamin A results in a breakdown of the nervous system, skin, and body linings. Calves may be born weak, dead, or partly blind.

Carotene, a yellow substance found in pasture grass, silage, and green hay, is the principal source of vitamin A. Both carotene and vitamin A may be stored in the body. Carotene is converted to vitamin A when needed. Six pounds per day of average quality alfalfa hay or 3 to 4 pounds of alfalfa silage provide ample vitamin A.

Vitamin D is called the sunshine vitamin because it is formed by the action of sunlight upon compounds found in plants and animals. Vitamin D regulates the metabolism of phosphorus and calcium. Calves kept indoors on poor hay may suffer from rickets, a vitamin D deficiency. Vitamin D is furnished by direct sunlight in the summer and from forages in the winter.

Most vitamins needed by dairy cows are present in the common feedstuffs or are manufactured by micro-organisms in the rumen. So they need little consideration when balancing rations.

Other Factors

Palatability—A ration that provides the required nutrients also must be palatable. Cows, like man, differ in their likes and dislikes for food.

Variety—Some variety in the ration is desirable. But palatability and nutritive merits of individual feeds are more important than the number of ingredients. Cows crave some dry forage in their ration.

Bulk—Cows are capable of handling large quantities of bulky feeds and perform well on rations in which 75 percent of the nutrients are supplied by forage. On the other hand, 60 percent or more of their nutrients may be furnished in the form of concentrates. With high-producing cows it may be necessary to limit forage consumption and feed larger amounts of concentrates to meet nutrient needs.

Cost—Cost is important in making up a ration. The choice and the combination of feeds are big factors in holding the cost down. Cost per unit of digestible nutrient supplied by various feeds—not the price per ton—is the most important consideration. See page 49, how to compute cost of nutrients.

With the development of hybrid corn and improved tillage methods, concentrates may now provide nutrients as cheap or cheaper than forage crops.

Terms On the Feed Tag

Minnesota law requires that manufactured feeds must have a tag or label giving the manufacturer's guaranteed analysis and list of ingredients. This guarantee is based on a laboratory chemical analysis and has the following terms:

Crude protein not less than: To secure the protein percentage, the feed is first chemically analyzed for the nitrogen it contains. Since proteins average about 16 percent—or $\frac{1}{6.25}$—nitrogen, the amount of nitrogen found in the analysis is multiplied by 6.25 to give the crude protein percentage.

Crude fat not less than: The fat is extracted from a given weight of feed with a fat solvent and the percentage calculated.

Crude fiber not more than: A given weight of feed is boiled, first in a weak acid solution and then in a weak alkali solution, and the dissolved material is washed out. The remaining material is dried and the percentage of the original sample calculated. This is considered the percentage crude fiber.

Nitrogen-free extract: The crude protein, fat, water, ash, and fiber are added and the sum is subtracted from 100. The difference is listed as nitrogen-free extract. It is composed mostly of carbohydrates, starch, and sugar. Feeds of higher feed value are high in protein, fats, and nitrogen-free extract, and low in fiber.

5. PRODUCING HIGH QUALITY FEED

The Minnesota dairyman produces most of his dairy feed on his own farm. This gives him a great advantage over dairymen in areas of the country where much feed must be shipped in.

In Minnesota legume hay and corn silage have been the basis of an economical winter dairy ration, and well-managed pastures have provided the cheapest summer feed. Improved methods have lowered corn production costs, and dairymen today feed more grain, especially corn, resulting in increased production at lower costs. On high-priced land, pasture, unless unusually well managed, no longer produces nutrients as cheaply as corn. So there is a definite trend towards more year-round stored feeding; higher levels of grain feeding, especially to higher producing cows; more corn silage; and less pasture.

Minnesota Farm Management Association records show the cost of producing 100 pounds of TDN in different feed crops under typical southern Minnesota conditions (table 6). All costs, including labor, are considered.

A high-producing cow must use the space in her digestive system to digest only high quality feed. Taking up this space with materials of low feed value quickly results in lower and less efficient production.

Table 6. Comparative costs of producing 100 pounds TDN

Crop	Production per acre	Cost per 100 pounds TDN
Corn	66 bushels	$1.80
Oats	55 bushels	3.97
Alfalfa	2.8 tons	1.99
Corn silage	10 tons	1.63

Therefore the production of high quality feed, especially forages, is of great importance.

Variations in analyses of hay and corn silage samples recently submitted by Minnesota dairymen are shown in table 7.

Table 7. Variation in samples of hay and corn silage

Crop	Dry matter	Fiber	Digestible protein	TDN	Net energy
Alfalfa hay					
Sample 1	92.4	20.2	16.0	71.7	65.1
Sample 2	90.3	29.4	11.3	54.2	40.7
Sample 3	88.3	36.6	10.4	44.2	31.0
Corn silage					
Sample 1	37.5	7.4	1.1	26.4	23.8
Sample 2	28.0	6.7	0.8	18.4	15.9
Sample 3	21.0	4.8	1.4	14.3	12.7

In both hay and silage, sample 1 had approximately twice the net energy of sample 3. Making high-energy hay and silage is very important in providing high quality cow feed.

Hay

Legumes make the best hay for dairy cattle. Alfalfa provides the greatest yield of high protein hay. Addition of bromegrass may increase the yield and make the hay easier to cure. If cut early it will provide desirable feed.

The time of cutting is the greatest single factor in producing high quality hay. Alfalfa should be cut before one-tenth bloom. This means starting haying the first few days of June and finishing the first crop by June 15.

Each day cutting is delayed after June 1 the useable feed value in forage decreases at least 1 percent, the digestibility is lowered one-half of 1 percent, and the amount eaten drops at least one-half of 1 percent. On the average, weather records show as many good

Table 8. Average composition of alfalfa-grass mixtures harvested at different dates and growth stages, average of 19 locations in Minnesota, 1960-62, excellent harvesting conditions

Cutting date and stage of growth	90% dry matter hay basis			
	Protein	Fiber	TDN*	ENE*
	——percent——			therms/ 100 lb.
First cutting				
June 1 (prebud)	18.0	23.2	61.6	54.9
June 14 (late bud-1/10 bloom)	14.9	29.0	54.3	44.6
June 23 (½ bloom)	13.6	31.1	51.7	40.7
July 1 (full bloom-mature)	11.9	33.3	48.6	36.4
Second cutting				
6-8 weeks regrowth	15.0	29.1	53.1	44.5
Third cutting				
5-6 weeks regrowth	17.3	24.4	60.3	52.7

* TDN and ENE are calculated by formula from protein and fiber.

Table 9. Effect of date and frequency of cutting on dry matter yield, protein, TDN, and ENE per acre; average of 19 locations in Minnesota, 1960-62

Cutting dates	Dry matter per acre	Protein per acre	TDN per acre	ENE per acre*
	tons	——pounds——		therms
June 1, July 15, Aug. 31	3.4	1,295	4,435	3,810
June 14, July 26, Aug. 31	3.8	1,382	4,770	3,900
June 23, August 15	3.6	1,105	4,125	3,357
July 1, August 31	3.8	1,059	4,160	3,275

* The ENE in this forage is equivalent to 85, 87, 75, and 73 bushels of No. 2 corn respectively. Protein is 2½ to 3 times greater in forage than in corn.

haymaking days in the first half of June as the last half, so delayed cutting does not assure better haymaking weather.

