NEW ENGLAND COLLEGE CONFERENCE

DAIRY FEEDING PROGRAMS

COOPERATIVE EXTENSION SERVICE
UNIVERSITIES OF
MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, RHODE ISLAND AND CONNECTICUT

FORWARD

A publication entitled "Dairy Grain Mixtures" originally was prepared as a pamphlet in 1953 by the New England College Conference on Dairy Cattle Feeding. This was compiled and published in response to numerous requests from local feed manufacturers and dairy producers in New England for information on standard formulas for dairy grain mixtures. Since its inception, the pamphlet has been expanded and reprinted with revisions as warranted to keep pace with progress in dairy cattle nutrition.

In view of changing practices in dairy cattle feeding it has become increasingly evident that a simple listing of standard dairy grain mixtures no longer serves as an adequate guide for the dairy industry in feeding today's high producing herds. Proper nutrition for dairy cattle can be obtained by using any one of hundreds of formulas differing in ingredient content and levels. However, instead of merely selecting an appropriate grain mixture to be fed with an available forage at a particular time of the year, the economic success of the modern dairy producer is vitally dependent on development of a dairy feeding program which will give maximum return for every resource and facility available and for every dollar invested in the enterprise. Although there are many variations in dairy feeding programs, most have a few common characteristics. These include emphasis on a single type or blend of high quality forages requiring only one set of specialized forage handling equipment. Such an approach results in a more uniform and consistent feeding regime throughout the year.

In recognition of the need for information on dairy cattle feeding programs, the New England College Conference members have undertaken the expansion and modification of their traditional publication to include examples and guidelines for the planning and development of individual dairy cattle feeding programs.

Contributors to the New England College Conference Dairy Cattle Feeding Bulletin in 1987 are:

Lynn R. Brown, Chairman, University of Connecticut, Storrs, CT
Barbara A. Barton, University of Maine, Orono, ME
Marvin Colburn, H.K. Webster Co. Inc., Lawrence, MA
Kendall Dolge, Agway, Inc., Syracuse, NY
Stewart K. Gibson, University of Vermont, Burlington, VT
Walter A. Gross, University of Rhode Island, Kingston, RI
James B. Holter, University of New Hampshire, Durham, NH
Sydney J. Lyford Jr., University of Massachusetts, Amherst, MA
Charles G. Schwab, University of New Hampshire, Durham, NH
Gordon Smith, United Cooperative Farmers Assn., Fitchburg, MA

Issued in furtherance of Cooperative Extension Service work, Acts of Congress of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture and the Cooperative Extension Services of: Connecticut, Maine, Massachusetts, Rhode Island, New Hampshire and Vermont. Hugo H. John, director of the Cooperative Extension Service, The University of Connecticut, Storrs, CT 06268.

CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF EXAMPLES

LIST OF FIGURES

PRINCIPLES OF DAIRY NUTRITION

Today's dairy cattle have been selected for their genetic ability to produce large quantities of milk starting at an early age and continuing over long periods of time. This selection also has caused an unmistakable increase in the cow's ability to consume large quantities of forage. However, the increase in forage capacity has not kept pace over the years with the increase in the cow's milk-producing ability. As a result, it has been necessary to find ways to concentrate or enrich the nutrient density of the cow's diet.

In order to concentrate the diet of our cattle, we first replaced some of the forage in the ration with grain by-products. Years ago corn stover was replaced by corn silage, including the ear. Then we concentrated the nutrient content of haycrops by earlier harvest and improved plant breeding. Pasture grass (20% dry matter) was cut, wilted (30% dry matter) and ensiled, thus increasing its nutrient concentration. Corn plant breeders were able to increase the ratio of ear to stalk in their newer varieties. These changes permitted the modern cow to consume enough feed to meet or exceed the energy and protein requirements throughout all of the lactation period except the first one to three months after calving.

During early lactation, the heavy producer cannot consume enough feed energy to balance the energy uses and losses (e.g. milk, manure, urine, methane, body heat, physical activity and perhaps growth) unless fed a high-grain, low-forage diet. Even then the cow probably will have to use some stored nutrients (body fat and protein) to support milk production. Since the dairy cow's digestive system is designed basically as a "forage burner", it takes a little extra management skill to feed her a higher amount of concentrate, but it must be done to obtain efficient milk production.

Carbohydrates

The terms used to characterize the carbohydrate fraction of forages include crude fiber, acid detergent fiber, neutral detergent fiber, and particle size and/or length. Traditionally, carbohydrates have been considered a source of energy; however, this is an oversimplification when balancing dairy cattle rations. Carbohydrates also function as a source of fiber, which is important in optimizing dry matter intake and digestibility, as well as maintaining normal rumen function and preventing milk fat depression. The various carbohydrate fractions within a forage and their relative digestibilities are depicted in Table 1.

In order to discuss the role of carbohydrates in dairy cattle rations, it is necessary to define a number of terms and their interrelationships.

Crude Fiber (CF): measures the residue that is insoluble after boiling a feed in dilute alkali and acid solutions. It is comprised of most of the cellulose, about one-half the lignin, and other components that approximate the indigestible portion of a feed. It contains a variable amount of hemicellulose.

Acid Detergent Fiber (ADF): measures the portion of a feed that is insoluble in an acid detergent solution. It is comprised of lignin, cellulose, insoluble ash, and unavailable protein (ADF-N), but not the hemicellulose portion of the fiber.

Neutral Detergent Fiber (NDF): consists of the ADF fraction plus hemicellulose (NDF = ADF + hemicellulose). It is comparable to the cell wall portion of the plant and is a good estimate of the bulk of a ration, and is negatively correlated to energy concentration.

Particle Size/Length: is used as an indication of the "effectiveness" of fiber in stimulating rumination and, therefore, of saliva production.

TABLE 1. Detergent System of Forage Analysis

Plant Fraction	Analytical Fraction	Chemical	Primarily digested by
	Neutral detergent fiber	Neutral detergent	
Cell walls	Hemicellulose	" "	Fiber bacteria
" "	Cellulose	" "	Fiber bacteria
" "	Lignin	" "	Unavailable
" "	Insoluble protein	" "	"
" "	Insoluble ash	" "	"
" "	Acid detergent fiber	Acid detergent	
" "	Cellulose	" "	Fiber bacteria
" "	Lignin	" "	Unavailable
" "	Lignin	72% sulfuric acid	Unavailable
Cell contents	Solubles	Neutral detergent	Starch & Sugar
"	Protein	" "	Bacteria & protozoa
"	Lipid	" "	
"	Minerals	" "	" "
"	Starch	" "	" "
"	Sugars	" "	" "
"	Pectins	" "	" "

Values for each of these fractions are listed in Appendix Table 1. The fiber content of grains is quite consistent, on the other hand, forages are quite variable in fiber content. It is recommended that forages be analyzed for fiber on a regular basis. In ration formulation, ADF and NDF have replaced CF analysis because they more accurately correlate with feed intake, digestibility, productive energy, and milk production. Rations have been balanced to provide a minimum of 17% CF for early lactation cows; but now nutrient recommendations include a minimum of 21% ADF and about 36% NDF in the ration of early lactation dairy cows. As a general thumb rule, % ADF is greater than % CF, and % NDF is greater than % ADF. NDF contains hemicellulose and ADF does not. These fiber values can also be used to estimate the net energy of lactation (NE_L) for a given forage (see formulas Page 59 of this publication).

NDF is highly correlated with intake because it contains hemicellulose, while ADF is correlated to feed digestibility because it contains the indigestible lignin fraction. One other concern with regard to fiber that must be emphasized is its particle size. Fiber must be present in the ration in particle sizes that promote effective rumination and sufficient "chewing time" for saliva production. Current recommendations are that 5 pounds of forage of at least 1 to 1.25 inches in length be included in a ration to maintain fat test and stimulate adequate rumination. Fine grinding (particles less than 1/4 inch) and the grinding preceding pelleting a forage reduces its effectiveness as a fiber source. The proper amount and form of fiber is an essential component of dairy cow rations; efficiency of milk production will be lowered if there is too little or too much.

NDF content of forages varies according to the species and maturity of the plant. Grasses are generally higher in NDF and lower in cell solubles than legumes. This fact explains why legumes are more digestible and result in higher intake than grasses. The differences in ADF between grasses and legumes at similar stages of maturity are minor. Figure 1 depicts feed classification based on NDF and demonstrates how NDF allows a quantitative ranking of all feeds on a single scale. This scale was developed from work by Wisconsin researchers and illustrates how early vegetative alfalfa, well-eared corn silage, and early vegetative bromegrass all contain 24% CF and 31% ADF with 41, 51 and 60% NDF, respectively. Dairy cow responses to these feeds is better correlated to NDF than to CF or ADF.

Recent research indicates that NDF would be a more useful fiber index than CF or ADF. <u>Optimum milk production was achieved from diets formulated to provide an optimum daily NDF intake of 1.2(+/-0.1)% of body weight</u>. With this guideline, optimal milk production was obtained consistently at 35 to 36% NDF in the total ration, even though the rations varied in CF and ADF. The NDF fraction, which represents the total fiber content of a forage, is a better indicator of the fiber for both maximum milk and normal rumen function provided the forage is not chopped too fine. Research currently is fine-tuning recommendations with regard to formulating lactating and dry cow rations using NDF.

FIGURE 1. Neutral detergent fiber classifies feeds on a single continuum from 0 to 100% and allows quantitative ranking of all feeds on a single scale

Feed Classifications: Neutral Detergent Fiber Scale (% DM)

0	20	40	60	80	100
Grains	Protein By-Products	Legumes	Hulls	Stalks	
Oil Meals	Energy By-Products		Grasses	Straw	

<u>Optimizing the Nitrogen Economy of the Dairy Animal</u>

The amino acid requirements of dairy cattle for growth, milk production, and other essential body functions are met from microbial protein synthesized in the rumen and feed proteins escaping ruminal degradation. Because of the various nitrogen fractions in feedstuffs and the nitrogen transactions that occur in the rumen, crude protein values of feedstuffs by themselves are inadequate for predicting animal performance.

Protein nutrition is optimal when the ration contains a "proper" balance of degradable nitrogen (N) and digestible undegraded protein, and when the amino acid composition of the latter compliments the rather constant ruminally-synthesized microbial protein. The degradable N fraction of a feedstuff includes all nonprotein nitrogen (NPN) (free amino acids, amines, amides, ammonia, and nitrates) and variable amounts of natural protein. This fraction yields the peptides, amino acids, and ammonia needed by rumen microbes for synthesis of microbial protein. The remainder of the dietary protein, which constitutes the undegraded protein fraction, escapes ruminal degradation and passes with the microbial protein to the small intestine where both are predominantly digested and amino acids released for absorption. Undigestible or bound protein continues on through the tract and is excreted in the manure.

Ruminant nutritionists often forget that the ration must contain adequate amounts of both degradable N and undegraded protein for maximum animal performance. Adequate amounts of degradable N are needed to meet the N requirements of the rumen microbes. Only by meeting this requirement can ruminal digestibility (especially of fiber) and feed intake be maximized. On the other hand, feeding degradable N in excess of microbial requirements is wasteful because the excess ammonia is not used for microbial growth but is absorbed and excreted as urea in urine.

The amount of undegraded protein required in the diet is equal to the difference between the animal's protein requirement and the yield of ruminally-synthesized microbial protein. An insufficient supply will depress production and amounts in excess of host needs will be metabolized and used for energy. Quantitative information therefore is needed on the extent of protein degradation in the rumen. Table 2 contains tentative estimates of degradable protein in some common feedstuffs.

These values should be considered relative rather than absolute because for each feedstuff they will vary with level of feed intake, particle size and density, ruminal pH, degree of heat treatment or heat damage, and possibly other factors.

Because *in vivo* determinations of protein degradation, as in Table 2, are labor intensive and expensive, several alternative techniques have been developed. These include extracting protein with a variety of solvents and suspension of feed ingredients in dacron bags in the rumen of fistulated cows. The dacron bag technique, when coupled with rate of passage information, provides the best estimate of *in vivo* protein degradability across a wide variety of feedstuffs that differ greatly in their physical and chemical properties.

The poor quantitative relationship between N solubility and *in vivo* protein degradability is expected because the solvents used mainly extract NPN with limited and variable amounts of degradable true protein. For example, while soybean and cottonseed meals are low in soluble N (14 and & 7% of total N), they are degraded as rapidly in the rumen as linseed meal and peanut meal with solubilities of 40 to 50%. True protein accounts for less than 15% of the soluble N in corn silage, haycrop silage, hays, high-moisture corn, distillers grains, corn gluten feed and meal, and possibly other higher protein containing feeds.

Nitrogen solubility has been a useful tool in diet formulation largely because it is a good index of NPN constituents. Maintaining the N solubility of total rations between 25 and 33% for early lactation cows helps to ensure that microbial needs for N are met and that excessive amounts of degradable N are not wasted. Whether optimum N solubility is 25%, 33% or somewhere in between for early lactation cows appears to depend on factors such as the solvent used, the ingredient composition of the ration (because of differences in protein makeup and physical properties of individual feeds), and method of feeding concentrates (meal feeding vs. TMR's). The N solubility of the total ration crude protein can be higher in later lactation and for dry cows.

