Extension Bulletin 218 Revised 1970

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-eight editions have been printed, and close to 560,000 copies have been distributed to Minnesota farmers. This is more than any other bulletin issued by the University's Agricultural Extension Service.

The first edition 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.

Since 1924, the bulletin has been revised seven times: 1924 by C.H. Eckles and O.G. Schaefer; 1932 by C.H. Eckles; 1938 by T.W. Gullickson and J.B. Fitch; 1943 by J.B. Fitch, H.R. Searles, E.A. Hanson, and R.D. Leighton; 1952 by H.R. Searles, R.W. Wayne, T.W. Gullickson, and R.D. Leighton; 1963 by R.W. Wayne, C.L. Cole, J.D. Donker, J.W. Mudge, and C.L. Wilcox; and 1970 by R.W. Wayne, J.D. Donker, J.W. Mudge, and D.E. Otterby.

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Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Roland H. Abraham, Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55101.

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Changes in Minnesota Dairying

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

- Dairy products accounted for 22 percent of Minnesota cash farm income in 1969.
- About 40 percent of the value of the beef marketed from Minnesota farms and feedlots is from cows, calves, and steers originating from dairy herds.
- For many years, Minnesota has led all states in the production of butter and dry milk products.
- Minnesota ranks third in number of dairy cattle and total milk production.

There have been some decided changes in the dairy industry in Minnesota, especially in recent years. For many decades, dairy herds were located on a high percentage of farms in the state, with several counties having dairy herds on nearly every farm. With most of the milking done by hand, the size of herds was limited to the number of people available to do the milking. Most milk was marketed at a local creamery as farm separated cream with the skim milk used as calf and pig feed. During World War II, there was a great demand for human food, which fostered a shift to selling whole milk instead of cream. Following the war, this trend continued and the introduction of mechanized milking machines, barn cleaners, silo unloaders, bulk tanks, and automatic feeding made growth in herd size possible. Competition from efficient herds and the alternatives available on many farms have resulted in a great increase in production per cow, a decided reduction in number of herds and, to a lesser degree, a reduction in number of milk cows. Milk now leaves the farm almost entirely as whole milk, with 63 percent in bulk in 1968.

Table 1 shows some of these changes. These trends will continue. Dairying in Minnesota has become highly technical and specialized, with only efficient dairymen staying in the business.

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	DHI 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
1955	1,378,000	116,230	11.9	29.6	70.4	6,410	9,512
1960	1,265,000	85,018	14.9	10.7	89.3	8,030	11,018
1965	1,232,000	67,250	18.3	5.4	94.6	8,550	11,951
1969	1,008,000	46,062	21.9	1.5	98.5	9,650	12,690

Keys to Profitable Dairying

Successful 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.

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.

HIGH PRODUCTION PER COW. A dairyman 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 cow producing 15,000 pounds of milk is far more than twice that from a 7,500 pound producer.

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 cows not on the Dairy Herd Improvement (DHI) test in 1969 was 8,970 pounds of milk, with an annual labor return of $87. Cows enrolled in the DHI program averaged 12,690 pounds of milk and returned $207 for labor. Higher production per cow with fewer cows clearly

Table 2. As milk production increases, percentage of feed energy used for production increases*

Milk production, pounds	Percentage of energy in feed consumed used for: Maintenance	Milk production
5,000	67.3	32.7
8,000	56.4	43.6
12,000	45.4	54.6
15,000	39.2	60.8
18,000	34.2	65.8
21,000	30.0	70.0

* Figures based on a cow weighing 1,350 pounds producing milk with 3.5 percent butterfat.

results in greater returns and less total production on the market.

Ability of Cow to Produce. Breeding is the first limiting factor affecting production level 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. 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 that have proven themselves through the production of their daughters.

All Minnesota artificial breeding associations now make available the services of outstanding proved sires. Information on these sires is available through publications of the breeding associations and *Who's Who In Minnesota A-I Sires*, issued by the University of Minnesota Agricultural Extension Service.

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

Table 3. Number of cows and production level per cow needed to return $5,000 annually for labor at different production levels in 1969 using the average price ($4.39 less 18 cents hauling) received for grade B milk with 3.54 percent butterfat

Average production, pounds	Annual labor return per cow	Cows needed	Total production, pounds
	dollars		
6,225	NONE	INFINITY	INFINITY
8,970	87	57	511,290
12,690	207	25	317,250
15,000	282	18	270,000
17,000	333	15	255,000

KEEPING AND USING PRODUCTION AND BREEDING RECORDS. Good records are necessary in a successful business. On January 1, 1970, 5,448 of Minnesota's top dairymen were 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 by keeping similar records.

DHI 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.

DHI lactation records are used in all proved sire analysis work. In fact, the entire proved sire program is built on DHI records. Every dairyman using artificial breeding thus benefits directly from this use of DHI records, even if he is not a member. The fact that Minnesota's 5,448 DHI members pay over $1 million annually for this service shows that they appreciate the value of these records.

Good Care and Management. The successful dairyman must know how to get the most from his herd. This requires gentle handling, a healthful environment, close observation, provision for comfort of the animal, quick detection and treatment of sick animals, regular feeding and milking, and knowledge of the 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 utilize feed, labor, and his investment in farm and equipment most efficiently. 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.

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 provide effective treatments, prevention of cattle diseases is enhanced by good management, close observation, and an understanding of diseases.

Regular Calving. Annual production of a 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, the closeness with which the dairyman watches his cattle for evidence of heat, and the time of service. Except where the ration may be deficient in essential nutrients, feeds apparently have 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.

Providing for Good Herd Replacements. Even with good management, cows are removed from the herd and must be replaced. DHI records show that about one-fourth of the cows in the herd are removed during the year for various reasons.

PRODUCING HIGH QUALITY MILK. Full returns from a dairy herd are realized only when that herd produces high quality milk. Processors are becoming more and more insistent on high quality milk. Only the dairyman who meets this demand will be successful. Factors to be considered are bacterial count, leucocyte count, contamination by foreign material, drugs administered to cattle, and odor and taste of the milk.