Tips for Top Total Yield of Nutrients in Hay:

1. Use best quality seed of recommended variety on well-prepared seedbed.
2. Fertilize according to soil test recommendations.
3. Cut hay early by the calendar.
4. Use hay conditioning equipment to save one-half to 1 day in field curing.
5. Rake hay with the dew on to avoid excessive leaf shatter.
6. Don't harvest fields after September 1 that are to be kept in production the following year.

Silage

Silage is a moist feed produced through fermentation in the absence of air. Fermentation is carried out by bacteria acting on plant sugars (carbohydrates). This fermentation produces lactic and acetic acids. When these acids reach a certain level they prevent further bacterial action, resulting in the preserved feed we call silage.

Good silage is easy to make if the crop is cut at the proper stage of growth, cut fine and ensiled as rapidly as possible at 65 to 70 percent moisture, evenly well packed, and stored in a silo free of air leaks. The feeding value of the silage is no better than that of the material put in.

Corn Silage—Corn silage is an excellent energy feed for dairy cattle. It is easy to make and is very palatable. In at least the southern one-third of Minnesota, more nutrients can be grown per acre in corn silage than any other crop. Equipment is now available to easily make and feed silage with a minimum of labor. For these reasons corn silage is making up more of the dairy cattle ration on many farms.

The feeding value of corn silage varies according to moisture content and the amount of corn grain it contains. Corn silage unusually high in moisture has less feed value, is usually higher in acid content, is less palatable, and is subject to more freezing in winter.

The best time to fill the silo is influenced by weather. In years of high rainfall, especially late in the summer, the plants contain more juices.

Corn generally is ready for filling when it is dented. Corn silage highest in the amount of dented corn is also highest in feed value. Silage without ears and high in moisture may contain only 13 percent TDN while silage made from fields yielding 100 bushels per acre will have up to 26 percent TDN, or twice the feed value.

Oat silage—Oats is the most common small grain crop used for silagemaking. Although the yield per acre of nutrients in oat silage is about twice that of the grain alone, the yield of feed value both per acre and per ton of silage is much less from oats than from corn. So oats usually is not a good yield competitor with corn.

On very fertile fields where oats may lodge and kill out new seedlings, removing the oat crop early and making silage may be highly desirable. However, this means sacrificing straw which may be needed for bedding.

Since oats changes from the milk to dough stage in a few days, especially in hot weather, the time in which good silage can be made is limited. For best results it should be cut at the early- to mid-dough stage when it can be harvested direct with no preservative added.

Hay crop silage—Because of weather hazards in making quality hay, many dairymen make silage from the first crop, in many cases saving more feed value. It may make it possible to get the first crop off quicker. Since hay crops, especially legumes, are much lower in fermentable sugars, it is much more difficult to make quality hay crop silage than to make quality corn silage.

Wilting the crop to 65 to 70 percent moisture and chopping fine to insure good packing is essential. Even then the quality sometimes may be lower than desired. Filling material at higher moisture levels is almost certain to result in a silage high in butyric acid that has objectionable odors and is low in palatability.

Adding preservatives gives some assurance of a higher quality feed. The preservative may be either a carbohydrate such as ground corn or molasses that ferments to acetic acid, similar to the condition in corn silage, or a compound such as sodium metabisulphite which holds down the action of bacteria that produce the bad odors.

Table 10. Rates at which to add silage preservatives, pounds per ton of silage

Preservative	Legumes	Legume-grass mixture	Grass and immature cereals
Liquid molasses	80 to 100	60 to 80	60
Corn and cob meal	200 to 250	150 to 200	150
Ground grain	150 to 200	150	100
Beet pulp	150	100	100
Sodium metabisulfite	8 to 10	8	8

Haylage (low moisture silage)—To avoid silage with objectionable odor and low palatability many dairymen have turned to low moisture silage, commonly called *haylage.* The hay crop is wilted to 40 to 45 precent moisture before filling. Properly made haylage is a good smelling, palatable, high quality feed. Cows usually receive more dry matter and net feed value in haylage than in silage made from the same crop.

Haylage is easy to preserve in a gastight silo where air is excluded. It can also be made successfully in a conventional silo if:

- ♦ The silo is free of any air leaks around doors or cracks in the walls.
- ♦ The material is chopped fine and thoroughly packed to exclude air.
- ♦ The silo is filled quickly and the surface covered when filling is complete.

Haylage is growing in popularity. Its feed value depends on the stage of growth of the crop when filled and the percent of dry matter in the silage. On a dry matter basis, feed value of haylage is equal to that of hay or silage made from the same crop at the same time.

Green chop (fresh forage)—Many dairymen harvest and feed *green chop* daily. Green chop reduces wastage as compared to pasture; with tall-growing crops 50 percent more feed value may be realized from a given area. However, green chop requires special equipment and harvesting every day, has harvesting problems in wet weather, and results in variation of feed quality as the season progresses. So this system is gradually giving way to stored feeding.

Ensiled Concentrates

Corn; oats; barley; and under certain conditions, rye; all make good cow feed. But unless they are stored in a dry condition they mold and drop rapidly in feed value.

Corn often is too high in moisture at harvest to store safely in warm weather. Such corn requires artificial drying which involves additional handling and cost without enhancing its feed value. So many livestock producers have ensiled all or part of their corn crop as ear or shelled corn silage.

This is a relatively new approach in corn utilization. The ear is picked and ground, or picked, shelled, and ground before ensiling. A hammer mill or burr mill may be used for grinding.

The basic rules for silagemaking and the following factors are important:

Moisture content of the grain and cob mixture should be about 30 to 35 percent. Moisture content of ground grain should be 27 to 32 percent.

Coarsely ground material makes the best silage.

Water may be added to drier corn to bring it up to recommended moisture levels for storage.

Storage in a gastight silo make it possible to remove any amount at any time from the bottom of the silo.

Where a conventional silo is used, at least 3 inches must be removed from the top daily to avoid spoilage when the temperature goes much above 50° F.

This may offer a problem with smaller herds unless the corn can be fed at the same time to other livestock.

Pasture

Pasture has the advantage of providing a highly nutritious feed that cows relish, especially when fresh growth is maintained. Also, the cow does the harvesting.

Its main disadvantage is the considerable waste of the crop through trampling, with lower yield of nutrients per acre than from harvested crops. Also, it is sometimes difficult to maintain growth of even feed value because of variable weather conditions. This results in fluctuation in milk production. In areas of high-priced land and yield potentials of 100 bushels of corn per acre, pastures must be exceedingly well managed to compete with corn as a feed. Many dairymen, especially in the more fertile areas, are shifting from pasture to continuous feeding of stored feed.

Pastures on untillable land usually have grasses that produce most of their growth early in the season and should be utilized then. They cannot be depended on for full-season grazing. While they may be improved by renovating and reseeding to more desirable grasses and legumes, they return to their original state in a few years.