TABLE 2. Tentative Estimates of Degraded Protein in Some Common Feedstuffs[a,b]

Feedstuff	Degradability	Feedstuff	Degradability
Oil meals		By-product feeds	
Peanut Meal	.75	Brewers Wet Grains	.55
Sunflower Meal	.75	Brewers Dried Grains	.50
Cottonseed Meal (solvent)	.70	Corn Gluten Meal	.45
Linseed Meal	.70	Distillers Dried Grains	.45
Soybean Meal	.70	Fish Meal	.35
Cottonseed Meal (expeller)	.65	Meat Meal	.35
		Meat and Bone Meal	.35
Feed grains		Forages	
Barley	.80	Alfalfa Silage (<35% DM)	.80
Oats	.80	Alfalfa Hay	.75
Corn	.55	Alfalfa Silage (>55% DM)	.70
Sorghum	.55	Corn Silage	.70
		Alfalfa (Dehydrated)	.55
Other			
Soybeans (unprocessed)	.80		
Cottonseeds	.65		

[a]From Satter and Stehr, Distillers Feed Conference Proceedings, Vol. 39, 1984.
[b]Estimates are based on one or more in vivo measurements reported in one or more of 27 different studies. Measurements were the flow of protein out of the stomach in cattle and sheep having abomasal or duodenal cannulae.

As noted in Appendix Table 1, common dairy feeds vary greatly in N solubility. Urea and liquid protein supplements may be considered 100% soluble. When high N solubility feeds (40 to 75% of total N) such as corn and haycrop silages and high-moisture corn constitute much of the early lactation cow's diet, it is necessary to select protein supplements such as brewers dried grains, corn gluten meal, meat meals and extruded soybeans that have low solubility and low degradability. Feed manufacturers also provide concentrate mixtures with "low" protein solubility. Use of these ingredients and concentrates generally are advantageous.

However, the degree to which low rumen degradable protein sources are advantageous in rations depends on how well the amino acid pattern of their undegraded protein fraction complements that from the microbial protein synthesized in the rumen. For example, lysine and methionine are known to be the first limiting amino acids for lactating cows consuming a diet primarily of corn grain and corn silage. Such may be the case for other feeding programs as well. Using estimates of degradability in Table 2, distillers grains will supply 20% less lysine and corn gluten meal 40% less lysine to the cow than an equal amount of protein from the more highly degradable soybean meal. Although these two resistant forms of protein supply greater amounts of other amino acids for absorption, it is of no benefit. This probably explains why several studies have shown little or no advantage of distillers grains or corn gluten meal over soybean meal for milk production.

The use of N solubility in ration formulation represents the first attempt to improve efficiency of N utilization by dairy animals. Further research is needed to more effectively characterize feed proteins with respect to ruminal degradation as well as the amino acid composition of the available undegraded protein. Trials are needed to determine the optimum ratios and amounts of degradable N and undegradable protein relative to levels of production and stage of lactation. Current research has shown that balancing rations on the basis of degradable/undegradable N is inadequate because the amino acid content of undegraded protein must be considered. In fact, only recent application of computer technology to ration balancing has provided opportunity to balance protein according to individual cow's needs.

Minerals

The minerals essential to dairy cattle nutrition are shown in Table 3. They must be supplied in the proper amounts and proportions in order to support milk production, growth, reproduction and health. When balancing a ration for minerals, one must consider the minerals supplied by all ration components including the forages, grains and mineral supplements. As a general rule, the mineral content of grains and protein supplements (such as soybean meal) is fairly constant, therefore, tabular mineral values can be used for these feeds. On the other hand, the mineral content of forages is quite variable. It is recommended that forages be analyzed for at least calcium, phosphorus and magnesium. Appendix Table 1 lists the amount of calcium, phosphorus, magnesium, potassium, and sulfur found in some common feeds and mineral supplements. The recommended nutrient allowances for calcium and phosphorus are listed in Table 6 of the text.

It is not yet practical to balance for all of the minerals listed in Table 3. In most situations, the ration (basal feeds and trace mineral supplements) provides adequate levels of these elements to meet an animal's needs. The range between safe and toxic levels of most minerals is quite wide and mineral toxicity problems are not common. It is costly to analyze the ration frequently for all elements listed in Table 3. Therefore, in most cases, it is more cost effective to supplement the ration to standardized levels. Examples of concentrates balanced to provide certain levels of nutrients, including minerals, are listed in Table 17.

For lactating dairy cows, minerals that are balanced include calcium, phosphorus, magnesium, and salt (NaCl). The amount and proportion of the first three minerals to be added to a ration depend on the type of forage being fed. For example, a corn silage based ration would require a larger amount and a different ratio of calcium and phosphorus than a legume or grass based ration. Legumes inherently have higher levels of calcium than grasses. Salt must be provided in all rations; generally it is supplemented by including 1% trace mineral salt (TMS) in the concentrate and by offering it free-choice as well. Cows need about 1 ounce of salt for maintenance and an additional ounce for every 30 lbs of milk.

It is important to recognize that cows cannot balance their mineral intake according to their mineral needs. Cows should be force-fed (i.e., mineral supplements should be mixed with grain and/or forages) in order to insure adequate intake. With force-feeding, you decide how much mineral the cow consumes. Top dressing minerals can also be an effective way to get minerals to a cow if the feeding system allows this. The decision on the appropriate means of mineral feeding should be based on your existing management system and facilities, type of mineral that complements your forage program, costs of mineral supplements, and labor required by the system.

A cost evaluation of a mineral supplement should be based on the cost of the supplement per 100 lb (cwt) and the concentration of the element(s) in question in the supplement. For example, a 15% phosphorus supplement at $15.00/cwt actually costs you $1.00 per lb of phosphorus. The calculation is demonstrated below:

a. $$\frac{\text{Supplement cost per cwt}}{\text{\% of element in supplement}} = \text{\$ per lb of element}$$

b. $$\frac{\$15/\text{cwt}}{15\%\ P} = \$1.00/\text{lb } P$$

Mineral requirements are not very precise. This is because of the large number of factors which affect mineral requirements. There are numerous interactions between and among minerals that influence their absorption and use. This means that the correct level for each nutrient must be determined in relation to all other nutrients to obtain the best productive response. There is considerable variation also in the availability of a mineral to an animal depending on the source. The proportion of a mineral which can be used by the animal to meet its needs is termed biological availability. There is no "magic" mineral or inorganic ingredient that is a panacea. Decisions to buy mineral supplements should be based on a critical evaluation of the ration currently offered to your cows.

TABLE 3. Minerals Required in the Dairy Ration and Some Common Supplement Sources

Mineral	Common Sources
Calcium (Ca)	Limestone, mono or dicalcium phosphate, alfalfa, clover and other legumes
Phosphorus (P)	Monosodium, monoammonium and mono and dicalcium phosphates, oilseed meals, grains
Sodium (Na)	Salt
Chlorine (Cl)	Salt
Magnesium (Mg)	Magnesium oxide, forages
Sulfur (S)	Sulfur; sodium, magnesium or potassium sulfates, protein supplements, legume forages
Potassium (K)	Legume forages, potassium chloride or sulfate
Iodine (I)	Iodized or trace mineral salt
Iron (Fe)	Forages, grains, trace mineral salt
Copper (Cu)	Forages, grains, trace mineral salt
Cobalt (Co)	Trace mineral salt
Manganese (Mn)	Forages, grains, trace mineral salt
Zinc (Zn)	Forages, trace mineral salt
Molybdenum (Mo)	Widely distributed
Selenium (Se)	Oil meals, forages, trace mineral salt

Avoid Sudden Ration Changes

A cow relies heavily upon the micro-organisms in her rumen to predigest and synthesize many nutrients required for milk production and normal body function. Several hundred different species of micro-organisms live in the rumen digesting feed components and producing by-products which the host later digests and absorbs. Any changes in composition of the ration, particularly major changes in type or proportion of forage, must be carried out gradually over a two-week period in order to allow the micro-organisms time to adjust to their new "raw materials". Abrupt ration changes will reduce the efficiency of microbial digestion and nutrient synthesis in the rumen resulting in a drop in milk production and with some cows going "off-feed". The stress caused by sudden ration changes, especially during early lactation, can lead to ketosis and other metabolic disorders. Abrupt changes in composition of the cow's ration frequently are made unintentionally by dairymen.

Have "Tail-Enders" in Good Condition, Not Over-Conditioned

In order to discuss the problem of feeding a high producer during early lactation, we have to go back to when she was a "tail-ender" in the previous lactation. Before a cow is dried off, not afterwards, is the time to get her into proper body condition for the next lactation. Research at the USDA, Beltsville, MD, has shown that a pound of feed will produce body fat much more efficiently when a cow is milking than after she is dry.

Avoid Fat Cows

Dry cows should be in good flesh but never fat. Fat cows are more inclined to have calving difficulties and a dull appetite after calving. Dull appetite and low feed intake after calving forces a good cow to rely excessively on body reserves. Rapid body fat mobilization, along with low feed intake, predisposes the fresh cow to ketosis (acetonemia). Ketosis further reduces feed intake and a vicious circle results. Meanwhile, milk production drops and veterinary expenses increase. Fat cows are "slow" breeders, so such cows are apt to have a long dry period. Furthermore, being off-feed and sick after calving prevents a cow from reaching her maximum peak level of production. On the other hand, thin cows tend to exhibit more milk fat depression the first 12 weeks after calving. All of this can be avoided by investing a little time at the end of the previous lactation taking care to get this cow in "good order" for calving.

New Nutrition Technology

It is impossible to predict what will happen in the future with a high degree of accuracy. However, we expect that new developments will continue to become available at an ever increasing rate. How will new technology affect the principles of dairy nutrition that we are emphasizing in this publication? In recent years we have seen the development and/or recommendation of isoacids, rumen bypass fat, supplementation with certain water soluble vitamins, new fermentation enhancers, new buffers and bovine somatotropin. So far it appears that none of these new developments alter the principles of nutrition that are discussed here. On the contrary, these principles become more important as old limitations are removed and new efficiencies are gained.

The Lactation Cycle

The concept of balancing a ration based upon the phases of the lactation cycle is a useful and necessary one because it helps integrate the physiology of the cow with milk output per unit of feed input. The lactation cycle (Figure 2) is based on one calf per cow per year, a 12-month calving interval. The cycle is divided into four periods: early (calving to 10 wks), mid (10 to 20 wks), late (20 to 44 wks), and the dry period (44 wks to calving). Understanding the changes and potential limitations of the cow's body weight, dry matter intake and milk production during each of these phases makes it possible to balance a ration efficiently. Peak milk production occurs during early lactation (5 to 7 wks) while peak dry matter intake usually occurs later (8 to 12 wks). This relationship between production and intake causes a cow to lose weight in early lactation and regain it in late lactation. For each pound of weight loss, there is enough energy mobilized from fat to support the production of 6.6 pounds of 3.5% fat milk, but heavy reliance on this process can result in metabolic disorders. The objective of the feeding strategy should be to reduce the interval between peaks of milk energy output and maximum energy intake thus shortening the period of weight loss.

Dry Period

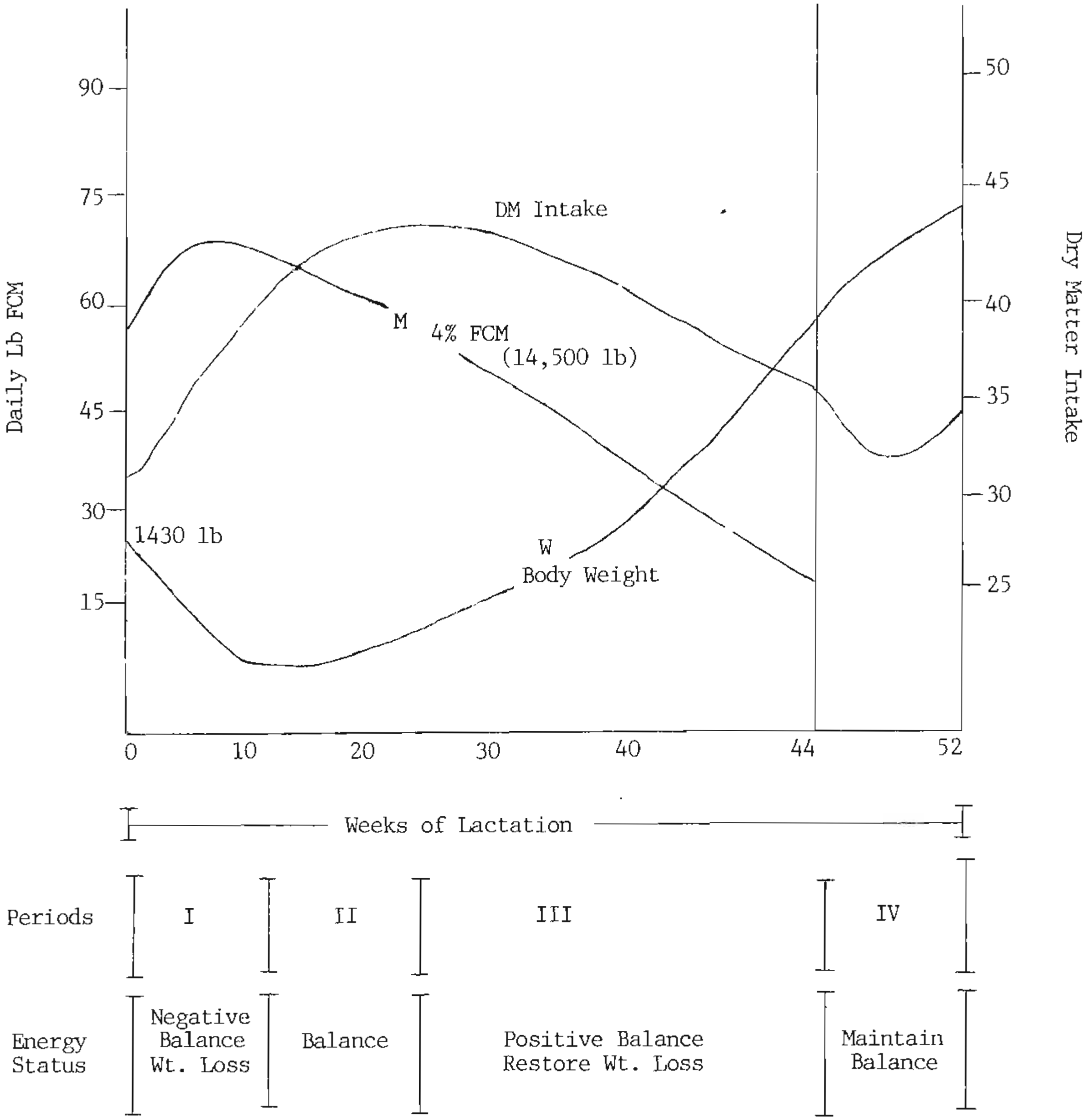
The dry period should be considered as the start of a new lactation rather than the end of an old one. The management regime during the dry period has a major impact on the amount of milk produced in the following lactation. Proper dry cow management can result in an extra 500 to 3,000 pounds of milk/cow/lactation. The dry period should be 50 to 70 days long to provide the proper amount of time for rest and regeneration of mammary tissue, mastitis treatment when milk does not have to be discarded, and repletion of body nutrient reserves. Figure 3 demonstrates the impact of number of days dry on lactation performance. Research based on records of 281,816 cows revealed that a 60-day dry period results in highest milk production (expressed as difference from herdmates) in the next lactation.