How a Cow Digests and Uses Feed

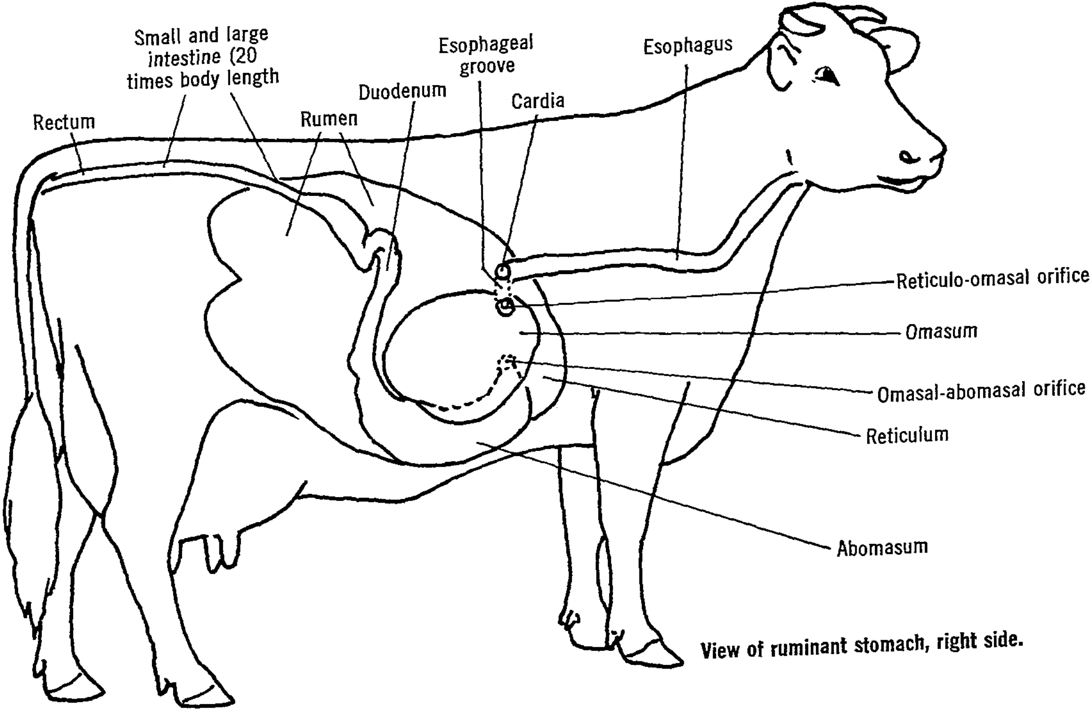
THE DIGESTIVE PROCESS

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

The feed a cow eats is masticated in the mouth, where it is mixed with an abundant supply of saliva. The saliva moistens the feed so the cow can swallow it easily and also serves as a buffer in maintaining a desirable pH or acid-alkaline relationship in the rumen.

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 cow's body: in an adult cow, it may weigh over 200 pounds when filled with feed and water. The R-R contains blind sacs and is very muscular. Waves of contractions 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 par-



View of ruminant stomach, right side.

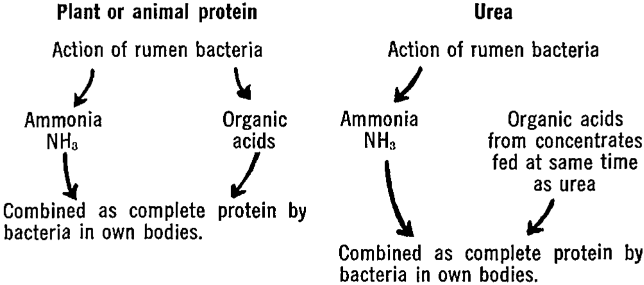
allel to the path of the feed. Considerable water and organic acids are removed in the omasum. The drier material then passes on to the abomasum or true stomach and the small and large intestine as in other animals.

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 also is 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, mostly cellulose, not digested by simple-stomached animals, but effectively utilized by cattle. Considerable starch also is changed to volatile fatty acids. The bacteria and other microrganisms in the R-R convert cellulose to organic acids, mainly acetic, propionic, and butyric acids, as a source of nutrient energy. These are absorbed directly through the rumen wall into the bloodstream. These organic acids are readily used in the body and have a direct influence in the production of milk fat in the udder. An imbalance of these organic acids may result in a decrease of fat in the milk produced. Over half of all the energy nutrients in a cow's ration are made available through rumen digestion.

The bacteria in the rumen also break down proteins and other nitrogenous compounds, such as urea, that are fed in the ration into simple compounds (ammonia and amino acids). These are then recombined into essential protein in the form of bacteria that are then digested.

The following diagram shows how bacteria in the rumen can make a nutritionally complete protein from incomplete plant or animal proteins and how they can utilize the nitrogen in urea.



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 legume pasture.

After this microbial digestion in the rumen, the remaining feed passes on to the true stomach and intestines, where enzymatic digestion takes place.

A great number of different enzymes are active in this part of the digestive tract. Each has a specific chemical action on the constituents of feed. These products of digestion are then absorbed through the intestinal wall into the bloodstream and transported to different parts of the body for use in maintaining health and normal body functions. Proteins are absorbed as amino acids. Starches and sugars are changed to simple sugar glucose, the form in which it is absorbed. Fats are absorbed mainly as fatty acids and glycerol. Minerals are dissolved principally in the hydrochloric acid in the stomach and are absorbed along with organic nutrients. Vitamins are absorbed in the small intestine. Water readily passes through the wall of the intestinal tract.

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 have been 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: tables giving the nutrient requirements for the several classes of animals and tables giving the nutrient contents of various feedstuffs used in feeding animals.

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

The energy in feed is determined by burning and is known as *gross energy*. This amount, however, does not constitute the amount a cow can use. So a given weight of feed is fed to an animal over a period of several days in a digestion trial. The feces are collected and the energy content determined. This amount is subtracted from the gross energy in the feed fed and the difference is the apparent digestible energy (close to TDN value). It is an expression of what the cow has done to the feed or the part she has digested out. However, there are some losses of energy in the urine, in expelled gases, and in the heat generated by the work of digestion. When these are subtracted from the digestible energy, the remainder is called net energy or estimated net energy

(ENE). Feed energy consumed by animals is partitioned as follows:

Feed energy (fuel value when burned)
↓
digestive process (40-80 percent efficiency)
↓
Digested energy of feed (equivalent to TDN value) + **Fecal energy**
↓
metabolic process of assimilation (70-85 percent efficiency)
↓
Metabolizable energy of feed + Energy in gases and urine
↓
metabolic process of production (70-90 percent efficiency)
↓
Net energy of feed + Heat (energy) loss from above processes
↓
partition between maintenance and production (0-70 percent efficiency)
↓
Energy in product + Heat from maintenance

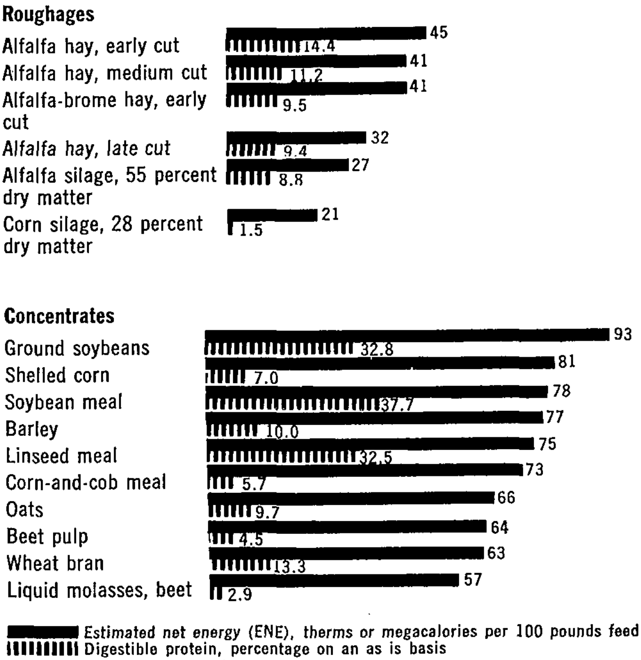
Energy for animal use means the incorporation of energy and use of energy to incorporate nonenergy containing nutrients into such things as growth of the animal itself (meat, fat, etc.), milk production, development of the unborn calf, and energy for maintenance.