Good pasture requires tillable cropland. Mixtures of alfalfa and brome provide the best pasture; under some conditions clover and other grasses may be desirable. For best results, pastures should be shifted to new fields every 2 or 3 years.

Pastures should be divided into several strips and the herd rotated to a new strip every 4 or 5 days. Better yet, move a cross fence each day for a single day's grazing. This results in less waste, greater utilization of the growing crop, and uniform feed from day to day. Under no condition should a dairy herd be allowed to graze over the entire pasture area.

Producing high quality feed requires study and close management by the dairyman. Available land, topography (the lay of the land), erosion problems, soil fertility, and available labor and equipment must all be considered in working out the most desirable feed-producing program for each farm.

Table 11 is a useful guide for comparing yields of ENE from several crops commonly grown as feed for dairy herds.

Table 11. Annual crop yield per acre required to produce an equivalent quantity of ENE. Yields listed in each column result in the same amount of ENE

Crop	Yield per acre		
Corn (shelled), bushels	60	80	100
Oats	129	172	215
Corn (corn and cob), bushels	53	71	89
Barley, bushels	74	98	123
Corn silage (80 bu./acre), tons	6.5	8.6	10.8
Alfalfa hay (early cut), tons	3.2	4.2	5.2

In fully evaluating the nutrient value of feeds listed in table 11, the difference in protein value must also be considered. Alfalfa hay contains 2½ to 3 times as much protein as corn.

6. BUYING FEED WISELY

A basic principle in buying feed is to purchase it on the basis of its analysis. For dairy cattle the source of protein is of little concern so long as the feed is palatable.

Cows can efficiently utilize corn as the only concentrate if it is palatable and if sufficient protein to meet their needs is supplied by the roughage.

Often it is possible to purchase either energy or protein more cheaply in concentrate than in roughage. When this is the case, limit the hay and/or silage and increase the concentrate. When costs are reversed, increase roughage somewhat and limit concentrates.

The price per pound of digestible protein, or of TDN, or, preferably, of ENE, is the important consideration. For dairymen with adequate storage facilities, quantity purchases at the season of greatest supply usually are most economical.

7. SUMMER FEEDING PROGRAMS

Pasture has long been used as summer feed for cattle. Whether or not pastured cattle are well fed depends on:

1. Their production level.
2. The specie of plants, the quantity of plants, and the stage of growth.
3. Pasture management.
4. Weather.

High-producing cows need concentrates with pasture. These concentrates generally need not be high in protein but should be high energy feeds. Farm grains are satisfactory supplements for high quality pasture. If the winter ration has been developed to supplement good alfalfa hay there is usually no need to change the concentrate mixture for summer feeding. Bunk feed hay with pasture regardless of pasture quality. Although cows may eat little dry hay it provides a welcome change, gets the cows to eat just a little more feed, and perhaps prevents an occasional case of bloat.

Treat pastures as any other valuable crop. Proper fertilization, rotation, clipping, and neither undergrazing nor overgrazing will insure maximum returns. Most permanent pastures provide early and late season feed but often lack in feed supply during much of the season.

An adequate pasture program provides feed throughout the season. This may be accomplished by rotation and fertilization of seeded pastures containing several grasses and legumes and by planting annuals to meet the seasonal needs. Properly managed combinations of bluegrass pasture, alfalfa, bromegrass, fescue, or Sudan grass can generally provide a full season's supply of pasture when seeded on regularly cultivated fields and managed as any other crop.

Many good dairymen provide corn silage or hay crop silage to supplement pasture. Often the excess hay growth during the early season is ensiled for feeding later in the summer. A constant supply of fresh water and trace-mineralized salt should be provided at the pasture site. Shaded areas are highly desirable but should be large enough to prevent crowding and contamination.

8. WINTER FEEDING PROGRAMS

In most herds cows should receive all of the forage they will eat. The amounts eaten are greatly influenced by the palatability of the hay or silage. With good quality hay and silage, cows will eat from 2 to 2½ pounds of hay equivalent per 100 pounds of body weight.

Silage is converted to hay equivalent on the basis of equal dry matter; approximately 3 pounds of corn silage or grass silage, or 2 pounds of low-moisture grass silage (haylage) has the same dry matter as 1 pound of hay.

With good quality forage, a 1,200 pound cow eats from 12 to 16 pounds of hay and 35 to 50 pounds of silage. If only 5 pounds of hay is fed, she probably would eat from 60 to 75 pounds of silage. If no silage is fed she should eat from 25 to 30 pounds of hay.

If grain is relatively cheap (less than twice as much per ton as hay) forage feeding may be limited to 1½ pounds of hay equivalent per 100 pounds of body weight to encourage higher grain consumption.

The kind of forage fed depends on what a dairyman has available. It is wise to inventory feed early so that any extra hay needed may be purchased at haying time. If hay of average or low quality must be fed and some good hay is available, the good hay should be rationed so that some is fed every day. Cows eat more hay if it is fed more than once a day, because they prefer fresh hay to that which has been blown upon.

Although corn silage can make up most of the forage ration, cows crave some dry forage and should be fed a small amount of hay along with the silage. If large amounts of corn silage are fed, the protein in the grain mix must be increased to replace that which was otherwise supplied by hay. Corn silage alone does not provide sufficient energy and must be supplemented with grain for efficient production.

Concentrates

The high-producing cow cannot eat enough forage to meet her energy needs, so concentrates are fed to supply these needs. The kinds and proportions of various grains and protein supplements to feed depends on which grains are grown, the prices of purchased grains and protein supplements, and the kind of forage fed.

Simple mixtures of home-grown grains supplemented with oilseed meals for protein have given as good results as more complex mixtures containing several grains and more than one source of protein. Cows prefer coarsely ground grain to finely ground grain and coarse grinding costs less; however, all kernels should be cracked. Grains are all low in protein and are primarily sources of energy in the dairy ration.

Cows differ greatly in their grain needs, largely due to difference in production. The dairyman handling the feed scoop should follow a general guide and then adjust up or down for each cow according to her production response, condition of flesh, and appetite.

1. Increase grain gradually following calving until the cow hits her peak milk flow. Hold grain at this level until production starts to drop. Then decrease grain 1 pound for each 3-pound drop in milk. This is called "challenge" or "lead" feeding; it gives each cow the opportunity to produce at her inherited capacity.

2. The Central Processing DHIA record computes a "concentrates indicated" amount for each cow in

the herd. This is a good guide if the amounts and quality of hay and silage eaten are accurately reported.

3. Hay and silage provide enough nutrients to maintain body weight and produce 20 to 25 pounds of milk in the low-test breeds or 12 to 15 pounds of milk in the high-test breeds. Feed 1 pound of grain for each 2 pounds of milk produced over these amounts. Since feeding is based on production, this method gives the individual cow less opportunity to reach high level production than "lead" feeding.

Feeding High-Producing Cows for Maximum Returns

Many of the overhead costs per cow, such as housing, equipment, and labor, remain about the same regardless of the level of milk production. To reach maximum net return it is important to give each cow an opportunity to produce at her maximum level.