The challenge is to manage the cow so she can make a rapid, smooth transition from a time of very low nutrient demand (dry period) for maintenance and fetal growth to a time of very high nutrient demand for milk production. In order to facilitate smooth transition, there are a number of things that dairy producers can do easily. It is important to remember that it is cheaper and much more effective to prevent metabolic disorders such as milk fever, retained placenta, ketosis, and/or downer cow syndrome than to treat them. You have the chance of saving a substantial amount of milk as well as saving the cow.

Goals for the Dry Period

Before making decisions about the nutritional management of the dry cow, one must consider:

a. Production during the previous lactation
b. Body condition of the cow at drying off
c. Length of the dry period
d. Age of the cow
e. Previous health record



M = ½ milk output reached

W = return to week 1 body weight

FIGURE 2. Relationship of dry matter intake (DMI), milk production and body weight changes during the lactation cycle

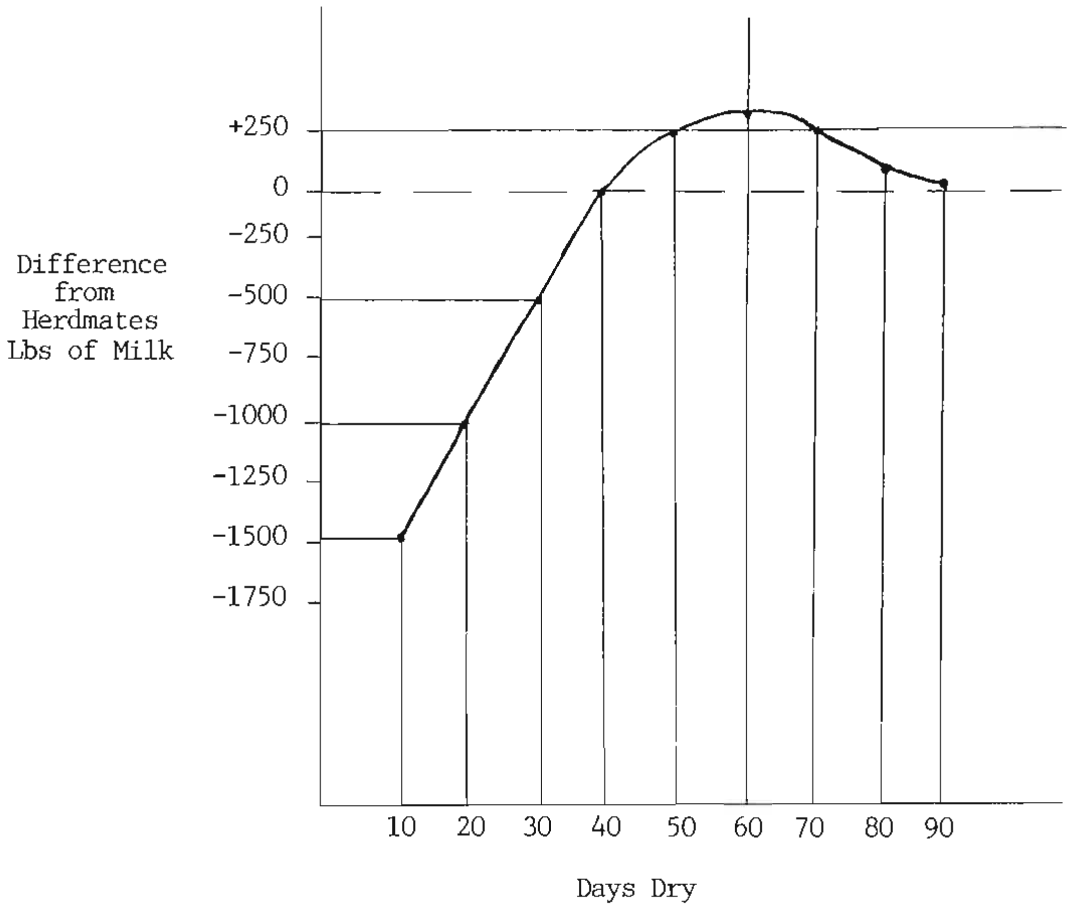


FIGURE 3. Effect of Days Dry on Lactation Performance

Knowledge of each of these factors will help a producer put together the best ration for the dry cow. For example, once a cow has had milk fever, she is prone to have it in following lactations. Aged cows have a higher incidence of milk fever than do young cows. Cows that are overconditioned are more likely to have disease problems at calving and show secondary problems such as milk fever. Where cows have a history of milk fever, the calcium intake should be restricted to 50 to 100 g/day for the last two weeks before calving.

Goal 1. Body Condition: The goal should be to have the cow in good body condition at drying off. She should then be fed to maintain her body weight and to allow weight gain only for the fetal/placental unit of about 1 to 1.5 lbs/day for a 60-day dry period. Daily energy intake needs to be reduced if the cow is fat or if the dry period exceeds 60 days. Nutrient needs are low at this time (as compared to lactation) and if dry cows are fed to their appetite on high energy forages, they will overconsume in relation to their needs. We are more worried about nutrient excesses (energy and calcium) during the dry period than nutrient deficiencies. This point is illustrated in Figure 4.

If the cow is thin at drying off, she will need to be fed a little extra energy and protein in order to replenish body reserves as well as to allow for fetal/placental growth. Late lactation gain, however, is about 25% more efficient (lbs feed energy/tissue energy) than gain during the dry period, so it is better to restore weight in late lactation before drying off.

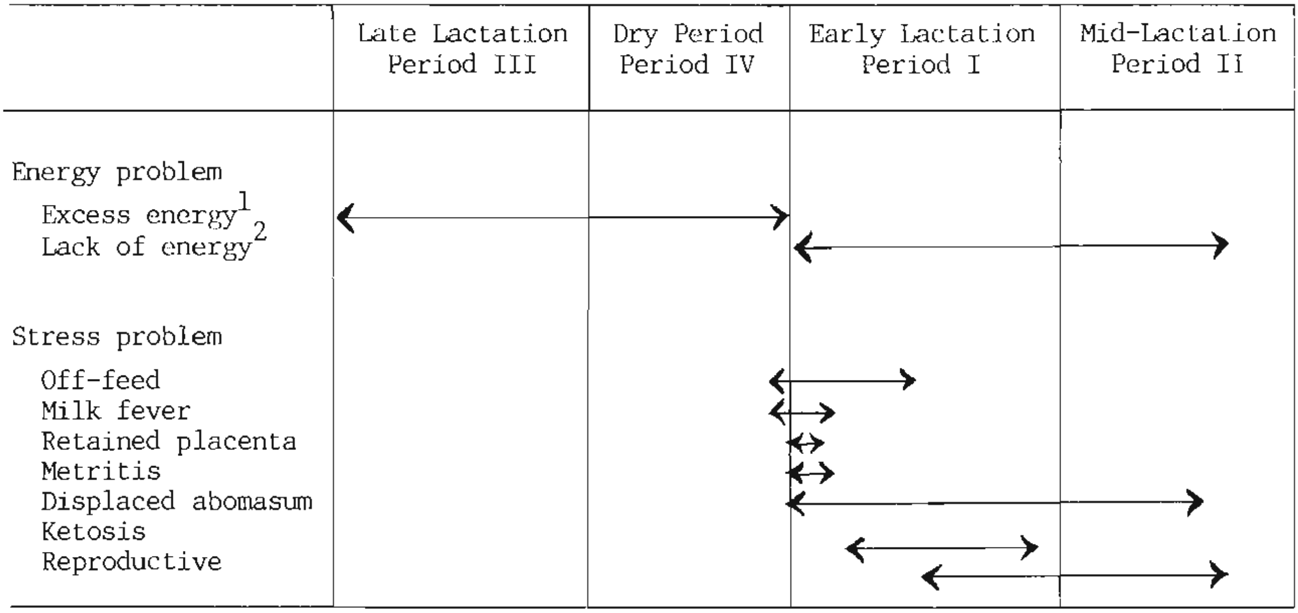
Goal 2. Smooth Transition: It is important for the cow to have a smooth transition from a period of low nutrient demand to a period of high nutrient demand for milk production. A loss of both profits and animals occurs when the farmer does not manage dry cows to prevent the metabolic and nutritional disorders that often occur in early lactation. They are preventable! This goal can be achieved by following the feeding recommendations listed below.

Feeding Programs for the Dry Period

The National Research Council recommends ration nutrient concentration as listed in Table 4. Dry cows should be fed separately from the cows in the milking string and, ideally, should be split into two groups (based on an eight-week dry period). This may not be practical on all farms but it is an important consideration in order to achieve the smooth transition from the dry to lactating periods.

Group 1 includes cows from dry-off until two weeks prior to calving. The nutrient needs of these cows are easily met by feeding medium quality forage. Cows that are thin or young cows may need a few pounds of concentrate in addition to forage in order to regain body weight or to allow for growth. Supplemental grain may be needed if poor quality forage is fed.

Group 2 includes cows in the last two weeks of gestation. Gradually increase to 5 to 8 pounds of concentrate (no more than .5 to .8% of body weight) in addition to forages. This concentrate should be the same as the milking herd receives (perhaps minus calcium if problems with milk fever or other metabolic diseases occur). The purpose of this practice is to accustom the cow (and the rumen fermentation system) to concentrates from an all forage ration. This is a limited form of lead feeding and aids measurably in creating a smooth transition.



[1] Over-feeding during late lactation and the dry period results in excessively fat cows at freshening.

[2] Lack of energy in early lactation is caused by excessive requirements of high producers, but is exaggerated by poor appetite of over fat cows and poor feeding practices.

FIGURE 4. Energy status and associated stress problems

TABLE 4. Recommended Nutrient Concentrations for a Dry Cow Ration and the Nutrient Content of Selected Forage Sources

	Crude Protein %	NE_L Mcal/lb	Calcium %	Phosphorus %
Dry Cow Recommendations	11	.61	.37	.26
Grass Hay	10	.52	.37	.31
Alfalfa Hay	17	.59	1.25	.25
Corn Silage	8	.72	.27	.20

Forages

Forages should be the major, if not the only feed in dry cow rations. The dry cow's nutrient requirements are easily met by medium quality forages. While many forages fulfill the energy requirements, few have the proper balance of other essential nutrients, particularly protein and minerals. Legume forages are a good energy and protein source and are high in most essential minerals and vitamins. Their relatively high level of calcium can lead to a high incidence of milk fever. It is recommended to substitute some nonlegume for part or all of the forage in the dry cow diet.

Corn silage should not be the only component in the dry cow diet. It is particularly low in protein, essential minerals and vitamins. If fed free-choice, dry cows tend to overeat corn silage which can lead to an excess energy intake and contribute to "fat cow" problems.

Corn silage should be restricted and properly supplemented when fed to dry cows. Grass hay comes the closest to meeting requirements. It may be slightly low in protein and energy but these deficiencies could be made up with a small amount of properly balanced concentrate. Although none of these forages are ideal as the only feed for dry cows, a combination of the above forages would result in a good dry cow ration. Usually, a mix of 1/3 legume and 2/3 nonlegume (grass hay or corn silage) would provide the proper combination. Base these decisions on actual nutrient analysis reports from a forage testing laboratory. Dry cows should have some long forage; avoid diets of finely chopped forage during this time.

Summary

1. Avoid "fat" cows by limiting weight gain during the dry period. Restore body condition in late lactation. Restrict calcium intake where milk fever is a problem.
2. Feed dry cows separately from the lactating herd.
3. Aim to have dry period length in the range of 50 to 70 days.
4. Rely on forages during the dry period. Initiate grain (.5 to .8% of body weight) two weeks prior to calving. Be sure to restrict and supplement as needed.
5. Evaluate each cow's disease history and body condition and take this into account when making nutritional management decisions about the dry period.

Fresh Cow Nutrition

Calving time for a high-producing cow is a very traumatic experience. Suddenly her whole body metabolism shifts from "neutral to high gear". If you have been lead feeding her, the rumen bacteria already are prepared for the jolt. Although many cows have a depressed appetite for several days after calving, a skilled herdsman can get most of these cows on full feed very quickly without changing the nature of the diet markedly. A heavy producer cannot consume sufficient energy to balance her energy output. Consequently, she will be forced to rely on body stores of fat and perhaps protein to supplement her diet. The objective in feeding the fresh cow is to keep her dependence on stored energy and protein as small and short in duration as possible. "Off-feed" is the greatest hazard and should be rigorously avoided.