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

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 or utilization 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 commonly predicted



Average levels of certain nutrients in some common feeds.

with formulas using the composition. Compared to TDN, ENE is a more accurate way to estimate a cow's response to feeds in her ration.

TDN is based on digestion coefficients or on the percentage of energy containing nutrients that are 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 kilocalories). Feeds high in fiber have a relatively lower percentage of ENE 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. Relationship between TDN and ENE in evaluating 100 pounds of feed for livestock

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

As table 4 shows, pounds of TDN and therms of net energy in 100 pounds of shelled corn, which is very low in fiber, are equal. However, as the fiber content of other feeds increases, the difference between TDN and the net energy value widens.

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.

Hay quality can be best estimated from the cutting date, appearance, and a chemical analysis.

The main factors contributing to protein content are species, stage of maturity at harvest, and level of nitrogen fertilizer used.

Table 5. 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

Digestible protein also can be determined in a digestion trial in which the nitrogen content in the feces is subtracted from that in the feed. The difference is multiplied by 6.25 and expressed as digestible protein.

Feed Constituents

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:

GROWTH. Nutrient need is great when the animal is young. A progressively smaller portion of feed intake is required for growth as the animal approaches maturity.

BODY MAINTENANCE. This is a continual requirement to rebuild worn tissues, maintain body temperature, provide energy for muscular activities, and keep vital organs functioning.

PREGNANCY. Requirements are greatest during the last 2 months of pregnancy.

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 much milk production can take place. For this reason, it does not pay to underfeed. The cow produces most economically when working 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 the nutrients they contain.

Protein is essential for growth and the maintenance of life. Proteins are made up of various combinations of amino acids and form components of the skin, hair, muscles, blood, bones, horns, and milk. Proteins are involved in all body processes. Animals with simple stomachs must be supplied with all of the essential amino acids through their diet. In cattle, however, microorganisms 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 as important as in nonruminant diets.

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 of sugars and starches. They are used as 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 concentrated forms of energy. Compared to carbohydrates, fats are worth two and a fourth times as much per pound in heat and energy.

Water is the cheapest of all 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 3-5 pounds of water for each pound of milk she produces.

Minerals make up approximately 5 percent of the weight of a dairy cow. This amount is mostly calcium and phosphorus, found chiefly in the skeleton. Minerals also are needed for cell activity, digestion, milk production, and development of the unborn calf.

Cattle are thought to need 14 mineral elements for the following functions. Phosphorus is a vital ingredient in the chief protein of all nuclei or life centers. Phosphorus in combination with calcium makes up over 90 percent of the skeleton. Phosphorus deficiencies result in fragile bones that are easily broken, unthrifty condition, retarded growth, and reduced production and reproduction. Calcium is important in bone development and in milk production, since milk is rich in calcium. Reduction of calcium in the blood results in the comatous condition known as milk fever. Iodine is important, since metabolic rate is controlled by the action of an iodine containing hormone, thyroxine, secreted by the thyroid gland. Iodine deficiencies may result in goiter in newborn calves. Small traces of copper and iron are needed in the formation of hemoglobin, the oxygen-carrying compound in the blood. Lack of cobalt results in emaciated, extremely unthrifty animals. Cobalt is essential for bacteria in the rumen to synthesize vitamin B_{12}. Sulfur is an essential part of proteins and some B vitamins. Chlorine is necessary in the formation of hydrochloric acid in the stomach. Sodium, potassium, manganese, zinc, selenium, and magnesium also are required by animals. Fortunately, most of these are supplied in adequate amounts in the common feeds. Trace mineralized salt and a phosphorus supplement added to the ration will provide adequate needs that may not be provided by other feeds. On a high corn silage ration with little or no hay, a calcium supplement also may be needed.

Vitamins are feed constituents that 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. Vitamins K and C and the B complex vitamins are synthesized by the rumen microorganisms or by body tissue. Vitamin E is abundant in most feeds.

Vitamin A increases the resistance of the soft mucous membrane tissues to infection. 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 partially 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 can be stored in the body. Carotene is converted to vitamin A when needed. Six pounds per day of average quality alfalfa hay or 3-4 pounds of alfalfa silage provide ample vitamin A.

Vitamin D is called the sunshine vitamin because it is formed by the action of the sunlight upon compounds found in plants and animals. Vitamin D regulates the metabolism of phosphorus and calcium in the body. Cattle exposed to sunlight or fed good quality suncured forages will absorb adequate quantities of vitamin D. Cattle kept indoors continuously and eating little or no suncured forage (cattle fed entirely on corn silage in confinement, for example) may develop vitamin D deficiencies. Calves on vitamin D deficient rations often will develop rickets.

While the dairy rations usually fed in Minnesota provide adequate vitamins, certain conditions such as badly weathered hay, forages growing in a season of adverse weather, and limited forage feeding may result in conditions that require close attention to detect possible vitamin deficiencies.

Vitamin A can be provided by adding high level vitamin A supplements to the grain mixture at about 1/3 cent per cow daily. Many of these supplements also contain vitamin D in adequate amounts to supply the needs for this vitamin. Irradiated yeast is a low cost source of vitamin D.

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 can 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. High levels of grain feeding with limited roughage may result in a depressed fat content of the milk produced.

COST. Cost is important in making up a ration. The choice and the combination of feeds are big factors in holding cost down. Cost per unit of digestible nutrient supplied by various feeds, not the price per ton, is the most important consideration. See page 42 for an explanation of figuring nutrient costs.

Producing High Quality Feed

PRODUCTION FACTORS

The Minnesota dairyman produces most of his dairy feed on his own farm, which gives him an advantage over dairymen in areas of the country where feed must be shipped in. Homegrown oats, corn, and barley are good dairy feeds. Corn supplies an abundance of readily available energy and it yields more feed energy per acre than other feeds. It has become the main ingredient in the concentrate ration in areas where corn is grown for grain.