In many herds the limiting factor to higher milk production is the failure to feed enough grain to meet the cow's need for producing at her inherited capacity. This is most important during the first part of the lactation. The cow that is underfed, either due to feeding poor quality forage or insufficient grain, fails to reach her peak production. Production cannot be completely recovered by normal feeding later. It costs less to feed enough to keep the cow from losing excessive weight than to put flesh back on a cow during her dry period.

Feeding grain more than twice a day may be a practical way to increase grain consumption of cows that otherwise do not eat enough to meet their needs. In stanchion barns this may be done easily during the winter. Replacing part of the oats or ground ear corn with shelled corn or barley gives a ration higher in energy, so that it is easier for the high producer to eat enough. But more skill is required for the feeder to keep the cow "on feed."

Cows milked in parlors often are not in the parlor long enough to eat sufficient grain, so extra grain should be fed at other times. Some grain may be fed on top of bunk-fed silage so that cows need less in the parlor. Another method is to put high producers into a separate lot once a day where they may be bunk fed extra grain. Or cows may be grouped according to production in two or more lots, so that extra grain may be bunk fed according to the average level of the production of the group.

A good job of producing high quality forage (see chapter 5) and timely purchase of feeds not raised on the farm (see chapter 6) will help insure having enough good feed on hand to feed liberally.

Feeding Minerals and Vitamins

The dairy cow's mineral needs have been discussed in chapter 4. These needs may be met by making available trace mineral salt and a calcium-phosphorus supplement—either steamed bonemeal or dicalciumphosphate.

Salt and a calcium-phosphorus supplement may be added to the grain mixture at the rate of 1 percent each, or 1 pound of salt and 1 pound of a calcium-phosphorus supplement to each 100 pounds of grain mix. In addition, both the salt and the calcium-phosphorus supplement should be available free choice. Using separate boxes in the exercise lot is preferable to mixing, because cows may require more of one than the other; if separate boxes are used the cows will eat what they need.

Vitamin needs also have been discussed in chapter 4. Normal dairy rations will meet cows' needs without additional feeding of vitamin supplements, except the possible need for additional vitamin A when poor quality forage that has lost its green color or hay that has been stored for over a year must be fed. One pound per day of dehydrated alfalfa provides an economical source of vitamin A. Some sources of synthetic vitamin A in premixes are also relatively inexpensive. Cows on good pasture or green chop have no need for supplemental vitamin A.

9. MANAGEMENT FACTORS

Special Feeds

Molasses has 70 to 75 percent of the feed value of ground shelled corn. It contains about 55 percent sugar and 26 percent water, and is low in protein; 6½ gallons of molasses equal 1 bushel of corn in energy value. Because molasses is unusually palatable it is often diluted and mixed with less palatable feeds.

Urea is a natural secretion from animal bodies as a waste product. Synthetic urea is made commercially from carbon dioxide and ammonia. It is poisonous if overfed. It contains six times as much nitrogen as 44-percent soybean meal. The bacteria of the rumen can combine some of this nitrogen with carbohydrates, especially starches, to form protein. Each pound of urea added to 100 pounds of grain mixture raises protein equivalent level 2.6 percent. Because of its toxic characteristics, great care must be taken in adding urea to a ration:

- It should be thoroughly mixed with the ration.
- It should not provide over 30 percent of the protein equivalent of the grain mixture.

Beet pulp is a bulky, very palatable feed. It is often used as an appetizer to either put a fill on cows for showing or to increase grain consumption. It is usually soaked and fed wet. Dry beet pulp has about the same energy value as ground oats, but somewhat less energy value than ground corn. It is relatively low in protein.

Potatoes are very low in protein and vitamins A and D. They have only 22 to 25 percent of the feed value of grains, but in the potato-growing areas of

Minnesota are often available at low prices for livestock feed. When fed to cattle they should be chopped or sliced to avoid possible choking. They should not be fed before milking. They can be substituted for silage although they are less palatable.

Special Feeding Programs

The dry cow—Feed some grain to dry cows to help build up body reserves. The amount to feed depends on the cow's condition, from 3 to 5 pounds daily is common. Three weeks before calving increase the daily ration to 1 pound of grain to each 100 pounds live weight, and continue this rate through calving. A cow freshening in good condition starts off better and maintains a higher level of production. Also, her milk is usually higher in total solids.

The fresh cow—The cow's body is subject to sudden stress when she calves, first from delivery of the calf, then from the sudden drain on her system through milk production. Changing her ration adds extra adjustment problems. Increase grain fed gradually under the "lead system" discussed on page 38.

Feeding under the lead system does not increase udder edema or mastitis. It will get the cow off to a better start with higher production.

Calf feeding—For details on calf feeding and management see Extension Bulletin 305, "Feeding and Managing Dairy Calves and Heifers."

10. FEEDING AND CARE OF LIVESTOCK IN CASE OF NUCLEAR ATTACK

1. Radioactive fallout from the atmosphere is like dust, with each particle giving off radiation like a minature X-ray machine.

2. This radiation can injure or kill livestock, mainly from particles on the ground, on roofs of buildings, or in the feed supply.

3. A two-story basement-type barn with a mow full of hay will reduce radiation exposure by 80 percent; a wooden barn will reduce radiation exposure by 50 percent.

4. Feed free of fallout dust is safe for livestock.

5. Hay and grain stored in tight mows, bins, covered silos, and covered haystacks are safe to feed.

6. Water from springs and wells will be safe. Open water and streams will be unsafe for several days.

7. In case of nuclear attack get as much of your livestock as possible under the best shelter available. Consider milk cows first. Stay inside until advised by defense authorities that it is safe to be outdoors.

11. USING FEEDING STANDARDS IN COMPUTING RATIONS

Most dairymen will use the feeding plans suggested on page 37 as a matter of convenience. Directions for balancing a given ration are found in the following pages.

Feeding standards have been developed from feeding trials showing the requirements for maintaining body weight and production of milk. The first feeding standard was developed by Profesor T. L. Haecker from extensive research he carried out at the University of Minnesota and published in 1903. The feeding standard used in this bulletin is a modification of the original Haecker standard based on more recent studies.

Calculating Requirements

A 24-hour period is used in calculating requirements and nutrients supplied to balance a ration. A 1,200-pound cow producing 40 pounds of 3.5-percent milk daily may be used as an example. Appendix table 1 shows that a 1,200-pound cow requires 0.76 pounds digestible protein and 9.3 pounds of TDN for maintenance. Appendix table 3 gives requirements for milk production: 1.88 pounds (0.047 x 40) of digestible protein and 14.4 pounds (0.36 x 40) pounds of TDN. For convenience, write these requirements as follows:

	Digestible crude protein	Total digestible nutrients
	pounds	pounds
For maintenance of 1,200 pound cow	0.76	9.3
For 40 pounds of 3.5 percent milk	1.88	14.4
Total requirements	2.64	23.7

So the total requirement per day for such a cow is 2.64 pounds digestible protein and 23.7 pounds TDN.

Balancing the Ration

With the requirements known, a dairyman may calculate a ration to meet his needs. Most will feed the roughage available and balance the ration with home-grown grains and purchased high protein feed.