After calving, challenge feeding calls for increasing the grain allowance several pounds per day above the cow's exact requirements at the time. The objective is to allow each cow to reach peak production at or near her genetic potential. Challenge feeding helps a cow to reach peak production earlier than she otherwise might, thus taking advantage of the fact that her system, at this time, is geared most strongly toward heavy production. The advantage of achieving maximum peak production will be carried on throughout the remaining months of lactation. After peak production is reached, the amount of grain fed should be determined according to a grain feeding guide based on body weight, milk production and fat test.

During the period in which concentrate is being increased, a point will be reached when forage intake will be depressed. For a 1200 lb cow this may happen at about 14 lb concentrate per day. As you exceed this point, each additional pound of concentrate will reduce forage intake by about .5 to .7 lb of hay equivalent. This, of course, reduces the fiber content of the total ration and may increase the incidence of milk fat depression. This is a temporary problem and should be viewed on the basis of its effect on the total lactation record. It is important to remember that a 15% increase in milk yield will pay for one whole percentage unit drop in test on today's market. When we cease "challenging" the cow after peak milk flow is attained, then forage intake will gradually increase and fat test will return to normal.

Conclusions: for maximum efficient (profitable) milk production over a cow's productive life, consider these points:

a. Avoid over or under conditioned dry cows.

b. Prepare the rumen bacteria for the "jolt" of heavy postpartum concentrate feeding by lead feeding 1 to 2 wks before due date, increasing grain at the rate of 1 lb per day.

c. Invest your grain dollar where you can get the biggest return, between calving and the peak of lactation, but do not over-grain first-calf heifers.

d. Make maximum use of your forage during middle and late lactation and during the dry period when total nutrient and energy intake is not a factor limiting production. Always balance forage with needed nutrients.

NUTRITIONAL REQUIREMENTS AND FEEDING PRACTICES

Although proper dairy cattle nutrition can be accomplished through a great variety of feeding programs, basic nutrient requirements of the individual cow remain reasonably predictable. The two principal nutrients required are energy and protein. The requirements vary with body size, rate of growth, level of production, fat test, activity, etc. Differences in digestibility of feed between cows appears to be relatively small; much larger differences exist between cows in rate of feed intake due to level of production, fat test, body weight, ration energy density, season of the year, and days in milk. In Table 5 are estimates of free-choice dry matter intake when the ration is offered on a truly free-choice basis at all times. When cows have free access to feed less than 22 hours out of 24, you cannot consider that they are being fed free-choice and dry matter intake would be less.

Daily requirements for energy, protein, calcium and phosphorus can be determined from the information in Table 6. This table also indicates additional allowances for growth of cows not yet of mature body size. The requirements for milk production must be added to the needs for maintenance. For example, a mature 1300 pound cow producing 60 pounds of 4% milk has the following requirements (Table 6):

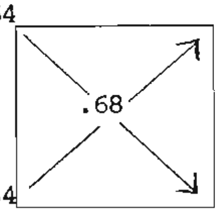
	Energy Mcal	Protein lb	Ca lb	P lb
Maintenance	9.57	1.06	.046	.037
Production	20.40	5.22	.276	.186
Total	29.97	6.28	.322	.223

Table 5 indicates this cow's free-choice dry matter intake will be about 44.1 lb (avg. 41.9 and 46.3). A diet with .68 Mcal/lb dry matter (29.97/44.1), 14.2% protein (100 x 6.28/44.1), .73% Ca (100 x .322/44.1) and .53% P (100 x .233/44.1) is needed. Let's say your concentrate, on a dry matter basis, contains .84 Mcal NE_L/lb, and any desired protein, and that forages consist of (DM basis) 40% grass silage plus 60% corn silage. Forage analysis reports indicate the following which can be used, along with proportions fed, to compute forage mix composition:

Proportion of DM	% DM	DM basis % CP	DM basis NE_L/lb
.60 Corn silage	30	8.5	.70
.40 Grass silage	45	12.5	.55
Forage mix (weighted average)	36[1]	10.1[2]	.64[3]

(1) % DM = (.60 x 30) + (.40 x 45)
(2) % CP = (.60 x 8.5) + (.40 x 12.5) = 10.1
(3) Mcal NE_L = (.60 x .70) + (.40 x .55) = .64

The proportion of concentrate needed in the bunkmix to meet this cow's energy requirement can be calculated using the Pearson Square method as follows:



	Parts		Prop.	DMI	LB DM
Forage .64	.16	$\frac{.16}{.20}$ =	.80 x	44.1 =	35.28 lb DM forage
Grain .84	$\frac{.04}{.20}$	$\frac{.04}{.20}$ =	$\frac{.20}{1.00}$ x	44.1 =	8.82 lb DM grain

The forage dry matter is 60% corn silage and 40% grass silage.
Corn silage dry matter = 35.28 x .60 = 21.17 lb DM
Grass silage dry matter = 35.28 x .40 = 14.11 lb DM

The dry matter figures must be converted to an as fed basis to do the feeding. This can be accomplished by dividing the dry matter fed by the percent of dry matter present in the feed:

	LB DM	LB as fed	LB CP	Mcal NE_L
Corn silage	21.17 / .30 =	70.6	1.80	14.82
Grass silage	14.11 / .45 =	31.4	1.76	7.76
Grain	8.82 / .90 =	9.8	(____)	7.41
Total	44.1		6.28	29.99

This cow needs "x" amount (2.72) lb of protein in 9.8 lb grain as fed (2.72/9.8 = 27.8% protein). Use the same sort of computation to balance Ca and P as well. This cow is consuming ration DM containing 20% grain, 80% forage. A useful thumb rule is not to exceed 50, 60, or 70% grain in total ration DM when feeding forage consisting of corn silage, half corn silage + half haycrop, or all haycrop, respectively. These maximum grain proportions can be adjusted for specific farms so as to prevent milk fat depression, off-feed and digestive upsets resulting from excess grain feeding.

DRY MATTER INTAKE

An accurate estimate of dry matter intake is extremely important in balancing dairy rations. In the example above, if DM intake (44.1 lb/day) were erroneously estimated to be only 1 lb less (43.1 lb), grain needed per day would increase by 3.4 lb (from 9.8 to 13.2 lb). Significant factors (variables) influencing DM intake include: milk energy output (FCM), days in milk, body weight at time of estimate, season, and energy density of forage mixture as well as the general moisture content of the diet. In addition, 25 (mature cows) to 44% (first-calf heifers) of the variation in free-choice DM intake is attributed to factors other than those listed. Hence it is very unlikely that two cows in a herd would have precisely the same DM intake. Energy (NE_L) requirement is a function of body weight (plus growth requirement of immature cows) and of FCM, the latter being controlled by milk yield and percent fat. Since energy density needed in a cow's ration is computed as total energy requirement/DM intake (Mcal NE_L/lb DM), very few cows in a herd need exactly the same ratio of grain to forage.

Until recently it was impossible, because of the time and effort required, to balance the ration for each cow in a herd or to do so at frequent intervals (e.g. weekly). Now we have microcomputer software that will compute DM intake, project FCM and body weight, and balance rations for each cow in the herd on a weekly basis with only one hour of operator time per month (1.5 sec/cow) for a 100-cow herd. With this new technology it is possible to feed each cow according to her unique needs while maximizing dry matter intake and rate of forage feeding. Such a feeding strategy has a positive effect on cow health, fat test, and income above feed cost. Some producers will not be able to capitalize on this modern system of feeding dairy cows for one or more of the following reasons: lack of regular monthly milk weights and accompanying fat tests, measured body weights after calving, regular forage tests, facilities to offer grain individually, blended bunkmix to eliminate or reduce individual cow sorting, or cannot provide a bunkmix containing 12% to 14% protein (for herds with average or high production, respectively).

Good bunk management will improve dry matter intake. Cows do not like stale feed; bunks should be cleaned everyday. Stale, spoiled, picked over feed should be discarded or fed to heifers or dry cows that also receive a ration that is balanced for their needs. High producing cows should have access to feed for 22 out of 24 hours everyday. Feeding twice a day will increase feed intake for high producing cows. Some studies indicate that feeding three or four times per day may increase intake even further.

The Economics of Ration Balancing

The first way to improve dairy cow profitability is to meet nutrient needs. It is false economy not to meet the nutrient needs for milk production. The costs of maintenance and production must be paid. Insufficient nutrient supply results in depressed milk production, reduced reproductive performance and general animal health followed by reduced income over feed costs. The largest fixed costs for milk production are cow maintenance requirements and the costs of raising her replacement. Reducing feed intake reduces milk production but does not reduce the feed used for maintenance. Within limits, increased levels of production and extended herd life improve profitability. This is illustrated in the following table (data from the New York Dairy Records Processing Laboratory dated February 4, 1987 for Holstein herds on official test in the Northeast; all values are per cow per year and represent a large number of herds at each production level):

Milk Production (lb)	Value of Product ($)	Value of Feed ($)	Income over Value of Feed ($)
13,790	1692	708	985
15,997	1971	773	1196
17,333	2137	807	1330
19,287	2369	863	1504

Using nutrient supplies wisely provides a second way of increasing farm profitability. Feeding a balanced ration reduces the cost of feeding some nutrients in excess while production is being limited by another. Required for wise nutrient utilization are accurate feed analyses and a working knowledge of feedstuffs, and how they may be used to meet the dairy cow's needs. Nutritionists with the aid of computers are able to consider feedstuff analysis, digestive characteristics and costs to most profitably meet the needs of high production. The most important ration characteristic is dry matter intake. Using the best quality roughage will reduce the dependance on concentrates, improve rumen fermentation and allow the meeting of nutrient requirements.

Substitution of nutrients from different supplies may provide a third way of reducing nutrient costs. Substitution of the basic concentrates, corn and soybean meal with by-product feeds and locally grown products often should be considered. Least cost or maximum profit total ration formulations should be made prior to purchase to evaluate these alternatives. Ingredients such as wheat middlings, brewers grains and distillers grains are difficult to evaluate as they cannot be considered on the simple basis of being either an energy or protein source. Total ration formulation best considers both nutrients being supplied as well as others that often are expensive such as phosphorus.

The objective for most dairy farms should be to obtain maximum net returns. This involves producing as much milk as possible without being detrimental to the health of the animals and keeping all costs under control so that the final result is a profitable operation. That is why a balanced ration is important; rations that are properly balanced will enable the cow to produce milk up to her genetic potential, to conceive and produce a calf on a regular 12- or 13-month interval and to maintain good health and productivity over a period of several years.

An example following Table 6 shows how to balance a ration for a lactating dairy cow. As a general rule, a dairy cow should receive daily an amount of forage dry matter equal to 1.0 to 1.5% of body weight in order to maintain proper rumen function and avoid milk fat depression. When feeding high-fiber forages (medium to late cut haycrop) the 1.0% minimum is satisfactory, but with corn silage or very early cut haycrops, the 1.5% minimum is recommended because of the lower fiber content of these feeds.

TABLE 5. An approximate guide to free-choice dry matter intake[1] during December and January[2] in lactating cows beyond 40 days in milk[3]

Breed	Jersey		Holstein			
Body Weight[4]	900 lb	1100 lb	1100 lb Heifer	1100 lb Cow	1300 lb Cow	1500 lb Cow
FCM[5] LB/DAY			Dry Matter Intake[6,7], LB/DAY			
25	22.9	24.9	26.8	27.1	30.0	31.9
35	27.5	29.5	31.0	30.2	33.0	34.9
45	32.5	34.5	35.1	34.6	37.5	39.4
55	34.4	36.4	36.2	39.0	41.9	43.8
65	37.7	39.7	38.3	43.4	46.3	48.2
75	41.0	43.0	40.0	45.2	48.1	50.0
85	-	46.5	41.6	48.7	51.6	53.5
95	-	-	-	52.4	55.3	57.2
			% Body Weight[4]			
25	2.54	2.26	2.44	2.46	2.31	2.13
35	3.06	2.68	2.82	2.75	2.54	2.33
45	3.61	3.14	3.19	3.15	2.88	2.63
55	3.82	3.31	3.29	3.55	3.22	2.92
65	4.19	3.61	3.48	3.59	3.56	3.21
75	4.56	3.91	3.64	4.11	3.70	3.33
85	-	4.23	3.78	4.43	3.97	3.57
95	-	-	-	4.76	4.25	3.81

[1]Days in milk affects dry matter intake and differs among FCM and breed/weight combinations.
[2]For June and July intakes subtract 1.6 lb (heifers) or 3.4 lb (cows) of dry matter per day.
[3]Intakes at 20 days in milk will be lower: -2.1 lb for heifers and -3.5 lb for cows.
[4]Body weight refers to measured (current) weight at time of feeding, not at time of calving.
[5]Fat corrected milk (FCM) = (.4 x lb milk) + (.15 x lb milk x percent fat). FCM for a cow producing 75 lb of milk with 3.1% fat would be computed: (.4 x 75) + (.15 x 75 x 3.1) = 64.9 lb.
[6]These dry matter intakes assume forage dry matter is 70% corn silage; for forages composed primarily of hay adjust first-calf heifers + .5 lb and older cows -2.3 lb of dry matter.
[7]Dry matter intakes are based on actual consumption; they do not include wastage, so the amount offered might be 5 to 10% higher.