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-

Table 6. Comparative costs of producing 100 therms ENE

Crop	Production per acre	Therms ENE per acre	Cost per 100 therms ENE
			dollars
Corn	90 bushels	4,082	1.49
Oats	60 bushels	1,267	3.31
Alfalfa	3.3 tons	2,904	1.94
Corn silage	15 tons	6,300	1.22

round stored feeding; higher levels of grain feeding, especially to higher producing cows; more corn silage; and less pasture, with many dairymen using no pasture at all.

Minnesota Farm Management Association records show the cost of producing 100 therms of ENE 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. So pro-

Table 7. Variation in composition of samples of hay and corn silage

Crop	Dry matter	Fiber	Digestible protein	TDN	ENE
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

ducing 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.

In both hay and silage, sample 1 had approximately twice the net energy of sample 3. Producing 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.

Time of cutting is the greatest single factor in producing high quality hay. Alfalfa should be cut before one-tenth bloom. This means haying should be started the first few days of June and the first crop should be finished 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 haymaking days in the first half of June as in the last half, so delayed cutting does not assure better haymaking weather.

The best measure of the value of hay is its fiber content. As the plant develops, much of the cellulose is encased in an undigestible material, lignin, to give the plant the stiffness to stand up. It might be considered a plant cement. Since this material is undigestible, the cellulose it surrounds is not as available to the rumen bacteria for digestion into useable organic acids. As a result, much of the cellulose passes through the cow undigested. This is why it is so important to make hay before lignin develops. An experiment at the University of Minnesota where cows were fed only forage showed

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 percent dry matter hay basis			
	Protein	Fiber	TDN*	ENE*
First cutting	......percent......			therms per 100 pounds
June 1 (prebud)	18.0	23.2	61.6	54.9
June 14 (late bud—one-tenth bloom)	14.9	29.0	54.3	44.6
June 23 (one-half 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, August 31	3.4	1,295	4,435	3,810
June 14, July 26, August 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 two and a half to three times greater in forage than in corn.

that for each percentage increase in fiber, milk production decreased 400 pounds annually.

TIPS FOR TOP TOTAL YIELD OF NUTRIENTS IN HAY:

1. Use best quality seed of a recommended variety on a well-prepared seedbed.
2. Fertilize according to soil test recommendations.
3. Cut hay early by the calendar.
4. Use hay conditioning equipment to save ½-1 day in field curing.
5. Rake hay with the dew on to avoid excessive leaf shatter.
6. After September 1, don't harvest fields 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, ensiled as rapidly as possible at 65-70 percent moisture, evenly well-packed, and stored in a silo free of air leaks. The feeding value of the silage is no better than what is put into the silo.

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 third of Minnesota, more nutrients can be grown per acre in corn silage than any other crop. Equipment is now available to make and feed silage with minimum 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 depends on the weather. In years of high rainfall, especially late in the summer, plants contain more juices.

Corn generally is ready for filling when it is dented. Corn silage highest in dented corn also is 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 new seedlings, removing the oat crop early and making silage may be highly desirable. However, this means sacrificing straw that 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, oats should be cut at the early to mid-dough stage, when it can be harvested directly, 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.

During the first years that dairymen made hay crops, especially alfalfa, into silage, it was common to wilt the crop to not below 65-70 percent moisture. This often resulted in poor quality feed that was high in butyric acid and was not readily eaten. Preservatives often were added, but with varying success.

To avoid silage with objectionable odors and low palatability, many dairymen have turned to low moisture silage. The hay crop is wilted to 50 percent moisture before filling. Properly made low moisture silage is a good smelling, palatable, high quality feed. Cows usually eat more dry matter and get more feed value from low moisture silage than from silage made from the same crop.

Low moisture hay crop silage is easy to preserve in a tight silo when an attempt is made to exclude air. It also can 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 is covered when filling is complete.

Low moisture hay crop silage is growing in popularity. Its feed value depends on the crop's stage of growth when filled and the percentage of dry matter in the silage. On a dry matter basis, feed value of low moisture hay crop silage is equal to that of hay or silage made from the same crop at the same time.

ENSILED CONCENTRATES

Corn, oats, barley, and, under certain conditions, rye, all make good cow feed. However, if grains are stored with high moisture contents in contact with air, they will mold and deteriorate and perhaps become toxic.

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 feed value. So many livestock producers ensile all or part of their corn crop as ear or shelled corn silage. This is a relatively new approach to 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 30-35 percent. Moisture content of ground grain should be 27-32 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 makes it possible to remove any amount at any time from the bottom of the silo. When 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 necessity may present a problem with smaller herds unless the corn can be fed at the same time to other livestock. Feeding liberal amounts of high moisture shelled corn silage may result in a lower butterfat content of the milk produced. See Agronomy Fact Sheet 9, *Corn Silage*, for further details on storing high moisture corn.

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.

The main disadvantage of using pasture is the considerable waste of the crop through trampling, which results in a lower yield of nutrients per acre than with harvested crops. Also, it is sometimes difficult to maintain a growth that has even feed value because of variable weather conditions, which 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. Most dairymen in the more fertile and level areas of the state have shifted 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 2-3 years.

Pastures should be divided into several strips and the herd rotated to a new strip every 4-5 days. Better yet, move a cross fence each day for a single day's grazing. Doing so results in less waste, greater utilization of the growing crop, and uniform feed from day to day. A dairy herd should not graze over the entire pasture area.

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 the rest of the season. An adequate pasture program provides feed throughout the season. This can be accomplished by rotation and fertilization of seeded pastures containing several grasses and legumes and by planting annuals such as sudangrass to meet seasonal needs.

High producing cows need concentrates with pasture. These concentrates generally need not be high in protein and 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 usually is no need to change the concentrate mixture for summer feeding. It usually is desirable to feed some hay with pasture, regardless of pasture quality. Although cows may eat little dry hay, it provides a change, gets the cows to eat just a little more feed, and perhaps prevents an occasional case of bloat. Many dairymen also feed some corn silage along with pasture, especially when pastures decrease in growth. Drastically changing the feeds fed often results in decreased milk production, so sudden changes of ration should be avoided if possible.

GREEN CHOP (FRESH FORAGE)

Some dairymen harvest and feed green chop daily. Green chop reduces waste compared to pasture; with tall growing crops, 50 percent more feed value can be realized from a given area. However, green chop requires special equipment and harvesting every day, presents 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.

CROP MANAGEMENT

Producing high quality feed requires study and close management. Available land, topography (the lay of the land), erosion problems, soil fertility, and available labor and equipment all must 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 in each column result in same amount of ENE)

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

In fully evaluating the nutritive value of feeds listed in table 11, the difference in protein value also must be considered. Alfalfa hay contains two and a half to three times as much protein as corn.

Winter and Stored Feeding Programs

On an increasing number of dairy farms, cows are fed the same ration throughout the year with no pasture. The following are some of the principles to consider in developing such a feeding program.