For example, suppose the cow in the example above is fed average quality corn silage and medium quality alfalfa-brome hay. She eats an average of 35 pounds of silage and 12 pounds of hay per day and is fed 1 pound of grain per 4 pounds of milk.

Guide for digestible nutrients in each feed:

	Digestible crude protein	Total digestible nutrients
Ration:	pounds	pounds
35 pounds corn silage	0.53	7.0
12 pounds alfalfa-brome medium quality hay	0.91	5.8
10 pounds corn-and-cob meal	0.57	7.4
Total	2.01	20.2
Short of requirement	0.63	3.5
Add:		
4 pounds corn-and-cob meal	0.23	2.9
1 pound soybean oilmeal	0.42	0.8
	0.65	3.7

The check on this cow's ration shows it was short in both digestible protein and TDN. The balanced ration now consists of 35 pounds corn silage, 12 pounds alfalfa-brome hay, 14 pounds corn-and-cob meal, and 1 pound soybean oilmeal.

Rations may be short of both protein and TDN as shown in this illustration, or they may lack only protein or TDN.

Shortage of TDN means more energy feeds are needed. Shortage of protein is usually met by purchasing a high-protein feed and adding to the ration. This is especially true if a dairyman has an ample supply of low or medium quality hay.

High quality alfalfa hay supplies an abundance of protein because it is both high in digestible protein and is palatable so cows will eat more. For example, suppose that a 1,400-pound cow produces 70 pounds of 3.5-percent milk per day:

	Digestible protein	TDN
Requirements:	pounds	
Maintenance, 1,400-pound cow	0.87	10.6
Production, 70 pounds 3.5-percent milk	3.54	28.0
Total requirements	4.41	38.6
Feed to balance:		
45 pounds corn silage	0.68	9.0
18 pounds early cut alfalfa hay	2.59	9.9
27 pounds corn-and-cob meal	1.54	20.0
Total	4.81	38.9

The above illustrations show how to calculate a ration meeting feeding standard requirements for digestible protein and total digestible nutrients. But these, as any suggested feeding plans, serve primarily as guides. The successful dairyman must adjust them to his conditions and to the responses of individual cows as discussed on page 38. Since the mineral and vitamin content of feeds varies greatly it is not practical to calculate a balanced ration for them. For best results, follow the recommendations on page 21.

TDN is used in these illustrations because it is more easily understood. The same procedure is followed when using net energy (ENE); ENE provides more realistic values.

Calculating the Cost of Purchased Protein

Since feeds high in protein are purchased to balance the protein requirements in a ration it is of practical importance for a dairyman to purchase his protein as cheaply as possible. To find the cost of 1 pound of crude protein in a given feed divide the price per 100 pounds by the crude protein percentage, which must be given on the feed tag according to state law.

Table 12. How protein cost may vary at a given time

Feed	Price per ton	Price per 100 pounds	Percent crude protein	Cost per pound of crude protein
A	$138	$6.90	32	$.215
B	100	5.00	32	.156
C	80	4.00	32	.125
D	85	4.25	36	.118
E	90	4.50	44	.102

Table 13 provides feed evaluation factors for estimating relative values of the energy and protein content of common feedstuffs compared to corn and soybean meal. To evaluate any feed on the list:

1. Multiply the current price for corn by the evaluation factor for corn (first column opposite the feed you're evaluating).
2. Multiply the current price for soybean meal by the evaluation factor for soybean meal (second column opposite the feed you're evaluating).

3. Add the two figures. (Note that some evaluation factors have negative values. In such cases, subtract.) Use the same weight units (pounds, cwt., tons, etc.) for corn, soybean meal, and the feed you wish to evaluate.

Example: What is the value of corn silage on your farm when No. 2 dent corn is worth $40 and soybean meal worth $80 per ton?

$40 x .265 = $10.60
80 x .011 = .88 **(Subtract, since this is a negative value.)**
$ 9.72

So corn silage is worth $9.72 per ton as an energy food when corn is worth $40 and soybean meal $80 per ton. This does not imply that the feed is balanced between energy and protein.

Table 13. Feed evaluation factors for estimating relative values of the energy and protein content of common feedstuffs compared to corn and soybean meal

Feed	Feed evaluation factors: Corn	Feed evaluation factors: Soybean meal
Dry Roughages		
Alfalfa hay, low quality	0.263	0.153
Alfalfa hay, average	0.296	0.212
Alfalfa hay, high quality	0.286	0.259
Brome grass hay	0.415	0.060
Corn fodder, high in water	0.327	0.005
Corn fodder, well eared, dry	0.478	0.014
Mixed hay, good, less than 30% legume	0.427	0.039
Oat hay	0.423	0.049
Green Roughages		
Alfalfa, green	0.093	0.069
Bluegrass pasture	0.155	0.073
Corn fodder, dent, in milk	0.147	−0.002

Table 13 (continued). Feed evaluation factors for estimating relative values of the energy and protein content of common feedstuffs compared to corn and soybean meal

Feed	Feed evaluation factors: Corn	Feed evaluation factors: Soybean meal
Silages		
Alfalfa, not wilted, no preservatives	0.091	0.047
Alfalfa, wilted	0.140	0.080
Alfalfa-brome, wilted	0.143	0.075
Corn, dent, well matured, well eared	0.265	—0.011
Grass silage, small proportion legumes	0.144	0.022
Concentrates		
Barley	0.765	0.116
Beet pulp	0.931	—0.051
Brewers' grains	0.374	0.464
Corn, dent, grade No. 2	1.000	0.000
Corn, dent, grade No. 3	0.984	—0.002
Corn, dent, grade No. 4	0.917	0.006
Corn-and-cob meal	0.918	—0.018
Corn gluten meal	0.158	0.848
Cottonseed meal, 43%	0.130	0.834
Distillers' dried corn grain with solubles	0.710	0.350
Fish meal	—0.457	1.349
Linseed meal, 36%	0.201	0.699
Molasses, beet, not over 10% of concentrates	1.058	—0.169
Oats	0.924	0.076
Screenings, grain, good grade	0.534	0.134
Soybean meal, 44%	0.000	1.000
Wheat bran	0.619	0.218
Wheat standard middlings	0.743	0.222
Yeast, torula dried	—0.242	0.989

12. APPENDIX

These tables are included to help you select the most profitable ration for your dairy cattle.