TABLE 6. Daily Nutrient Recommendations[1,2] of Lactating and Pregnant Dry Cows

Body Weight, lb	NE_L (Mcal)	Total Crude Protein (lb)	Calcium (lb)	Calcium (g)	Phosphorus (lb)	Phosphorus (g)
Maintenance of Mature[3] Lactating Cows						
700	6.02	.71	.029	13	.023	11
800	6.65	.77	.032	15	.026	12
900	7.27	.83	.035	16	.028	13
1,000	7.86	.89	.038	17	.030	14
1,100	8.45	.95	.040	18	.032	15
1,200	9.02	1.02	.043	20	.034	16
1,300	9.57	1.06	.046	21	.037	17
1,400	10.12	1.12	.048	22	.038	18
1,500	10.66	1.17	.051	23	.041	19
1,600	11.19	1.22	.054	24	.043	20
1,700	11.71	1.27	.056	25	.045	20
1,800	12.22	1.32	.058	26	.046	21
Maintenance Plus Last 2 Months Gestation of Mature Dry Cows						
700	7.82	1.51	.066	30	.046	21
800	8.65	1.66	.074	34	.053	24
900	9.45	1.80	.082	37	.058	26
1,000	10.22	1.93	.089	41	.063	29
1,100	10.98	2.06	.097	44	.068	31
1,200	11.72	2.19	.104	47	.074	33
1,300	12.44	2.31	.112	51	.079	36
1,400	13.16	2.44	.119	54	.084	38
1,500	13.85	2.55	.126	57	.089	40
1,600	14.54	2.67	.133	61	.094	43
1,700	15.22	2.79	.140	64	.099	45
1,800	15.88	2.90	.147	67	.104	47
Milk Production--Nutrients Per Pound of Milk of Different Fat Percentages						
Fat (%)						
2.5	.27	.072	.0041	1.86	.0027	1.24
3.0	.29	.077	.0043	1.93	.0028	1.29
3.5	.31	.082	.0044	2.01	.0030	1.34
4.0	.34	.087	.0046	2.09	.0031	1.39
4.5	.36	.092	.0048	2.16	.0032	1.44
5.0	.38	.098	.0049	2.24	.0033	1.49
5.5	.40	.103	.0051	2.32	.0034	1.55
6.0	.42	.108	.0053	2.40	.0035	1.60

1 Energy and protein recommendations for maintenance of mature lactating cows and for milk production are 1987 NRC.

2 Equations to compute nutrient amounts (W=body weight in Kilograms)

Maintenance of mature lactating cows: Mcal NE_L =.080 $(W)^{.75}$; lb CP = .0148 $(W)^{.67}$; lb Ca = .0003836 $(W)^{.75}$; lb P = .8 (lb Ca).

Maintenance plus gestation of mature dry cows: Mcal NE_L = .104 $(W)^{.75}$, lb CP = .02836 $(W)^{.69}$, 14% above 1987 NRC; lb Ca = .0004932 $(W)^{.85}$, 20% above 1987 NRC; lb P = .704 (lb Ca).

Milk production (4% FCM) = [.4(lb Milk)] + [.15 (lb Milk) x (% fat)]; Mcal NE_L = .34 (lb FCM); lb CP/lb Milk = .04586 + .01036 (% fat); lb Ca/lb Milk = .0003357 (% fat), 35% above 1987 NRC; lb P = .667 (lb Ca).

3 To permit growth of young lactating cows, increase NE_L by .74 Mcal and crude protein by .16 lb daily after 70 days in milk. This is equivalent to 1 lb of 16% grain.

EXAMPLE 1. WORKSHEET FOR CHECKING ADEQUACY OF PRESENT FEEDING PRACTICES

Belle	1	1100	Aug 31	Oct 27
Name of cow	Lact. no.	Body wt.	Date fresh	Date calculated

Daily milk production 55 lb   Milk fat percent 4.0

REQUIREMENTS:	lb CP	Mcal NE_L
Maintenance & Growth (Table 6)	0.95	8.45
Milk Production (Table 6)	4.78	18.7
Total requirement	5.73	27.15
PRESENT FEEDING PROGRAM (per day)		
4 lb grass hay 9.0 % CP, .48 Mcal	.36	1.92
60 lb corn silage 2.4 % CP, .22 Mcal	1.44	13.2
TOTAL FROM FORAGE	1.80	15.1
DIFFERENCE = Nutrients required from concentrate	3.93	12.05

lb concentrate required = energy needed/energy per lb concentrate (assume a concentrate NE_L of .72 Mcal/lb):

12.05/.72 = 16.7 lb concentrate

% Protein needed in concentrate = lb protein needed/lb concentrate x 100.

3.93/16.7 x 100 = 23.5%

This indicates that with this forage the dairy producer could meet the needs of this cow by feeding 16.7 lb of a 24% protein supplement.

Automatic Feeders

There are four types of automatic grain feeders: (1) magnetic, (2) electronic with feed doors, (3) transponder, and (4) computer controlled. Magnetic and electronic feeders allow "keyed" cows to have free-choice access to grain for all or part of the day. The electronic door system also can be used to group-feed several different total mixed rations without physically dividing the herd. Various numbers of cows with the same key can have access to one or more doors behind which is the same feed or TMR. Transponder and computer controlled feeders are grain limiting, and they enable individual cow feeding. This eliminates the potential for over-consumption of grain, a problem which exists with magnetic and electronic feeders used to provide grain.

Computer controlled feeders have several features that make them attractive:

1. Individual cow grain allowances are changed at the central microprocessor unit, thus cows do not have to be handled manually on a routine basis.

2. The amount of concentrate dispensed to each cow can be obtained at any time, or on a 12- or 24-hour printout. Most computers are programmed to print an alarm list of those cows which do not consume their allotment. An unusual drop in intake may be an indicator of a health problem. There is some question as to whether or not this can be used as an indicator of heats.

3. The total concentrate allowance can be divided into several feeding periods. More frequent feeding reduces the rumen acid buildup which occurs immediately after a large amount of concentrate is consumed. A stabilized rumen pH can result in improved feed efficiency, increased fiber digestion, increased dry matter intake, production of more acetic acid which cows use for butterfat production and prevention of acidosis.

4. They provide the ability to dispense two feeds simultaneously, each at a different rate. Thus both an energy source and a protein source can be fed at different levels to each cow according to her own specific nutrient requirements. With most feeding programs a two-grain system will result in more nearly balancing the ration for a higher percentage of the cows in the herd than will a one-grain system. Most dairy producers can realize a feed savings by feeding two grains rather than one.

5. They may incorporate other herd management information. Most computer controlled systems have software for entry of reproduction and health data. These programs provide printouts of daily attention lists such as cows due to calve, due in heat, ready to dry off, etc.

The way in which electronic feeding systems are managed is the key to their success on any farm. Where to locate the feeder stalls, how frequently to calibrate them and how often to adjust individual cow grain allowances are important management considerations. Researchers at the University of Illinois have conducted management and behavioral studies in connection with electronic feeders. Feeding behavior is important with the use of automatic feeders. The boss cow syndrome has largely disappeared in the Illinois herd. They attribute this to management factors such as protective bars on the side of the feeder stalls, positioning feeder stalls with at least two vacant stalls between them, having all cows receive some grain through the system and the fact that cows are smart enough to know that a stall soon will be vacant if it is occupied when they first approach it.

Calibration of computerized feeder stalls upon installation and frequent recalibration (at least monthly) are of extreme importance. Computerized feeders operate on a timed delivery rate. Each cow is programmed for a certain number of minutes access per day. The total amount of feed delivered to a cow during a feeding period is a function of the delivery rate (lb/min) and the minutes of access. The density of the feed affects the delivery rate. Density varies from feed to feed. Even the same feed may differ in density from one load to another. Therefore, failure to recalibrate can result in either over or under feeding of grain.

The other management question, how often to adjust grain, also is pertinent. Illinois researchers have concluded that once monthly is often enough to adjust the grain allowance for cows past peak of lactation but adjustment more often than monthly is beneficial during early lactation. A good individual-cow ration balancing system is essential for a dairyman to achieve maximum feed efficiency and savings. Should such a system be available he could benefit from making adjustments every few days for cows during the first month of lactation, weekly, for cows in the second, third and last month of lactation and biweekly for cows in the other months of lactation.

The use of electronics on dairy farms may be justified by any one of the following: reduced drudgery, reduced labor per animal, reduced feed (grain) costs, improved animal performance, reduced fluctuation in body condition, or improved decision making. Computerized grain feeders have the potential for improving herd management. As with other technology, the good managers will benefit the most from their use.

Although a ration is calculated as "balanced", there are other factors that limit the amount of various ingredients in a ration. Table 7 is presented to offer some guidelines for the maximum amount of various ingredients that are recommmended.

TABLE 7. Suggested guidelines for maximum rates of incorporation of ingredients into balanced blended total rations for dairy cows (% DM basis)[1]

Type	Ingredient	Max %, DM
GRAINS	Total concentrate	65[2]
	Soybeans (whole)	10
	Barley	40
	Corn	40
	Wheat	40
	Oats	40
PLANT BY-PRODUCTS	Brewers grains	30
	Corn gluten feed	30
	Hominy	40
	Wheat bran	25
	Wheat middlings	35
	Corn distillers grains	30
	Malt sprouts	10[3]
	Corn gluten meal	10
PLANT PROTEIN PRODUCTS	Soybean meal	20
	Linseed meal	20
	Peanut meal	20
	Canola meal	20
	Cottonseed meal	20
OTHER	Molasses	10[3]
	Animal fat	2.5
	Potato	20
	Corn & cob meal	50
	Cottonseed	13[3]
	Urea	0.9
	Beet or citrus pulp	25

[1]These maximum limits may be exceeded for many ingredients only if they are part of a balanced ration.

[2]If forage is all corn silage, use 50%; if forage is all medium to poor quality hay or haycrop silage, use 70%; if concentrate is mainly ear corn, use 70%.

[3]Absolute maximum - should not be exceeded.

Blended Complete Rations

For the last ten years or so, many dairy producers have found that a complete blended ration offered to a group of cows can be a successful way to feed. Results have been good when the producer has enough groups, uses a properly formulated ration and follows the prescribed feeding program.

A variety of names have been given to this system where forages, primarily corn silage and haycrop silage, are mixed with a combination of individual ingredients or commercial concentrates, protein supplements, and mineral and vitamin supplements to form a single mixed ration balanced for the average (or above average, mean +1 S.D.) cow in the group and fed on a free-choice basis. This essentially defines the blended complete ration concept used in the Northeast.

Some of the advantages of blended complete rations are:

1. Every bite a cow takes is a balanced forage-concentrate mixture.
2. High production has been demonstrated using this system.
3. Free-choice mineral supplements are usually not necessary.
4. Fewer digestive upsets in early lactation or when cows are switched from a high forage diet to a high concentrate diet.
5. NPN and certain by-products can be utilized more effectively.
6. Changes in ration formulation can be made without greatly affecting consumption.
7. Less labor is required for feeding.
8. Fewer problems with low milk fat test.
9. It is no longer necessary to feed grain in the parlor.

There are several advantages of not feeding grain in the parlor:

1. Cows stand more quietly for milking.
2. No grain is left uneaten, but low producers may consume too much energy.
3. There is less dust and manure in the parlor.
4. When a new parlor is built there is no investment in grain feeding equipment.
5. The operator has more time to devote to milking.
6. It takes less time to milk.

Some of the problems encountered with blended complete rations include:

1. Lower producing cows in a group tend to be fed more grain than necessary and to gain weight (get fat).
2. It is difficult to feed hay in complete rations.

3. Hay can be offered in addition to the complete ration but the amount of hay consumed will vary greatly among cows. When this happens, the ration will be out of balance for some cows depending on the amount of hay consumed and the composition of the hay in relation to the composition of the blended complete ration.

4. Mixer wagons and electronic load cells are expensive; however, they are necessary for optimum use of the blended complete ration system and should be used in conjunction with routine moisture testing. Proper loading permits the use of chuck wagons.

5. An error in ration formulation affects all cows in the group.

6. Very few cows in the group are fed strictly according to needs.

The success of a dairy feeding program for maximum economical production is based on the quality of homegrown forages. It is generally accepted that high producing cows cannot consume enough feed to meet the production requirement for energy. Without high quality forage, dry matter intake of the cow is limited by rumen fill rather than appetite. One of the major advantages of complete rations is the opportunity to provide adequate blended amounts of protein, minerals and vitamins. Energy levels at high production may not be met because of the limitation of the capacity of the cow and the minimum level of fiber (forage) required to maintain normal rumen activity and minimize digestive upsets and fat depression.

Successful feeding of complete rations depends on four major factors:

1. Feed analyses. This is critical in order to balance the ration and reduce feed costs. Major problems can be avoided by using feed analyses at least to the extent of available nutritional knowledge.

2. Mixer-blender unit. This unit, whether it be stationary or mobile, is necessary to provide a uniform mix to all cows. Mixing time is a critical factor as short mixing time may not provide a uniform blend and extended mixing may shred or pulverize the blend. This is particularly true with auger types. Another important factor is the ability of the blender unit to handle haycrop silage. When haycrop silage is over 50% of the forage as fed, some units will not handle it satisfactorily and major breakdowns may occur. Haycrop silage must be fine cut to be handled well, particularly through the auger and drum type mixer.

3. Weighing devices are imperative when considering blended complete rations whether they are stationary scales or electronic scales on mobile mixer units. However, frequent determination of dry matter of silage from silos open to rain and snow <u>must</u> be used in conjunction with weighing devices.

4. The herd should be divided into different production groups based on the optimum grain to forage ratio computed for each cow; each group should be fed to a level slightly above the mean of the group.