FORAGES

In most herds, cows should receive all the forage they will eat. Amounts eaten are greatly influenced by the palatability of the hay or silage and the amounts of concentrates eaten. With good quality hay and silage, cows will eat 2-2½ 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 12-16 pounds of hay and 35-50 pounds of silage. If only 5 pounds of hay are fed, she probably will eat 60-75 pounds of silage. If no silage is fed, she should eat 25-30 pounds of hay.

If grain is relatively cheap (less than twice as much per ton as hay), forage feeding can 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 can 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 hay that has been blown upon.

Although corn silage can make up all or most of the forage ration, cows crave some dry forage and will eat more total nutrients if a small amount of hay is available to them. If large amounts of corn silage are fed, the protein in the grain mix must be increased to replace what 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 fulfill them. 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 homegrown 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. 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 production differences. 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. Beginning 2-3 weeks before the cow or heifer is due to calve, increase the grain fed gradually to at least 1 pound per 100 pounds body weight by calving time. Then continue to increase it until the cow hits her peak milk flow or to the point where she will not eat more grain. Hold grain at this level until production starts to drop. Then decrease grain 1 pound for each 3-pound drop in milk. This

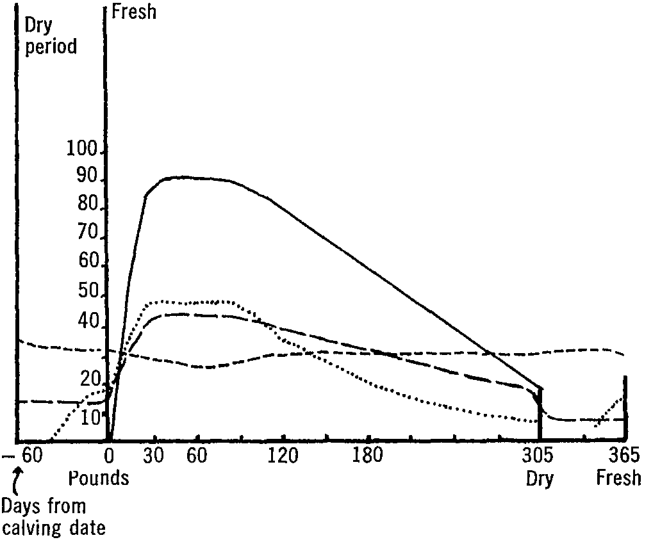
Per day basis

——— Milk production

- - - - Roughage consumption, hay equivalent basis

.... Concentrate consumption needed for lead feeding and meeting nutrient requirements

— — Nutrient requirement, therms of net energy



Production and nutrient needs during a lactation for a cow weighing 1,350 pounds and producing 17,500 pounds of milk. Note that during the first 3-4 months of the lactation the amount of concentrates needed to meet nutrient requirements may be more than the cow can eat, so she must draw on body reserves. Lead feeding prior to calving results in higher production and fewer adjustments after calving.

process is called challenge or lead feeding. It gives each cow the opportunity to produce at her inherited capacity.

2. The central processing DHI record computes a "concentrates indicated" amount for each cow in the herd. This measure 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 20-25 pounds of milk in the low test breeds or 12-15 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 does lead feeding.

COMMON FEEDING PROGRAMS WITH DIFFERENT FORAGES

ALFALFA HAY OR LOW MOISTURE LEGUME SILAGE AND CORN SILAGE. This combination fed with mostly homegrown grain is the most common feeding program in Minnesota. The protein percentage in the concentrate (grain mixture) is determined by the amount and quality of the alfalfa hay fed. Where 15-20 pounds of high quality alfalfa hay containing little or no grass hay are fed daily, only homegrown grains (corn, oats, or barley) need be fed. No high protein concentrate is needed, except for unusually high producing cows when some topdressing feeding of a high protein concentrate may be desirable. Where less hay is fed and/or the quality is lower and it contains some grass hay, some high protein concentrate will be needed in the concentrate feed, depending on the protein supplied by the hay. The total ration fed (hay, silage, and concentrate) should contain 12 percent crude protein for low producing cows, up to 14 percent for high producers. By evaluating the hay and other feed fed, and using the tables on page 51, the protein of the ration can be figured. Low moisture hay crop silage can be substituted for hay on an equal dry matter basis. If hay has 90 percent dry matter and low moisture hay crop silage has 45 percent, 1 pound of hay equals 2 pounds of low moisture hay crop silage. Minerals needed as a supplement are steamed bonemeal, dicalcium phosphate, or sodium phosphate to supply phosphorus, and trace mineralized salt to supply other minerals.

ALFALFA HAY OR LOW MOISTURE HAY CROP SILAGE. If either legume hay or low moisture hay crop silage or a combination of both is fed as the only forage, only homegrown grains are needed as the concentrate. No high protein concentrates are needed, since this forage ration supplies all needed protein, even though it contains as much as one-third grass. The mineral supplements to be fed are the same as those for the first ration.

ALL CORN SILAGE. Where corn silage is fed as the only forage, protein fed in the concentrate must be increased, since the corn plant is very low in protein. A grain ration containing 17-18 percent crude protein is needed. Since corn is unusually low in calcium, it is necessary to add some calcium carbonate or feeding grade ground limestone to the ration to supply needed calcium. Free choice feeding and adding 1 percent to the grain mixture are recommended. The phosphorus containing supplements and trace mineralized salt discussed above also should be fed.

ALL CORN SILAGE WITH UREA ADDED. One-half percent (10 pounds per ton) of urea may be added to corn silage at the time of filling. This addition will increase the average percentage of protein equivalent in the silage from 2.3 to 3.7 as fed or from 8.3 to 13.3 on a dry matter basis. When corn silage with ½ percent of urea added is fed as the only forage, a grain mixture of 14-15 percent crude protein should be fed. The same mineral supplement should be provided as with straight corn silage as the only forage.

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 production level. 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 lactation. Even then, high producing cows may not be able to eat enough to meet their nutrient needs. The cow that is underfed due to 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 can be done easily during the winter. Replacing part of the oats or ground ear corn with shelled corn or barley provides a ration higher in energy, so it is easier for the high producer to eat enough. But more skill is required 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 can be fed on top of or mixed with bunk fed silage so cows need less in the parlor. Another method is to put high producers into a separate lot once a day and bunk feed them extra grain. Or cows can be grouped according to production in two or more lots, so extra grain can be bunk fed according to the group's average production level.

For high producing cows, depending on the grain ration fed, it is often desirable to feed some high protein concentrate as a topdressing above that mixed in the grain mixture, except when a 17-18 percent or more grain mixture is fed.

In the future, other feeding systems will be developed and used to save labor and make more efficient use of feed. With a recently developed electronic system, each cow carries a transponder set to activate the release of a specific amount of grain in a feed stall when the cow enters it. It can be set to feed a cow a predetermined amount daily.