Appendix Table 1. Daily maintenance requirements of dairy cows for protein, TDN, and energy

Weight of cow	Digestible protein	TDN—Total digestible nutrients	ENE—Estimated net energy
	pounds		therms
700	0.48	5.8	4.6
750	0.51	6.2	4.9
800	0.54	6.5	5.2
850	0.56	6.9	5.5
900	0.59	7.2	5.8
950	0.62	7.6	6.1
1,000	0.65	7.9	6.3
1,050	0.68	8.3	6.6
1,100	0.71	8.6	6.9
1,150	0.73	9.0	7.2
1,200	0.76	9.3	7.4
1,250	0.79	9.6	7.7
1,300	0.82	10.0	8.0
1,350	0.84	10.3	8.2
1,400	0.87	10.6	8.5
1,450	0.90	11.0	8.8
1,500	0.92	11.3	9.0
1,550	0.95	11.6	9.3
1,600	0.98	11.9	9.6
1,650	1.00	12.3	9.8
1,700	1.03	12.6	10.1
1,750	1.06	12.9	10.3

Appendix Table 2. Requirements of dairy cattle: calcium, phosphorus, carotene, and vitamin D

Weight, pounds	Calcium	Phosphorus	Carotene	Vitamin D
Growth (daily basis)	grams		mg.	I. U.
100	7	6	4	300
200	13	10	8	600
400	13	12	16	1,200
600	13	12	24	1,800
800	13	12	32	2,400
1,000	12	12	40	3,000
Maintenance (daily basis per cwt. weight)	0.8	0.8	4	*
Reproduction (daily basis for last 2 months of gestation)	8	7	30	*
Milk production (per pound of milk produced)	1	0.7	†	*

* Vitamin D is required for maintenance, reproduction, and milk production but quantitative requirements have not been worked out.

† Milk secretion as such does not require carotene or vitamin A. However, considerable vitamin A and/or carotene is excreted into milk and a generous supply for maintenance should be provided. Adding 200 mg. carotene per day will insure a high vitamin A content of milk.

Appendix Table 3. Protein (digestible protein) and energy (ENE or TDN) requirements for each pound of milk produced, as related to level of production and fat content of the milk

Fat content of milk, percent	Pounds milk produced per cow per day																				
	20			30			40			50			60			70			80		
	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡
3.0	.032	.21	.23	.040	.28	.30	.044	.31	.33	.046	.33	.36	.047	.34	.37	.049	.35	.38	.050	.36	.39
3.5	.034	.23	.25	.043	.30	.32	.047	.33	.36	.049	.35	.38	.050	.36	.39	.052	.37	.40	.053	.38	.41
4.0	.036	.25	.27	.045	.32	.34	.049	.35	.38	.052	.37	.40	.053	.38	.41	.055	.39	.42	.056	.40	.43
4.5	.038	.27	.29	.048	.34	.37	.052	.37	.40	.055	.39	.42	.056	.40	.43	.058	.41	.44	.059	.42	.45
5.0	.040	.29	.31	.050	.36	.39	.055	.39	.42	.058	.41	.44	.059	.42	.45	.061	.43	.46	.062	.44	.48
5.5	.042	.31	.33	.053	.38	.41	.058	.41	.44	.061	.43	.46	.062	.44	.48	.064	.45	.49	.066	.46	.50
6.0	.044	.33	.36	.055	.40	.43	.060	.43	.46	.064	.45	.49	.065	.46	.50	.067	.47	.51	.069	.48	.52

*1. Digestible protein in pounds.

†2. ENE in therms.

‡3. TDN in pounds.

Appendix Table 4. Feed composition in terms of crude protein, digestible protein, and energy (TDN and ENE)

Feed	Crude protein	Digestible protein	TDN	ENE per 100 lb.
DRY FORAGE				
Alfalfa hay	percent	percent	percent	therms
Early cut, excellent quality	20.0	14.4	55	45
Early cut, good quality	17.7	12.3	52	41
Medium early cut, good quality	16.0	11.2	51	41
Medium early cut, fair quality	15.0	10.4	49	37
Late cut, fair-good quality	13.6	9.4	46	32
Mature, mostly stems	10.5	6.1	42	28
Meal	15.0	11.1	52	41
Leaf meal	21.0	16.3	57	48
Alfalfa-brome				
Early cut, good quality	13.5	9.5	51	41
Early cut, medium quality	12.0	7.6	48	35
Bluegrass, Kentucky				
Early cut	13.0	8.8	56	47
Clover hays				
Alsike	13.8	9.6	53	43
Common Red	14.0	9.7	55	45
Mammoth Red	12.0	7.7	53	43
Sweet	18.0	11.7	50	39
Field pea hay	17.0	11.4	55	45
Soybean hay				
Good quality	17.0	11.1	54	44
Poor quality	11.0	7.0	47	34
Hays low in protein				
Bluegrass, Kentucky, in bloom	7.1	4.0	52	41
Brome	9.4	4.7	47	34
Corn fodder	7.5	3.7	58	50
Corn stover	5.7	2.0	51	41
Oat hay	6.6	3.7	46	32
Oat straw	4.5	0.8	44	31
Prairie hay	7.4	2.8	45	32
Reed canary grass	7.1	4.5	45	32
Rye hay	5.0	3.0	45	32
Rye straw	3.5	0.3	41	27
Sudan grass hay	8.6	4.8	52	41
Timothy hay	5.8	2.9	48	37
Wheat straw	3.9	0.4	41	27

Appendix Table 4 (continued). Feed composition in terms of crude protein, digestible protein, and energy (TDN and ENE)

Feed	Crude protein	Digestible protein	TDN	ENE per 100 lb.
Silage	percent			therms
Alfalfa, wilted	6.5	4.5	20	15
Alfalfa, high moisture	5.5	3.4	16	13
Alfalfa, with molasses	4.9	3.2	16	13
Beet top	3.5	2.0	11	7.2
Clover				
Red	4.9	2.9	17	13
Sweet	5.8	4.4	20	16
Corn, average	2.8	1.5	20	18
Corn, 80 + bu./acre	2.6	1.5	23	21
Corn, cannery byproduct	2.3	1.3	18	15
Pea vine, cannery byproduct	3.1	1.8	15	12
Reed canary grass	3.3	1.9	16	14
Sorghum	2.2	1.3	16	14
Soybean	2.6	1.7	14	11
Sunflower	2.6	1.4	14	11
GREEN FORAGE				
Alfalfa, immature	5.0	4.1	13	12
Alfalfa, in bloom	3.5	2.5	13	11
Bluegrass, immature	5.0	3.6	19	17
Brome, immature	4.1	3.1	14	13
Corn fodder, immature	1.6	1.0	14	13
Corn fodder, mature	2.0	1.2	19	17
Red clover, immature	5.3	3.7	13	12
Red clover, in bloom	4.8	3.2	20	18
Oats pasture	3.1	2.1	11	9.5
Reed canary grass	3.0	1.8	10	8.3
Mangels	1.2	0.9	7	6.7
Potatoes	2.1	1.2	18	18
Rutabagas	1.3	0.9	10	10
Sugar beets	1.6	1.1	18	18
Rye pasture, immature	5.0	3.5	14	12
Rye pasture, mature	3.0	2.1	17	13
Rape	2.6	2.0	11	10
Turnips	1.3	0.9	8	7.4
CONCENTRATES				
Barley	12.3	10.0	77	77
Beet pulp, dried, plain	8.5	4.5	68	64
Beet pulp, dried, molasses	11.0	7.5	71	67
Bloodmeal	85.0	57.6	60	52
Brewers' dried grains	23.0	16.6	62	55
Buckwheat	9.8	7.2	62	55
Buttermilk, dried	33.0	30.9	83	84