While blended complete rations allow a good deal of latitude relative to ingredients and their effect on palatability, some ingredients available in the New England area have limitations (these are guidelines, not absolute limits) as to total pounds per average cow per day, e.g., oats, 12 lb; dried brewers grains, 9 lb; cereal by-products, 3 lb (expanded starch, low fiber); molasses, 4 lb (low fiber and laxative); potato meal, 8 lb; malt sprouts, 3 lb; whole cottonseed 6 lb. Some of the lower limit feeds may not be worth handling because of the small amounts used.

Handling Cows in Groups

When the concept of the blended complete ration was developed, the dairy producer was able to provide, in many cases, nutrition that was equal to or better than that provided in a stanchion barn. The single most important thing to remember regarding group feeding is that dry cows must be in a separate group. Beyond this, the number of groups and the number of cows per group will be determined by a number of factors including:

1. Herd size. Very large herds should have many groups; small herds may find a single group of lactating cows to be the only practical alternative.

2. Length of time a cow must spend in the holding area. If a cow must spend more than two hours per day waiting to get into the parlor, there probably should be fewer cows in that group so that the cow is not kept away from feed and the resting area for such a long period.

3. Physical arrangement of the facilities. Many barns impose definite limits on the number of groups that can be handled.

Some of the criteria for breaking cows into groups include:

1. Percent grain in ration dry matter computed for individual cows using a computer ration balancer.

2. Production level. Most producers prefer to group cows according to production level (considering also fat test and body weight) because this permits them to vary the nutrient density of the ration so that higher producing cows can be fed more energy and protein; the farmer can save by feeding less to the group of lower producing cows.

3. Reproductive status. Some producers group the herd into such groups as: (a) not ready to breed; (b) to be bred artificially; (c) to be bred with a bull; and (d) confirmed pregnant.

4. Mastitis or other health problems. In some situations it is helpful to keep all mastitic cows in one group and all clean cows in another group to reduce the spread of infection.

5. Age. Some farmers like to keep a separate group for first calf heifers.

Some of the problems encountered in handling cows in groups include:

a. Additional labor required to change groups at milking time and to sort cows to be moved to another group. This is not a serious problem when facilities are designed properly.

b. Switching cows to different groups may result in temporary decreased production because of fighting and/or ration changes. Research shows this effect is minor and of short duration in most situations.

c. Groups can be mixed up if someone leaves a gate open.

Table 8 lists the general recommendations for formulating complete rations based on four groups including dry cows. The dry cow ration also is adequate to support growth and reproduction in heifers. It should be noted that as production increases, the energy concentration per pound of feed is increased by higher concentrate and lower forage levels. In high producing cows, dry matter intake is higher because of sharper appetites and greater energy demand.

TABLE 8. GUIDELINES FOR FORMULATION OF COMPLETE RATIONS[1]

Lactation State:	Early	Mid	Late	Dry
Crude Protein, %	16-17[2]	15	14	11
Protein Solubility, % CP	2.5-3.3	4.0	5.0	7.3
Energy, Mcal NE_L/lb	0.78	0.69	0.64	0.61
TDN, %	75	71	66	60
Crude Fiber, %	17	17	21	26
Acid Detergent Fiber, (ADF) %	21	21	26	30
Neutral Detergent Fiber, (NDF) %	32	36	40	48
Calcium, %	0.80	0.60	0.50	0.37
Phosphorus, %	0.50	0.40	0.34	0.26
Magnesium, %	0.25	0.22	0.20	0.16
Potassium, %	1.15	0.90	0.80	0.80
Sodium, %	0.18	0.18	0.18	0.10
Sodium chloride, %	0.46	0.46	0.46	0.25
Sulfur, %	0.26	0.24	0.22	0.18
Iron, ppm	50	50	50	50
Cobalt, ppm	0.10	0.10	0.10	0.10
Copper, ppm	10	10	10	10
Manganese, ppm	40	40	40	40
Zinc, ppm	40	40	40	40
Iodine, ppm	0.50	0.50	0.50	0.50
Selenium, ppm	0.10	0.10	0.10	0.10
Vitamin A, IU/lb	1450	1450	1450	1450
Vitamin D, IU/lb	140	140	140	140
Vitamin E, IU/lb	2	2	2	2

[1]All values are expressed on a dry matter basis. For the above guidelines to be effective, rations must be fed on a free-choice basis so that all animals will have all the feed they will eat throughout the day. Cows fed on a resticted basis need a more concentrated ration.

[2]During the first few weeks of lactation, dry matter intake is low; therefore, additional protein is required during this period.

Calculation of nutrient levels in complete rations can be accomplished by multiplying the pounds of ingredient by the % of nutrient; totaling nutrient content from all ingredients; and dividing by dry matter intake. For example, if the ration provides 7.36 lb of protein in 42 lb DM, it is 16% protein (7.36/42 x100 = 16%).

Several points to keep in mind when feeding complete rations are:

1. Not all cows respond to this system of feeding and some may have to be culled.
2. Some cows in the herd may remain in the high group for the entire lactation and some may start in the medium energy group.
3. Hay does not fit easily into this type of feeding system.
4. Two-year old heifers should be kept in the high group at >55 lb production if the mature cows are fed for a production level of 70 lb.
5. Dry cows should be brought into the low group ten days prior to freshening and moved to the high group after calving.
6. Free-choice mineral feeding is not necessary if the ration is properly formulated.

While the above discussion centered around free-stall housing systems, with the mechanization available, this feeding system could be used in any type of housing.

FORAGE SUPPLY

As mentioned in a previous section, the success of a dairy feeding program, for maximum economical production, is based on the quality and amount of homegrown forages. The successful dairy producers will take an inventory of the quality and quantity of the forages available. They will use this information to plan the feeding program to make most efficient use of available forages throughout the year. A common mistake that many farmers make is to use up all of the best forages first and then be faced with the impossible task of maintaining production on the very poor quality forage that remains; this may be an advantage in a strictly fall-freshening herd, however. Or worse yet, they may run out of forage several weeks before the new crop is available. Planning the proper use of available forages avoids the pitfalls of making drastic ration changes to correct for previous failure to plan.

As a rule, the more profitable dairy farms are the ones that have the best quality forage and they usually have it in abundance. Regardless of harvesting system, haycrop forages must be harvested early to get the high quality that will ensure high economical milk production.

Forage quality is based primarily on available energy and secondarily on protein content. Forages of higher energy will also be consumed in larger amounts by dairy cattle. The type and form of forage best suited to a particular dairy operation must be treated as an individual matter for each farm with the decision based on such factors as facilities and resources available, as well as on efficiency of land and labor utilization. Forage blends can be <u>too high</u> in protein for efficient ration balancing.

Pasture

Pasture has been viewed by some dairy producers as an outmoded and inefficient means of feeding lactating dairy cattle. Because of its high moisture content, pasture cannot be expected to provide sufficient energy to meet the needs of high producing dairy cows. However, on some small farms that have adequate amounts of good pasture, this can be a low cost source of good feed during the growing season. Even on large farms, well fertilized and managed pastures can be used to supply heifers and dry cows with good to excellent forage for a major part of the spring, early summer and fall. Supplemental pasture crops can be used to fill in the midsummer gap.

Fresh pasture can be provided daily for cattle by strip grazing (a system of fencing to permit cattle to graze only as much forage as they will consume in one day). If strip grazing is not possible, then at least pasture fields should be rotated, giving the forage a chance to regenerate. When pasture becomes short or overmature, cows automatically cut down consumption and milk production drops. Particular attention should be given to providing supplementary protein, energy and minerals as needed.

Green-Chop Forage

Green chopping is a costly alternative to grazing. In a green-chop system, the forage is chopped and fed fresh every day but the cows remain confined in an area near the barn. Cows vary greatly in the amount of green-chop consumed. Dry matter intake does not fluctuate as widely as total intake. As the crop becomes more mature, cows will eat less and energy consumption will be significantly lower.

Hay

Hay still provides a vital part of many dairy feeding programs. Second or third cutting hay is usually of better quality; however, first cutting can be of excellent quality if it is harvested early. Stage of maturity at harvest is the most important single factor affecting quality of hay. Forage intake decreases with delayed cutting (Table 9). Date of harvest studies have shown consistent decreases in dry matter digestibility of forages when harvest is delayed beyond optimum harvest stage. For every day that forage is not harvested after June 1, the feeding value decreases by approximately 0.5%.

TABLE 9. EXPECTED HAY (OR EQUIVALENT IN HAYCROP SILAGE) AND ENERGY INTAKE FROM FORAGE HARVESTED AT VARIOUS DATES FED TO A COW WEIGHING 1,400 POUNDS

Date Harvested	Hay Intake		Energy from Forage	Grain needed to produce 50 pounds of 4% milk
	(lb/day)	(Mcal/lb)	(Mcal/day)	(lb/day)
June 1	38	.63	24	5
June 15	31	.58	18	13
July 1	25	.54	14	18

The harvesting system (conventional bales, large round bales, or stacks) and management practices you use significantly affect the quantity and quality of forages you preserve during harvest. Most harvesting loss results from leaves and small stems shattered during harvest. U.S.D.A. data suggest that hay retains about 60% of the leaves present in the standing crop whereas silage retains 80% of the leaves. Rain-damaged hay retained only 40% of its leaves, but this figure depends on the severity of rain damage and subsequent handling. Large round bales or stacks left uncovered on the ground for extended periods here in New England suffer substantial weather damage.

"Every leaf counts" should be the motto of all haymakers. The major source of leaf loss occurs during windrowing of forage that is too dry. Losses can be reduced by windrowing hay when it contains 35-40% moisture. The problem is more pronounced with legumes. Dry matter loss during baling in one study was 23% for legumes but only 10% for a grass-legume mixture.

Haycrop silage

Haycrop silage fits well with feeding programs that include corn silage. It complements corn silage because of its potentially higher protein content, particularly if the forage is cut early, harvested and stored properly, and contains a high proportion of legume.

High-moisture silage usually is described as silage resulting from the direct cutting of forage without wilting and it contains 15 to 25% dry matter. Wilted or medium moisture silage usually contains 25 to 40% dry matter. Haylage is accepted as containing 40 to 60% dry matter.

Research with medium moisture silage has shown that:

1. Cows consume it readily and produce well on it.

2. "Off" odors are not common as they are with high-moisture silage.

3. Successful harvesting is less dependent on the weather than haymaking.

4. Excessive heating may occur when making haylage containing more than 40% dry matter. This causes a marked decrease in digestibility of protein (heat damage, ADF-N) although crude protein content is not affected.

From a practical standpoint, dairy producers find that wilting the forage to around 60 to 65% moisture gives the best results. It minimizes nutrient losses in the silo. At the same time, it speeds up the harvesting operations as compared to making drier silage or hay. The lowest total dry matter losses (field and silo combined) occur when the forage is between 55% and 70% moisture.

On many farms there are fields that are not well suited to growing corn for silage but will produce grasses and legumes. Consequently, from the standpoint of management and machinery use, haycrop silage fits better with corn silage than does hay. Medium moisture haycrop silage can be fed as the sole forage quite successfully, providing it is of good quality (cut early).

For maximum yield of nutrients, haycrop silage should be harvested at the prebloom stage of growth. It is at this stage of maturity that the content of water-soluble carbohydrates in the plant is quite high and fiber is low. Water-soluble carbohydrates are necessary for bacteria to properly ferment the forage. With advanced maturity, water-soluble carbohydrates decrease and fiber increases, reducing the nutritive value.

Regardless of the method of harvesting or curing, haycrops must be cut early to be top quality. Normally there is only about one chance in three of harvesting hay without rain damage prior to the third week in June, which is about the latest that any first growth forages should be cut in the New England region. A practical solution is to put the first crop in the silo early and to make hay from the second and third crops.

Several factors important in making good haycrop silage are: (1) early-cut forages, (2) short chop (3/8 inch), (3) filling silo fast without long delays—every day if possible, (4) tight silo walls and sealed doors, (5) use of a mechanical distributor in vertical silos, (6) crown the center, (7) filling the top with several loads of wetter forage, and (8) sealing with a plastic cover. Do not start feeding for at least 3 to 4 weeks. Tight tower silos are most satisfactory; however, bunker silos can be used if special care is taken in compacting and sealing. Heavy (6 mil.) plastic covering the total area tightly is most desirable. Bunker silos should be sized according to the amount of haycrop silage that will be fed daily. Best results are obtained when haycrop silage is stored in a bunker used only for that purpose. Storage losses are reduced and flexibility is gained when the proper sized bunker is used to store haycrop silage.

In Appendix Table 1 are some data on the resulting composition of various lots of haycrop, whether it is made as direct-cut silage, wilted silage, haylage or hay. These are estimates of what might be the composition of forage at three different stages of maturity.

FORAGE TESTING

Although an estimate of the value of your forage can be obtained from the tables, this is a very poor guess of the value of a specific forage. For dairy producers to remain competitive today, they must take advantage of forage testing. Frequent testing of all forages is necessary to monitor changes in forage quality permitting the accurate balancing of rations. Several different forage testing laboratories are used in New England. Check with your Extension Agent, the State University or feed service representative about getting forage samples tested.

The first step is to get a representative sample. To sample a bunker silo, take fresh silage (not dried outer layer) from at least 12 representative locations from the face surface where the forage is being removed. Sample into a clean plastic pail (a galvanized pail will give test results that are high in zinc), mix thoroughly and subsample into your forage shipping bag. In the case of hay you will need to get core samples from at least 12 bales that are representative of the lot of hay that you will be feeding. Most Extension offices have core samplers available for loan, or you can purchase one for your own use.