A good job of producing high quality forage (see page 23) and timely purchase of feeds not raised on the farm (see page 42) 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 previously. These needs can be met by making available trace mineral salt and a phosphorus supplement, either steamed bonemeal, dicalcium phosphate, or sodium phosphate.

Salt and a calcium-phosphorus supplement can 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 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 have the choice of what they need.

Vitamin needs also have been discussed previously. Normal dairy rations will meet cows' needs without additional feeding of vitamin supplements, except for 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 also are relatively inexpensive. Cows on good pasture or green chop have no need for supplemental vitamin A.

FEEDING DRY AND FRESH COWS

Feed some grain to dry cows to help build up body reserves. The amount to feed depends on the cow's condition; 3-5 pounds daily is common. Three weeks before calving, start increasing the amount of concentrate fed so that at calving the cow may be consuming 1 pound per 100 pounds live weight. 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 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. So it is advisable to make the feeding adjustments outlined above and those discussed under lead feeding on page 34 prior to calving. Several experiments at experiment stations have shown that feeding under this lead system does not increase udder edema or mastitis.

FEEDING CALVES

Calves should be fed at least one feeding of colostrum after birth to supply quickly the vitamin A and natural antibodies lacking at birth. It can be fed as long as it is available. Whole milk or milk replacers should be fed the first 3-6 weeks, depending on the thrift and health of the calf. A grain mixture and top quality hay should be fed as soon as the calf will eat them. Limit grain feeding to 4 pounds per calf daily. For complete details on calf feeding, see Extension Bulletin 305, *Feeding and Managing Dairy Calves and Heifers.*

FEEDING YEARLING HEIFERS

Heifers 10-12 months old that are growing satisfactorily and are in desirable condition can do well on high quality hay and silage alone until 2-3 weeks before calving, when grain feeding should be started and increased to calving time as described above for dry cows.

Special Feeds

MOLASSES has 70-75 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 waste from animals. 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 45 percent nitrogen urea added to 100 pounds of grain mixture raises protein equivalent level 2.81 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.

See Dairy Husbandry Fact Sheet 4, *Using Urea as a Protein Substitute in the Dairy Ration,* for directions on mixing and using urea.

BEET PULP is a bulky, very palatable feed. It often is used as an appetizer either to put a fill on cows for showing or to increase grain consumption. It usually is soaked and fed wet. Dry beet pulp has about the same energy value as ground oats, but has 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 22-25 percent of the feed value of grains, but often are available at low prices in the potato growing areas of Minnesota. 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.

Dried BREWERS' GRAINS have about 22 percent crude protein and 67 percent TDN. They are bulky like wheat bran, but are not as palatable and should be limited to about one-third of the grain mixture. Wet brewers' grain varies in water content and can be fed in place of part of the silage.

YEAST is a good source of the vitamin B complex, but, since ruminants, including cattle, produce ample vitamin B in the rumen, there is no advantage to feeding yeast for this purpose. Adding dried yeast to the ration may aid in stimulating the appetites of badly rundown animals. Irradiated yeast is the best supplemental source of vitamin D.

Buying Feed Wisely

A basic principle in buying feed is to purchase it on its feeding value, usually based on its chemical analysis and on the cost per unit of nutrients it contains. These nutrients are energy, protein, mineral elements, and vitamins. In buying manufactured feeds, pay close attention to the guaranteed analysis.

TERMS ON THE FEED TAG

Minnesota law requires that manufactured feeds carry 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 ($\frac{1}{6.25}$) 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 is calculated.

CRUDE FIBER NOT MORE THAN: A given weight of feed is boiled, first in a weak acid solution and then in a weak alkaline solution, and the dissolved material is washed out. The remaining material is dried and the percentage of the original sample is calculated. This amount is considered the percentage of 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. High value feeds are high in proteins, fats, and nitrogen-free extract and low in fiber.

GENERAL CONSIDERATIONS

Generally, nutrients can be supplied cheapest in forages as hay and silage. Since forages are bulky, the transportation cost per unit of nutritive value is greater than for other feeds. Besides being bulky and lower in dry matter, silage also must be hauled daily, so one cannot afford to pay as much for nutrients in silage as for more concentrated feed that can be stored. Where feeds are purchased, the amount of concentrates to feed in comparison to forages should be varied according to the cost of the nutrients in each. Feeds containing more moisture are worth less. Whenever feeds mold or heat, some feed value is consumed, the digestibility of what remains is lowered, and palatability may be affected. Savings can be realized by purchasing a supply of feed when the price is low, such as grains at harvest and hay in the fall.

BUYING HAY

The fiber content of hay is the greatest single factor in determining its feeding value. As the plant develops, the fiber content increases and the nutrient value decreases. Therefore, early cut hay low in fiber is highest in feed value. A chemical analysis will give the fiber content. If an analysis isn't possible, select hay with fine stems, a large number of leaves, a bright green color, and be sure it is free of mold or mustiness. Avoid coarse-stemmed hay with few leaves. As hay is stored, it decreases in digestibility, palatability, and vitamin A content. So hay that is 2-3 years old is lower in feed value and worth less than new hay.

BUYING SILAGE

Corn silage purchase should be based on the convenience of unloading and transporting it as well as on its feed value. Silage of low moisture content with an abundance of well-formed kernels and free of mold and spoilage is worth most. When purchased, low moisture hay crop silage of equal quality is worth less than hay on a dry matter basis because of the inconvenience in handling the silage.

BUYING HOMEGROWN GRAINS

Homegrown grains can be purchased mostly on an ENE basis. Although oats has more protein than corn, both are relatively low in protein. Oats has about 90 percent of the feed value of corn and cob meal and 83 percent the value of shelled corn on a weight basis. So 2 bushels of oats are worth slightly less than a bushel of shelled corn as a source of energy. Moldy and high moisture grains are worth less.

BUYING PROTEIN CONCENTRATES

Protein concentrates should be purchased on the basis of the cost of a unit of protein, since a cow can

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

Feed	Price per ton	Price per 100 pounds	Percentage crude protein	Cost per pound of crude protein
	dollars	dollars		dollars
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

change one protein to another as needed. Find the cost of 1 pound of protein or protein equivalent by dividing the cost of a 100 pound sack of feed by the protein percentage printed on the sack or on the attached label. If 100 pounds of a 40 percent dairy concentrate cost $4, the price of 1 pound of the protein it supplies is 10 cents. Table 12 shows how these costs can vary for different feeds at a given time.

BUYING MINERAL SUPPLEMENTS

Mineral supplements are needed only to supply those elements that may not be adequately supplied in the ration fed. As mentioned on page 39, trace mineral salt will supply the chlorine and trace mineral needs. The cost per 100 pounds will serve as a guide in comparing trace mineral feeds if they supply the same percentage of trace elements.