Appendix Table 4 (continued). Feed composition in terms of crude protein, digestible protein, and energy (TDN and ENE)

Feed	Crude protein	Digestible protein	TDN	ENE per 100 lb.
	percent			therms
Corn-and-cob meal	8.1	5.7	74	73
Corn cobs	2.3	0.1	45	31
Corn, dent, shelled No. 2	9.1	7.0	80	81
Corn gluten feed	25.2	22.5	76	74
Corn gluten meal	43.0	36.6	80	80
Cottonseed meal	42.5	34.0	74	72
Fishmeal	62.0	55.8	77	75
Hominy feed	10.7	8.0	84	85
Linseed meal (33 to 38 percent)	37.5	32.5	77	75
Malt sprouts, dry	27.2	21.6	71	66
Molasses, beet	6.0	2.9	61	57
Molasses, cane	3.0	......	55	50
Oats, grain	12.5	9.7	70	66
Oats, millfeed	4.1	2.8	37	19
Rye, grain	11.0	8.8	78	78
Screenings, grain	13.6	10.2	63	57
Skim milk, dried	33.2	31.0	80	79
Soybean meal	46.2	42.4	78	78
Soybeans	37.0	32.5	90	95
Wheat, grain	12.3	10.1	80	80
Wheat bran	16.4	13.3	67	63
Wheat middlings	17.8	15.6	78	78
Whey, dried	14.0	12.2	78	75
Yeast, dried	49.0	42.0	72	68

Appendix Table 5. Average weight of 1 quart of feed

Feed	Weight, pounds	Feed	Weight, pounds
Alfalfa meal	0.6	Molasses, cane	3.0
Barley, whole	1.5	Oats, whole	1.0
Barley, ground	1.1	Oats, ground	0.7
Beet pulp, dry	0.7	Rye, whole	1.7
Corn, shelled	1.7	Rye, ground	1.5
Corn, ground	1.5	Soybeans, whole	1.8
Corn-and-cob meal	1.4	Soybeans, ground	1.4
Cottonseed meal	1.5	Soybean meal	1.3
Flax, ground	1.1	Wheat, ground	1.7
Gluten feed	1.3	Wheat bran	0.5
Gluten meal	1.7	Wheat middlings	1.0
Linseed meal	1.3		

Appendix Table 6. Cost of 100 pounds of feed at a given price and weight per bushel

Cost per bushel	Cost of 100 pounds when a bushel weighs: 32 pounds (oats)	48 pounds (barley)	56 pounds (shelled corn)	60 pounds (wheat)	70 pounds (corn-and-cob meal)
cents					
20	$0.63	$0.42	$0.36	$0.33	$0.29
21	0.66	0.44	0.38	0.35	0.30
22	0.69	0.46	0.39	0.37	0.31
23	0.72	0.48	0.41	0.38	0.33
24	0.75	0.50	0.43	0.40	0.34
25	0.78	0.52	0.45	0.42	0.36
26	0.81	0.54	0.46	0.43	0.37
27	0.84	0.56	0.48	0.45	0.39
28	0.88	0.58	0.50	0.47	0.40
29	0.91	0.60	0.52	0.48	0.41
30	0.94	0.63	0.54	0.50	0.43
31	0.97	0.65	0.55	0.52	0.44
32	1.00	0.67	0.57	0.53	0.46
33	1.03	0.69	0.59	0.55	0.47
34	1.06	0.71	0.61	0.57	0.49
35	1.09	0.73	0.63	0.58	0.50
36	1.13	0.75	0.64	0.60	0.51
37	1.16	0.77	0.66	0.62	0.53
38	1.19	0.79	0.68	0.63	0.54
39	1.22	0.81	0.70	0.65	0.56
40	1.25	0.83	0.71	0.67	0.57
41	1.28	0.85	0.73	0.68	0.59
42	1.31	0.88	0.75	0.70	0.60
43	1.34	0.90	0.77	0.72	0.61
44	1.38	0.92	0.79	0.73	0.63
45	1.41	0.94	0.80	0.75	0.64
46	1.44	0.96	0.82	0.77	0.66
47	1.47	0.98	0.84	0.78	0.67
48	1.50	1.00	0.86	0.80	0.69
49	1.53	1.02	0.88	0.82	0.70

Appendix Table 6 (continued). Cost of 100 pounds of feed at a given price and weight per bushel

Cost per bushel	Cost of 100 pounds when a bushel weighs 32 pounds (oats)	48 pounds (barley)	56 pounds (shelled corn)	60 pounds (wheat)	70 pounds (corn-and-cob meal)
cents					
50	$1.56	$1.04	$0.89	$0.83	$0.71
51	1.59	1.06	0.91	0.85	0.73
52	1.63	1.08	0.93	0.87	0.74
53	1.66	1.10	0.95	0.88	0.76
54	1.69	1.13	0.96	0.90	0.77
55	1.72	1.15	0.98	0.92	0.79
56	1.75	1.17	1.00	0.93	0.80
57	1.78	1.19	1.02	0.95	0.81
58	1.81	1.21	1.04	0.97	0.83
59	1.84	1.23	1.05	0.98	0.84
60	1.88	1.25	1.07	1.00	0.86
61	1.91	1.27	1.09	1.02	0.87
62	1.94	1.29	1.11	1.03	0.89
63	1.97	1.31	1.13	1.05	0.90
64	2.00	1.33	1.14	1.07	0.91
65	2.03	1.35	1.16	1.08	0.93
66	2.06	1.38	1.18	1.10	0.94
67	2.09	1.40	1.20	1.12	0.96
68	2.13	1.42	1.21	1.13	0.97
69	2.16	1.44	1.23	1.15	0.99
70	2.19	1.46	1.25	1.17	1.00
71	2.22	1.48	1.27	1.18	1.01
72	2.25	1.50	1.29	1.20	1.03
73	2.28	1.52	1.30	1.22	1.04
74	2.31	1.54	1.32	1.23	1.06
75	2.34	1.56	1.34	1.25	1.07
76	2.38	1.58	1.36	1.27	1.09
77	2.41	1.60	1.38	1.28	1.10
78	2.44	1.63	1.39	1.30	1.11
79	2.47	1.65	1.41	1.32	1.13

Appendix Table 6 (continued). Cost of 100 pounds of feed at a given price and weight per bushel

Cost per bushel	Cost of 100 pounds when a bushel weighs				
	32 pounds (oats)	48 pounds (barley)	56 pounds (shelled corn)	60 pounds (wheat)	70 pounds (corn-and-cob meal)
cents					
80	$2.50	$1.67	$1.43	$1.33	$1.14
81	2.53	1.69	1.45	1.35	1.16
82	2.56	1.71	1.46	1.37	1.17
83	2.59	1.73	1.48	1.38	1.19
84	2.63	1.75	1.50	1.40	1.20
85	2.66	1.77	1.52	1.42	1.21
86	2.69	1.79	1.54	1.43	1.23
87	2.72	1.81	1.55	1.45	1.24
88	2.75	1.83	1.57	1.47	1.26
89	2.78	1.85	1.59	1.48	1.27
90	2.81	1.88	1.61	1.50	1.29
91	2.84	1.90	1.63	1.52	1.30
92	2.88	1.92	1.64	1.53	1.31
93	2.91	1.94	1.66	1.55	1.33
94	2.94	1.96	1.68	1.57	1.34
95	2.97	1.98	1.70	1.58	1.36
96	3.00	2.00	1.71	1.60	1.37
97	3.03	2.02	1.73	1.62	1.39
98	3.06	2.04	1.75	1.63	1.40
99	3.09	2.06	1.77	1.65	1.41
100	3.13	2.08	1.79	1.67	1.43