Timing of forage tests may be a problem, especially haylage stored in upright silos. Often that forage has been fed by the time the analysis report is received. The best way to overcome this problem is to take samples as the forage is put into the silo. As each load goes into storage, take a representative sample, set it aside and add to it as each new load comes in during the day. At the end of the day mix all of the samples together, take a sample of this, put it into a closed plastic bag, label it, and put it in the freezer to prevent chemical changes. When you finish harvesting this particular forage, combine these individual samples proportionally by number of loads represented to give you a sample that is representative of the forage then send it in for analysis.

In tower silos, different lots of silage can be "marked" by tossing a handful of colored plastic strips into the blower at the point where the forage changes. Similar techniques can be used in bunker silos. Refer to Appendix Table 2, Page 58 for prediction equations to estimate the value of the forage from the analysis of the fresh material. You may need to consult your county agent for help on these calculations.

Unavailable or "Bound" Protein (ADF-N)

Bound protein is that portion of protein that has been rendered unavailable to the animal due to excessive heating during ensiling or in wet bales. Heat damage is much more prevalent in haylage and low-moisture haycrop silages than in hays or medium or high-moisture silage. Excess heat due to poor packing and air pockets can cause caramelization, resulting in up to a 40% reduction in digestible protein. Energy losses of similar magnitude can occur.

Many forage testing laboratories now run a test to estimate the amount of heat damage in haycrop silages after fermentation and calculate an available protein value by subtracting the bound protein content. Normally about 1% protein is found in the unavailable fraction. This is true for dry hay as well as haycrop and corn silages. Heat-damaged protein occurs in 74% of haycrop silages, 44% of sorghum-sudan silages, 12% of hay and very few corn silage samples analyzed. Therefore, it is critical to test haycrop silage or sorghum-sudan silage for unavailable protein. Heat damage may also be more severe near the surface (top) of the silo.

Silage Preservatives

Many additives are marketed for use in silage making. A few have been researched by neutral parties. Many await further testing. The original silage additives were high energy feed ingredients to increase the energy, enhance fermentation rate, and reduce seepage in direct-cut silage. Approximately 100 to 200 pounds of ground grains, dried beet or citrus pulps, soybran flakes, or hominy were added per ton of fresh forage. The use of a feed ingredient at these levels will help reduce seepage as well as fermentation losses. Storage dry matter losses may be held to 13 to 18 percent with the addition of feed ingredients to direct-cut forage.

If high-moisture silage is made from haycrop or annuals other than corn and stored in a horizontal silo, chemical preservatives may be considered as an alternative to the addition of a feed ingredient. Chemical preservatives include: propionic acid, and mixtures of acetic, propionic, and other organic acids. These should be applied according to the directions of the manufacturer. It is necessary to use a weighted plastic cover to take full advantage of chemical preservatives in horizontal silos.

Limited studies indicate that the use of organic acids, such as propionic or acetic-propionic mixtures, on the top quarter of a silo may improve silage quality and reduce storage losses when they are added at the rate of 10 to 20 pounds per ton of wilted forage. This is probably not necessary if the top portion of the silo consists of wetter forage. Bacterial culture or enzyme-type additives have produced variable (or no positive) results and should be tested further.

CORN SILAGE

High energy yields per acre, increased value at maturity (in contrast to haycrops) and ease of making high quality silage make corn the most important forage crop on many Southern and Central New England dairy farms. The farmers that are most successful in producing high yields of good quality corn silage: (1) select varieties that are adapted to their area, (2) follow a good program to maintain soil fertility, (3) plant as early as possible, and (4) harvest at the proper stage of maturity.

Stage of maturity of the corn plant is one of the most important factors determining the yield of dry matter per acre. On the average, it will take 25 days for the dry matter to increase from 19% to 30%. During this time each acre accumulates about two tons of dry matter. It pays to wait! But don't wait too long; when corn reaches advanced maturity, field and storage losses increase significantly. At the same time palatability and digestibility decrease due to slow silo fermentation, and accumulation of yeast and mold growth in the silo.

Optimum dry matter content for best storage, intake, and digestibility is between 29 and 34%. Good corn silage is harvested when the kernels have passed through the soft dough stage and reached the dent stage while most of the leaves are still green (about 30% DM). One of the best guidelines to tell when to harvest is the "Black Layer" test. When the grain reaches physiological maturity, several layers of cells near the tip of the kernel turn black forming the "black layer." This layer can be located by removing several kernels from the middle of the ear, split lengthwise or just cut off the tip and look for the "black layer" near the tip. If a black layer is found, the grain is physiologically mature and ready for the silo.

Corn silage chopped too coarse or too fine may result in a lower fat test. If corn silage is chopped so coarsely that there are pieces of cob a half inch or more in length, cows will be more likely to pick out the most digestible portions, leaving the larger pieces of cob. This reduces the fiber content of the feed consumed. In addition, research in Virginia and Michigan has shown that if chopping is fine enough to break every kernel, then the fat test is reduced. In most cases it appears that setting the chopper for 1/4 inch cut is most effective.

Corn silage is low in protein (approximately 8% on a dry matter basis). Therefore, when corn silage is the principal forage in a dairy feeding program, special care should be taken in balancing the ration. This will involve more protein, for example 24%, in the grain mixture, but a better alternative is to add urea (10 lb/ton) to corn as it goes into the silo or to add a protein supplement such as soybean meal to the silage at feeding time.

If cows receive most of their concentrates individually, the cows receiving small amounts of concentrates will be deficient in protein. In these cases, it is desirable to supplement the silage directly so that it contains an adequate level of protein to support low milk production. The bunkmix should contain 12 to 14% protein on a dry matter basis. Ten pounds of urea will increase the protein equivalent of a ton of 30% DM corn silage from 8 to about 12 or 13% on a dry matter basis; another alternative is to feed each cow approximately two pounds of soybean meal or 40% commercial supplement per day blended into the silage.

Table 10 is a general guideline for the protein level needed in the concentrate mixture with different amounts of corn silage and other forages in the program.

TABLE 10. SUGGESTED CRUDE PROTEIN CONTENT OF CONCENTRATES WITH DIFFERENT FORAGE PROGRAMS

Forage	Concentrate, % crude protein
100% corn silage	24
100% corn silage w/10 lb urea/ton @ 30% DM	18-20
75% corn silage, 25% grass haycrop	22-24
50% corn silage, 50% grass haycrop	18-22
50% corn silage, 50% legume haycrop	16-18

Level of grain feeding will affect the percentage of crude protein needed in a concentrate. Low producing cows receiving lower levels of grain require a higher percentage of crude protein in the concentrate when low protein forages are fed.

Because of its grain content, corn silage contains more energy per unit of dry matter than haycrops. This fact helps compensate for the somewhat lower dry matter consumption when corn silage is substituted for hay in the ration. Table 11 is a guide to forage intake and requirements for various combinations of corn silage and hay.

TABLE 11. APPROXIMATE FORAGE INTAKE LEVELS AND YEARLY SUPPLIES NEEDED USING VARIOUS PROPORTIONS OF CORN SILAGE AND HAY IN THE RATION (FORAGE OFFERED FREE-CHOICE)

Forage program	Proportions in forage ration, %		
Corn silage	100	75	50
Haycrop	0	25	50
Forage dry matter intake (% body wt. daily)			
During mid to late lactation	1.80	2.00	2.10
During total lactation cycle	1.65	1.87	1.98
Forage requirement per cow (tons/yr.)[a]			
900 lb avg. body weight			
Corn silage (30% DM)	8.13	6.91	4.88
Hay	0	.77	1.63
1300 lb avg. body weight			
Corn silage (30% DM)	11.74	9.98	7.05
Hay	0	1.11	2.35

[a]Year-round barn feeding. To calculate tons of forage required per cow per year at harvest, multiply: corn silage times 1.15 (tower silo) or 1.20 (horizontal silo) and hay times 1.03 to account for storage losses.

Corn Silage Additives

Some dairy producers are adding urea to corn as it goes into the silo, and a few are using anhydrous ammonia. These are very economical ways of balancing the protein needs of cows on low-protein forages. These products must be thoroughly mixed with the corn. The best method of adding urea is a metering hopper attached to the blower or chopper. Anhydrous ammonia must be applied with a cold flow applicator to change the ammonia to a liquid as it is applied. Anhydrous ammonia can be a very dangerous compound and must be handled properly to avoid injury.

The amount of urea or anhydrous ammonia to add to corn going into the silo should be proportional to its dry matter content. To get the desired increase in protein, it is necessary to add 10 pounds of urea or 7 pounds of anhydrous ammonia for 600 pounds of dry matter. Table 12 shows the quantities of urea or anhydrous ammonia needed at different levels of corn silage dry matter content.

TABLE 12. AMOUNT OF UREA OR ANHYDROUS AMMONIA REQUIRED AT DIFFERENT DRY MATTER CONTENTS TO INCREASE THE PROTEIN CONTENT OF CORN SILAGE TO 12 OR 13% OF THE DRY MATTER

Corn Dry Matter %	Dry Matter per ton of feed lb	Urea/Ton lb	Anhydrous Ammonia/Ton lb
25[a]	500	8	5.8
28[a]	560	9	6.5
30	600	10	7.0
32	640	11	7.5
35	700	12	8.2

[a] May lose some added nitrogen in silo seepage.

If corn is going into large upright silos, urea and anhydrous ammonia should not be added if corn is less than 30% dry matter. In horizontal silos these materials should not be added if corn is less than 27% dry matter. Seepage losses occur below these dry matter levels and much of the nonprotein nitrogen will be lost in the runoff. On the other hand, these materials should not be added to corn that is higher than 35% dry matter. In dry corn, the fermentation loss will be higher, palatability will be reduced and milk production results may be unsatisfactory.

Several other additives which include urea and other nutrients are on the market. Many of these cost significantly more than urea to obtain the same level of protein and may adversely affect the silage fermentation. For example, limestone has been widely used as an additive in corn prior to ensiling for beef cattle. Limestone acts as a neutralizer and results in greater production of organic acids and fermentation losses in the silo. This silage improves rate of gain in beef cattle but in dairy cattle it lowers fat tests without increasing milk production. In general corn silage additives of the bacterial culture or enzyme type have not proven to be economical. Protein supplements such as soybean meal and mineral supplements should be added to silage at feeding time rather than at ensiling time because of the fermentation loss incurred and reducing labor and investment costs in supplements.

A survey of corn silage in New Hampshire showed that sulfur content was .03% rather than the usual .12 to .15%. To obtain efficient microbial synthesis of protein in the silo and in the rumen, corn silage should contain .15 to .20% sulfur on a dry basis. This can be accomplished by adding 3 to 4 lbs sodium sulfate per ton of silage. This also indicates a need to test silage for sulfur.

How to compute the tonnage of forage in various structures

With regard to hay, most producers keep a reasonably accurate bale count. Lay aside in an accessible spot one bale from each load. These may be segregated by lots (cuttings, botanical type, etc.) if appropriate. After several weeks, core sample for forage analysis and weigh bales to compute tonnage stored. Average weight per bale x number of bales/2000 = tons of hay.

The primary principle in estimating tonnage of silage is that equal weights of dry matter (DM) of silage occupy similar volumes despite difference in percent DM Volume of tower silos is computed as follows: Volume (cubic feet) = 3.1416 x radius x radius x height of settled silage mass. Thus a 16 x 50 ft silo with 45 ft of silage in it would have a volume of 3.1416 x 8 x 8 x 45 = 9047.8 cubic feet. Average amount of DM per cubic foot varies from about 11 to 16 lbs, being less in very small tower silos and when a silo distributor is not used. Storage efficiency (100 minus % silo loss) generally averages about 87% for corn silage and 84% for haycrop silage stored in conventional tower silos. (Note that storage efficiencies are about 5 percentage units higher for oxygen limiting towers and 5 percentage units lower for properly-managed horizontal or bunker silos). In the above example, to estimate the weight of haycrop silage with 41% DM in a large conventional tower silo: (9047.8 cu ft x 15 lb DM/cu ft x .84 storage efficiency/0.41 DM content/2000 lb/ton = 139.0 tons of haylage as fed). The density of silage in the bottom one-quarter of the height of a tower silo is about double that of the average of the silo; therefore, a tower silo contains about one-half of its capacity when it is one-third full in terms of initial height of silage.

Bunker silos will vary in silage DM density from 16 to 19 lb DM/Cu ft depending on compaction (weight of tractor and amount of time spent packing the silage). Bunker silo volume is computed with somewhat less precision because you must "visualize", (1) the length starting midway up the ramp on the tapered end(s) of the silo, (2) the average width of silos with slanting walls, and (3) the average height of silage when mounded from the walls to the middle of the silo. Once this is done, volume is computed as length x average width x average height of silage. For corn silage (31.5% DM) in a bunker with 8 ft walls (mounded to 12 ft in center), 200 ft long sides, 14 ft bottom width, 18 ft top wall width, and compacted with a very heavy "payloader": Capacity (tons as fed) = 10 ft H x 190 ft L x 16 ft W x 19 lb DM/cu ft x .82 storage efficiency/.315 DM content/2000 lb/ton = 751.8 tons. Storage efficiency of bunker silos tends to be several points lower than tower silos because of increased surface spoilage, when fed out through the summer. Value of silage should be computed as $/ton at filling time divided by storage efficiency as a decimal, i.e., $30/.85 = $35.29 at feeding time.

Silo bags offer another alternative for storing haylage. The equipment is expensive but in some areas custom operators are available to put up haycrop forage in bags. It is important to keep animals away from the bags because punctures will introduce air and increase storage losses. Some reports indicate storage efficiency approaching oxygen-limiting structures but overall you should expect losses similar to large upright silos. Dry matter density should be about the same as in good bunker silos, i.e., between 16 and 19 lb DM/cu ft.