The cost of supplying phosphorus can be determined by the cost of a 50 or 100 pound sack and its phosphorus percentage content. The cheapest form usually is bonemeal, dicalcium phosphate, monosodium phosphate, sodium tripolyphosphate, or a mineral mixture high in phosphorus. If a 100 pound sack of the mineral feed costs $7.50 and contains 15 percent phosphorus, 1 pound of phorphorus will cost 50 cents ($7.50 ÷ 15).

BUYING VITAMINS

Vitamins that may be needed are A and D. Although the ration usually supplies adequate amounts of each, vitamin A can be purchased in concentrated form and in a premix. Alfalfa leafmeal is another source. Purchase this meal on its international unit (I.U.) basis. Figure what a million units will cost to make a comparison of costs. Irradiated yeast is a relatively inexpensive source of vitamin D, as is cod liver oil. Purchase these on their I.U. basis also.

Since urea is an inexpensive source of nitrogen from which the cow can make protein in her rumen as explained on page 14, many mixed and high protein feeds contain some urea. Including it in feeds enables the manufacturer to market them at lower costs. Dairymen may also realize a savings by buying urea and using it in the ration under certain conditions, as described on page 41.

The Petersen System of Evaluating Feeds

Many years ago, W. E. Petersen, of the University of Minnesota, developed a method of evaluating feeds considering both their energy and protein content. This method employs the use of feed evaluation factors in which common feeds are compared to corn and soybean meal. These factors are given in table 13. 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).

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	Fiber	Feed evaluation factors	
		Corn	Soybean meal
Dry roughages			
Alfalfa hay, low quality	Over 36	0.263	0.153
Alfalfa hay, average	30-36	0.296	0.212
Alfalfa hay, high quality	Below 30	0.286	0.259
Bromegrass hay	(Average)	0.415	0.060
Mixed hay, good, less than 30 percent legume		0.427	0.039
Oat hay		0.423	0.049
Green roughages			
Freshly cut corn		0.147	0.002
Silages			
Corn, dent, well-matured, well-eared		0.265	–0.011
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
Distillers' dried corn grain with solubles		0.710	0.350
Fishmeal		–0.457	1.349
Linseed meal, 36 percent		0.201	0.699
Molasses, beet, not over 10 percent of concentrates		1.058	–0.169
Oats		0.924	0.076
Screenings, grain, good grade		0.534	0.134
Soybean meal, 44 percent		0.000	1.000
Wheat bran		0.619	0.218
Wheat standard middlings		0.743	0.222

3. Add the two figures. (Note that some evaluation factors have negative values. In such cases, subtract.) Use the same weight units (pounds, hundredweights, 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 is worth $80 per ton?

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

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

This method does not always indicate completely the price one should pay for purchased feeds. For example, if one has an abundance of energy feed such as home-grown grains and silage and is interested in buying protein, he is concerned about getting the protein as cheaply as possible, with little regard for the energy it contains.

Using Feeding Standards in Computing Rations

Most dairymen will use the feeding plans suggested on page 33 as a matter of convenience. Directions for balancing a given ration appear on the following pages and can be used in checking on feeding programs to see if energy and protein nutrient needs are being met or exceeded.

Feeding standards have been developed from feeding trials showing the requirements for maintaining body weight and milk production. The first feeding standard was developed by Professor 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 can be used as an example. Appendix table 1 shows that a 1,200 pound cow requires 0.76 pound of digestible protein and 7.4 therms of net energy (ENE) for maintenance. Appendix table 3 gives requirements for milk production: 1.88 pounds (0.047 × 40) of digestible protein and 13.2 therms (0.33 × 40) ENE. For convenience, write these requirements as follows:

	Digestible protein, pounds	ENE, therms
For maintenance of 1,200 pound cow . .	0.76	7.4
For 40 pounds of 3.5 percent milk	1.88	13.2
Total requirements	2.64	20.6

So the total requirement per day for such a cow is 2.64 pounds of digestible protein and 20.6 therms of ENE.

BALANCING THE RATION

With the requirements known, a dairyman can calculate a ration to meet this need. 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 protein, pounds	Energy, therms
Ration:		
35 pounds corn silage	0.53	6.3
12 pounds alfalfa-brome, medium quality hay	0.91	4.2
10 pounds corn-and-cob meal	0.57	7.3
Total	2.01	17.8
Short of requirement	0.63	2.8
Add:		
3 pounds corn-and-cob meal	0.17	2.2
1 pound soybean oilmeal	0.42	0.8
	0.59	3.0

The check on this cow's ration shows that it was short in both digestible protein and ENE. The balanced ration now consists of 35 pounds corn silage, 12 pounds alfalfa-brome hay, 13 pounds corn-and-cob meal, and 1 pound soybean oilmeal.

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

Shortage of ENE means more energy feeds are needed. Shortage of protein usually is met by purchasing and adding a high protein feed to the ration. Doing so is especially necessary 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 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, pounds	ENE, therms
Requirements:		
Maintenance, 1,400 pound cow	0.87	8.5
Production, 70 pounds 3.5 percent milk	3.54	22.4
Total requirements	4.41	30.9
Feed to balance:		
45 pounds corn silage	0.68	8.1
18 pounds early cut alfalfa hay	2.59	8.1
20 pounds corn-and-cob meal	1.14	14.6
Total	4.41	30.8

The above illustrations show how to calculate a ration meeting feeding standard requirements for digesttible protein and energy. But these, like 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 33. 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 33.

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, or ENE

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. Protein (digestible) and energy [estimated net energy (ENE) or total digestible energy (TDN)] required for each pound of milk as related to production level and fat content of milk

Fat content of milk, percent	Pounds of milk produced per cow per day																				
	30			40			50			60			70			80			90		
	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡	1*	2†	3‡
3.0	.040	.27	.29	.041	.28	.30	.043	.29	.31	.045	.30	.32	.046	.31	.33	.048	.32	.35	.051	.33	.37
3.5	.043	.29	.31	.044	.30	.32	.046	.31	.33	.048	.32	.34	.049	.33	.35	.051	.34	.37	.054	.35	.39
4.0	.046	.31	.33	.047	.32	.34	.049	.33	.35	.051	.34	.36	.052	.35	.37	.054	.36	.39	.057	.37	.41
4.5	.049	.33	.35	.050	.34	.36	.052	.35	.37	.054	.36	.38	.055	.37	.39	.057	.38	.41	.060	.39	.43
5.0	.051	.35	.37	.052	.36	.38	.054	.37	.39	.056	.38	.40	.057	.39	.41	.059	.40	.43	.062	.41	.45
5.5	.053	.37	.39	.054	.38	.40	.056	.39	.41	.058	.40	.42	.059	.41	.43	.061	.42	.45	.064	.43	.47
6.0	.055	.39	.42	.056	.40	.43	.058	.41	.44	.060	.42	.45	.061	.43	.46	.063	.44	.48	.066	.45	.50

* Pounds digestible protein.
† Therms net energy.
‡ Pounds TDN.