Appendix Table 7. Cost of 100 pounds of feed at a given price per ton

Price per ton	Cost per 100 pounds	Price per ton	Cost per 100 pounds	Price per ton	per 100 pounds Cost
$ 3.00	$0.15	$20.50	$1.03	$38.00	1.90
3.50	0.18	21.00	1.05	38.50	1.93
4.00	0.20	21.50	1.08	39.00	1.95
4.50	0.23	22.00	1.10	39.50	1.98
5.00	0.25	22.50	1.13	40.00	2.00
5.50	0.28	23.00	1.15	40.50	2.03
6.00	0.30	23.50	1.18	41.00	2.05
6.50	0.33	24.00	1.20	41.50	2.08
7.00	0.35	24.50	1.23	42.00	2.10
7.50	0.38	25.00	1.25	42.50	2.13
8.00	0.40	25.50	1.28	43.00	2.15
8.50	0.43	26.00	1.30	43.50	2.18
9.00	0.45	26.50	1.33	44.00	2.20
9.50	0.48	27.00	1.35	44.50	2.23
10.00	0.50	27.50	1.38	45.00	2.25
10.50	0.53	28.00	1.40	45.50	2.28
11.00	0.55	28.50	1.43	46.00	2.30
11.50	0.58	29.00	1.45	46.50	2.33
12.00	0.60	29.50	1.48	47.00	2.35
12.50	0.63	30.00	1.50	47.50	2.38
13.00	0.65	30.50	1.53	48.00	2.40
13.50	0.68	31.00	1.55	48.50	2.43
14.00	0.70	31.50	1.58	49.00	2.45
14.50	0.73	32.00	1.60	49.50	2.48
15.00	0.75	32.50	1.63	50.00	2.50
15.50	0.78	33.00	1.65	50.50	2.53
16.00	0.80	33.50	1.68	51.00	2.55
16.50	0.83	34.00	1.70	51.50	2.58
17.00	0.85	34.50	1.73	52.00	2.60
17.50	0.88	35.00	1.75	52.50	2.63
18.00	0.90	35.50	1.78	53.00	2.65
18.50	0.93	36.00	1.80	53.50	2.68
19.00	0.95	36.50	1.83	55.50	2.78
19.50	0.98	37.00	1.85	56.00	2.80
20.00	1.00	37.50	1.88	56.50	2.83

Appendix Table 7 (continued). Cost of 100 pounds of feed at a given price per ton

Price per ton	Cost per 100 pounds	Price per ton	Cost per 100 pounds	Price per ton	Cost per 100 pounds
$57.00	$2.85	$71.50	$3.58	$86.00	$4.30
57.50	2.88	72.00	3.60	86.50	4.33
58.00	2.90	72.50	3.63	87.00	4.35
58.50	2.93	73.00	3.65	87.50	4.38
59.00	2.95	73.50	3.68	88.00	4.40
59.50	2.98	74.00	3.70	88.50	4.43
60.00	3.00	74.50	3.73	89.00	4.45
60.50	3.03	75.00	3.75	89.50	4.48
61.00	3.05	75.50	3.78	90.00	4.50
61.50	3.08	76.00	3.80	90.50	4.53
62.00	3.10	76.50	3.83	91.00	4.55
62.50	3.13	77.00	3.85	91.50	4.58
63.00	3.15	77.50	3.88	92.00	4.60
63.50	3.18	78.00	3.90	92.50	4.63
64.00	3.20	78.50	3.93	93.00	4.65
64.50	3.23	79.00	3.95	93.50	4.68
65.00	3.25	79.50	3.98	94.00	4.70
65.50	3.28	80.00	4.00	94.50	4.73
66.00	3.30	80.50	4.03	95.00	4.75
66.50	3.33	81.00	4.05	95.50	4.78
67.00	3.35	81.50	4.08	96.00	4.80
67.50	3.38	82.00	4.10	96.50	4.83
68.00	3.40	82.50	4.13	97.00	4.85
68.50	3.43	83.00	4.15	97.50	4.88
69.00	3.45	83.50	4.18	98.00	4.90
69.50	3.48	84.00	4.20	98.50	4.93
70.00	3.50	84.50	4.23	99.00	4.95
70.50	3.53	85.00	4.25	99.50	4.98
71.00	3.55	85.50	4.28	100.00	5.00

Appendix Table 8. Gestation table*

Date of:		Date of:		Date of:	
Service	Birth	Service	Birth	Service	Birth
Jan. 1	Oct. 8	May 6	Feb. 11	Sept. 8	June 16
6	13	11	16	13	21
11	18	16	21	18	26
16	23	21	26	23	July 1
21	28	26	Mar. 3	28	6
26	Nov. 2	31	8	Oct. 3	11
31	7	June 5	13	8	16
Feb. 5	12	10	18	13	21
10	17	15	23	18	26
15	22	20	28	23	31
20	27	25	Apr. 2	28	Aug. 5
25	Dec. 2	30	7	Nov. 2	10
Mar. 2	7	July 5	12	7	15
7	13	10	17	12	20
12	18	15	22	17	25
17	23	20	27	22	30
22	28	25	May 2	27	Sept. 4
27	Jan. 2	30	7	Dec. 2	9
Apr. 1	7	Aug. 4	12	7	14
6	12	9	17	12	19
11	17	14	22	17	24
16	22	19	27	22	29
21	27	24	June 1	27	Oct. 4
26	Feb. 1	29	6		
May 1	6	Sept. 3	11		

* The gestation period of cattle is from 270 to 290 days. The table is based on 282 days. Individual cows may vary several days from these figures. Research at several experiment stations indicates that there are more breed differences than was supposed. They average about as follows: Guernseys, 282 days, as given in the table; Holsteins, Jerseys, and Ayrshires, 279 days or 3 days less; Brown Swiss, 290 days or 8 days more. First-calf heifers average about a day earlier than cows.

Good Management in Feeding

1. More frequent feeding results in greater feed consumption and higher production.
2. Keep mangers clean—sweep out once a day.
3. Feed no more grain than the cows clean up. Waste raises costs.
4. Be regular in feeding and milking; develop a schedule and follow it.
5. Know each cow's response and follow it in feeding her.
6. A cow that isn't worth feeding well isn't worth keeping.
7. Don't force high-producing cows to eat low quality feed. They must be filled with high quality feed to do well.
8. Feed enough—underfeeding is costly.
9. Supply needed protein and minerals.
10. Provide plenty of fresh air and water at all times—they are the cheapest feeds.

FEEDING

THE DAIRY HERD

FEEDING

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