Appendix table 3. Daily requirements of dairy cattle for calcium, phosphorus, carotene or vitamin A, and vitamin D

	Calcium		Phosphorus		Carotene	Vitamin A	Vitamin D
	grams	pounds	grams	pounds	mg.	thousand I.U.	I.U.
Growth							
100	4	.008	3	.006	5	2	300
200	9	.019	8	.017	10	4	600
400	12	.026	11	.024	20	8	1,200
600	14	.030	13	.028	30	12	1,800
800	15	.032	14	.030	40	16	2,400
1,000	15	.032	14	.030	50	20	3,000
Maintenance for mature cows (daily per 1,000 pounds) ...	12	.026	12	.026	50	20	*
Reproduction (daily per 1,000 pounds) last 2-3 months gestation	11	.024	9	.019	25	10	*
Milk production (per pound of milk daily)							
Less than 44 pounds daily ..	1.0	.0022	0.73	.0016	†	†	*
44-77 pounds daily ..	1.1	.0024	0.82	.0018	†	†	*
Over 77 pounds daily ..	1.3	.0029	0.91	.0020	†	†	*

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

† Milk secretion does not require carotene or vitamin A. Vitamin A and/or carotene is used first for maintenance if limited amounts are supplied. If the ration is low in carotene, the supplemental feeding of 100 milligrams of carotene or 40,000 units of vitamin A per cow per day will provide for vitamin A in the milk also.

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 lbs.
DRY FORAGE				
Alfalfa hay	......	percent	.....	therms
Early cut, excellent quality	20.0	14.4	57	47
Early cut, good quality	17.7	12.3	55	45
Medium early cut, good quality	16.0	11.2	53	43
Medium early cut, fair quality	15.0	10.4	51	41
Late cut, fair-good quality	13.6	9.4	52	37
Mature, mostly stems	10.5	6.1	48	33
Meal	15.0	11.1	52	41
Leafmeal	21.0	16.3	64	55
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

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 lbs.
DRY FORAGE (continued)				
Forages low in protein	......	percent	.....	therms
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 canarygrass	7.1	4.5	45	32
Rye hay	5.0	3.0	45	32
Rye straw	3.5	0.3	41	27
Sudangrass hay	8.6	4.8	52	41
Timothy hay	5.8	2.9	48	37
Wheat straw	3.9	0.4	41	27
SILAGE				
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 + bushels per acre	2.6	1.5	23	21

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 lbs.
	......percent.....			therms
SILAGE (continued)				
Corn, cannery byproduct	2.3	1.3	18	15
Pea vine, cannery byproduot	3.1	1.8	15	12
Reed canarygrass	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 canarygrass	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
Sugarbeets	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

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 lbs.
CONCENTRATES	......percent		.....	therms
Barley	12.3	10.0	77	75
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
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 (33-38 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	44.0	37.7	78	78
Soybeans	37.0	32.8	88	93
Wheat, grain	12.3	10.1	80	80
Wheat, bran	16.4	13.3	67	63
Wheat middlings	17.8	15.6	78	77
Whey, dried	14.0	12.2	78	75
Yeast, dried	49.0	42.0	72	68

Dairymen can have feeds analyzed at a commercial laboratory, usually for crude fiber, crude protein, and dry matter. With this information and a formula, digestible protein, TDN, and ENE can be calculated. Crude fiber content is the greatest single factor affecting the energy value or ENE, especially with roughages, which are high in fiber content and low in ENE. The following table shows the average percentages of fiber and ENE content in some common feeds.

Appendix table 5. Crude fiber-ENE relationships

Feed	Fiber	ENE per 100 lbs.
	percent	therms
Alfalfa hay		
Early cut, excellent quality	23-24	47
Early cut, good quality	26-27	45
Medium early cut, good quality	28-29	43
Medium early cut, fair quality	29-30	41
Late cut, fair-good quality	33-34	37
Mature, mostly stems	36-40	33
Alfalfa leafmeal	17	55
Corn silage	7	21
Barley	6	75
Beet pulp, dry plain	19	64
Corn-and-cob meal	8	73
Corn, shelled No. 2	2	81
Corn cobs	32	31
Molasses, cane		50
Oats	11	66
Soybean meal	6	78
Soybeans	5	93
Wheat	3	80
Wheat bran	10	63

Appendix table 6. Calcium and phosphorus content of common feeds and supplements

Feed	Calcium	Phosphorus
	......percent......	
Alfalfa hay	1.47	0.24
Barley	0.05	0.38
Beet pulp, dry plain	0.68	0.07
Bromegrass hay	0.42	0.19
Corn silage	0.10	0.07
Shelled corn	0.02	0.27
Corn-and-cob meal	....	0.23
Molasses, cane	0.56	0.06
Molasses, beet	0.05	0.02
Oats	0.09	0.33
Soybean meal	0.32	0.67
Soybeans	0.20	0.60
Wheat	0.03	0.43
Wheat bran	0.12	1.32
Dicalcium phosphate	21.00	18.00
Steamed bonemeal	30.00	13.90
Monosodium phosphate	....	27.00
Tripolyphosphate	....	25.00
Limestone, calcium carbonate	38.30	....

Appendix table 7. 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 8. 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	dollars				
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
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

Appendix table 8 (continued). Cost of 100 pounds of feed at a given price and weight per bushel

Cost per bushel	32 pounds (oats)	48 pounds (barley)	56 pounds (shelled corn)	60 pounds (wheat)	70 pounds (corn-and-cob meal)
	Cost of 100 pounds when a bushel weighs				
	dollars				
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
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

Note: If the price per bushel is $1.02, take twice the hundredweight (cwt). cost of 51 cents per bushel. To get the cwt. price at 30 cents per bushel, divide the cwt. cost at 60 cents per bushel by 2. To get the price at $1.50 per bushel, add the cwt. cost and the cost at 50 cents per bushel.

Good Management in Feeding

1. Frequent feeding results in greater feed consumption and higher production.
2. Keep mangers clean. Sweep them 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. Learn each cow's response and use it in feeding her.
6. A cow not worth feeding well isn't worth keeping.
7. Don't force high producing cows to eat low quality feed. They must have 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 and Care of Livestock in Case of Nuclear Attack

Radioactive fallout from the atmosphere is like dust, with each particle giving off radiation like a miniature X-ray machine. This radiation can injure or kill livestock, mainly from particles on the ground, on roofs of buildings, or in the feed supply. 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.

Feed free of fallout dust is safe for livestock. Hay and grain stored in tight mows, bins, covered silos, and covered haystacks are safe to feed.

Since cows that consume feed containing radioactive material may transfer radioactivity to their milk, such milk is unsafe to use.

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

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.

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