HIGH-MOISTURE CORN

High-moisture corn (60-75% dry matter) is a very palatable feed that can be used as an energy supplement or as an ingredient to formulate your own grain mixture. It can be harvested as either shelled corn or ear corn; it is usually stored in a silo but could be stored in any dry place if a preservative is used. Similar to all silage processes, air penetration of the high-moisture (HM) corn must be prevented to ensure proper fermentation.

High-moisture ear corn (HMEC) is equal to high-moisture shelled corn (HMSC) on an equal dry matter basis when fed to dairy cattle. HMEC gives higher dry matter yields per acre (and also total energy per acre) compared to HMSC. The cobs have feeding value for dairy cows and the fiber from the cobs may prove beneficial in preventing milk fat depression with certain feeding programs. Research has shown that cattle utilize high-moisture corn more efficiently than dry corn.

Dividing the cost of HMEC or HMSC per cwt. by the NE_L value for the corn at that dry matter content will give the cost per 100 Mcal of NE_L. This value can be used to compare HM corn to other energy supplements as an economical source of energy. Because of its moisture content HM corn might, in some cases, not be a good energy buy when costs of storage, handling costs, interest on investment, storage efficiency, risk, etc., are taken into account.

Grinding and Storage

Prior to storage, HMEC must be ground but HMSC can be ground or rolled at the time of harvest or just prior to feeding as it is coming out of storage. When harvesting, HMEC should be ground so that all kernels are cracked or broken and with most cob pieces not larger than pea-size. The correct fineness of grind will result in finer portions of the cob and kernel to fill up the spaces between the larger particles, thus assisting in air exclusion upon storage and therefore more rapid fermentation. HMEC ground too fine might result in decreased keeping quality and palatability; fine grinding also may lower fat test.

High-moisture corn can be satisfactorily stored in either the conventional or sealed type tower silo. The sealed structures are commonly used for HMSC. Well packed HMEC can be stored in a horizontal (bunker) silo, provided it is fed out at a reasonable rate (at least 2-3 inches per day). Since HM corn is perishable, at least 2 inches (more in warm weather) must be fed out daily to prevent spoilage. The approximate number of cattle required to consume 2 inches daily from various diameter silos is shown in Table 13.

TABLE 13. RELATIONSHIP OF FEEDING RATE OF HIGH-MOISTURE CORN WITH SILO AND HERD SIZE[a]

Pounds of grain fed per head daily	Approximate Number of Cattle Required to Consume 2 Inches of Ensiled Grain Daily[b] — Silo Diameter in Feet[c] 10	12	14	16	18	20
Ground shelled corn (based on kernel moisture of 30% and 14.2 lb DM/cu ft)						
5	124	178	242	316	400	493
10	62	89	121	158	200	247
15	42	59	81	105	133	165
20	31	45	61	79	100	124
25	36	49	64	80	99	
Ground ear corn (based on ear moisture of 32% and 12.8 lb DM/cu ft)						
5	105	152	205	269	342	420
10	52	76	103	135	170	210
15	35	51	69	90	114	140
20	26	38	52	68	85	105
25	21	31	41	54	68	84

[a] From Jorgensen, et al. Research Report 59, Univ. of Wisconsin, May, 1970.

[b] Based on removal rate of 2 inches per day during cool weather to prevent spoilage. Removal of 2-4 inches during warm weather may be required.

[c] To determine silo height needed, multiply 2 inches (amount removed per day) by number of feed days and divide by 12 inches.

Use of Preservatives

Because ensiled HM corn removed from storage will heat and spoil, research has been conducted on the addition of a preservative (organic acids) to HM corn. Corn (or small grains) having a moisture content between 15% and 25% should be treated with organic acids. At this moisture level, the grain will not keep well as a silage or as a dry grain. Some of the advantages of using organic acids (acetic and propionic) on HM corn are:

1. Mold development and heating are reduced or prevented, so energy and nutrient losses are minimal. There is less chance for the solubility of the protein fraction to change.

2. Various types of storage, such as a barn floor, can be used as long as they are protected from the weather and movement of air is minimized.

3. Handling and selling surplus grains is possible anytime rather than just at the time of ensiling. Treated corn can be transported over long distances with reduced risk of spoilage.

However, some drawbacks include:

1. Cost, usually from $6 to $10 per ton, depending on moisture content.

2. Acetic and propionic acids are caustic and corrosive.

3. Improper treatment (poor coverage) or exposure to the elements after treatment can result in mold growth and spoilage.

4. Organic acid treatment of HMEC is more difficult than HMSC, but still possible.

Feeding Programs with High-Moisture Corn

High-moisture corn is being used on many New England dairy farms. Unfortunately, it is not always used to its greatest advantage. High-moisture corn is not a complete concentrate ration; it is relatively low in protein, minerals and fiber. Just as the name implies, high-moisture corn is high in moisture relative to dry shelled corn. Therefore, it will furnish fewer nutrients per pound than dry corn. High-moisture corn has no nutritional advantage over dry shelled corn, but may be more economical if the total cost including storage is lower than that for shelled corn. Also, high-moisture corn may be more palatable than dry corn. To use HM corn as an ingredient, it is necessary to test for moisture. Dry matter content has a profound effect on formulation and amount fed as shown in Tables 14 and 15.

TABLE 14. POUNDS OF CORN AT DIFFERENT MOISTURE CONTENTS NEEDED TO EQUAL DRY CORN

If daily intake of dry corn (12% moisture is):	Pounds of HM corn to feed when moisture percent is:			
	25	30	35	40
5	6	6	7	7
10	12	13	14	15
15	18	19	20	22
20	23	25	27	29
25	29	31	34	37
30	35	38	41	44

TABLE 15. USING A 40% SUPPLEMENT WITH HM CORN

% Moisture in Corn		Percent protein desired 16	20	24
		% in Mixture		
12	Corn	78%	65%	52%
	40% Supp	22	35	48
25	Corn	80%	68%	56%
	40% Supp	20	32	44
30	Corn	82%	70%	57%
	40% Supp	18	30	43
35	Corn	83%	71%	59%
	40% Supp	17	29	41
40	Corn	84%	72%	61%
	40% Supp	16	28	39

Some farmers believe that by using HM corn they will be able to eliminate the cost of purchased feed. This may be far from the truth. If your forage program indicates a need for a relatively high protein concentrate, for example the 24% in Table 15, you still will need to purchase half as much feed and it will be a high protein supplement, at high cost, to balance your ration. In this case feed costs may not decrease as much as anticipated.

If you choose to mix your own feed and not purchase a commercial supplement, Table 16 will give you an indication of what you need to make a 16% protein mixture that will be comparable to a good purchased concentrate.

If producers are willing to make the necessary effort to see that feeding programs are properly balanced, high-moisture corn can make an important contribution to feeding programs. It is imperative that adequate protein, minerals and vitamins are provided.

Problems with Feeding High-Moisture Corn

Corn is an abundant source of energy, but lacking in protein and minerals. Therefore, it blends nicely with a forage program high in legumes. However, when high-moisture corn is added to a feeding program based on corn silage, the deficiencies of corn are compounded. Corn is very low in calcium. Therefore, it is not uncommon for a high-producing cow fed substantial quantities of corn silage and high-moisture corn to need in excess of one-half pound of ground limestone per day. Corn is also deficient in the amino acid, lysine, and it may be low in sulfur.

TABLE 16. MIXING YOUR OWN 16% CONCENTRATE USING HMEC OR HMSC WITH VARYING DRY MATTER CONTENTS

% Moisture in corn:	12	25	30	35	40
Ingredient	Percent of mixture as fed:				
Ear Corn	77.00	79.90	80.65	82.05	83.00
48% Soybean meal	19.50	17.00	16.40	15.00	14.20
Dicalcium phosphate	1.50	1.30	1.20	1.20	1.10
Limestone	1.00	0.90	0.90	0.90	0.90
Trace mineralized salt	1.00	0.90	0.85	0.85	0.80
Vitamin supplement	x	x	x	x	x
% of mixture that must be fed to equal dry corn mix	100	113	119	126	135
Ingredient	Percent of mixture as fed:				
Shelled corn	78.30	80.35	81.40	82.90	84.00
48% Soybean meal	18.25	16.40	15.50	14.10	13.20
Dicalcium phosphate	1.30	1.15	1.10	1.05	1.00
Limestone	1.15	1.10	1.00	0.95	0.90
Trace mineralized salt	1.00	1.00	1.00	1.00	0.90
Vitamin supplement	x	x	x	x	x
% of mixture that must be fed to equal dry corn mix	100	113	119	126	135

x = recommended levels of vitamins A, D, and E per pound of final mixture (3000, 3000 and 4 IU, respectively)

Although high-moisture corn is not fed as a source of protein, a potential problem in feeding it is related to the protein solubility of the total ration. The protein portion of forages is more soluble after ensiling than prior to ensiling. The same is true for high-moisture corn. Since most high-moisture corn is ensiled and fed with silages, the protein solubility of the total ration will be higher than if the corn grain were not ensiled. If fermentation is not allowed, the solubility of the protein fraction of the high-moisture corn would probably remain unchanged.

The feeding of urea with high-moisture corn also presents some problems. In the first place, urea is 100% soluble and therefore should be fed with rations of low protein solubility. Urea should not be mixed with high-moisture corn at time of ensiling because high-moisture corn is much drier than is corn silage. To be preserved by ensiling, high-moisture corn should be between 25 and 40% moisture (60 and 75% DM) without any additives to insure proper fermentation.

Dairy Grain Mixtures

Good dairy grain mixtures can be made from an almost endless list of by-products, grains and supplements. The essential factors are nutrients (energy, protein, minerals and vitamins, etc.) and may be secured from an infinite combination of ingredients.

The information in Table 17 should be helpful if you are in need of some guidance in mixing your own feeds. These formulas are intended to show examples of good quality mixtures that could be made on the farm. However, it should be pointed out that these are generalized formulas and are not balanced for optimum protein degradability or other factors that a good nutritionist may recommend to improve production and/or profitability on your farm.

As economic conditions change, it will be desirable to substitute certain ingredients for others in these formulas. As a general rule, the feed ingredients listed in Appendix Table 1 may be divided into three groups on the basis of their protein content. Low protein ingredients include corn, hominy, molasses and oats. Medium protein ingredients include brewers dried grains, corn gluten feed, distillers dried grains, wheat bran and wheat middlings. Soybean, corn gluten meal and canola meals are high protein ingredients.

Feeds within one group can be substituted to some extent for other feeds in the group. For example, corn meal can replace hominy feed completely. Oats could be used to replace no more than half of the combined corn-hominy total. Barley and wheat also could be used, if available at lower costs, but should make up no more than 25% of the finished mixture. In most formulas, molasses usually is limited to 10% of the feed and if the mixture is to be pelleted, the limits will be 7 or 8% depending upon the formula and the conditions of manufacture.

Wheat bran can replace wheat middlings when consideration is given to the difference in fiber and energy. Oats also could be substituted for these wheat by-products. Brewers grains, corn gluten feed and distillers grains may be interchanged in most formulas. In most cases, the combined total of these three feeds should be no more than 25% of the total ration; any one of them should constitute no more than 15% of the total.

Other high protein feeds may be substituted for soybean meal if price justifies. Linseed meal, cottonseed meal, canola meal and ground soybeans can be used in dairy rations. Do not use urea with ground raw soybeans because the urease in the soybeans will release ammonia from the urea and the ration will be lower in protein. Care must be taken with formulas containing urea to assure thorough mixing. It is recommended that urea not be used in on-the-farm mixing. Often it is useful to know how to calculate a ration with a given percentage of protein. Example 2 on Page 51 shows how this can be done.

Each of the grain mixtures in Table 17 is formulated to go with a certain forage. In general the 24% protein mixture is formulated to be used with feeding programs that use large amounts of corn silage. The 14% protein mixture can be used with legume forages. The 16 and 20% mixtures can be used with various combinations of forages. The 32 and 40% mixtures have higher levels of minerals and vitamins to provide adequate amounts of these nutrients when these feeds are mixed with home-grown grains.

TABLE 17. SUGGESTED DAIRY GRAIN FORMULAS

Protein, %	12	14	16	20	24	32	40
Ingredients				Pounds			
Corn, ground	1223	970	829	728	453	0	0
Middlings	164	300	300	300	300	220	0
Distillers	300	200	200	200	200	300	198
Soybean Meal	0	30	115	400	570	935	1532
Wheat Flour	100	0	0	0	0	0	0
Molasses	120	160	160	160	160	130	130
Salt	20	20	20	20	20	40	40
DiCal	30	20	11	10	5	40	40
Limestone, ground	33	0	25	42	42	60	60
Vitamins	x	x	x	x	x	x	x
Total	2000	2000	2000	2000	2000	2000	2000
Calculated Analysis (DM Basis):							
NE_L, Mcal/lb	.86	.82	.84	.83	.82	.76	.78
CP, %	13.0	15.8	17.9	22.7	27.0	35.6	44.7
Ca, %	1.0	0.46	0.89	1.22	1.19	2.02	2.04
P, %	.72	0.72	0.65	0.66	0.69	1.09	1.06
CF, %	3.5	5.8	6.1	4.7	5.2	6.0	3.3

x - A prepared vitamin trace mineral supplement should be added in sufficient amounts to add at least 3000 I.U. of vitamins and A and D and 4 I.U. of vitamin E per pound of the finished feed.

Feed Tags and Guarantees

Regulation of the labeling or tagging of feeds and ingredients is the responsibility of feed control officials in each state and is based on the legislation in that state. Most state laws comply with the "Uniform State Feed Bill" recommended by AFCO (American Feed Control Officials).

In reviewing the tag on a purchased feed it is important to remember that the guarantees can be minimum or maximum and are so designated. Protein and fat guarantees are minimum, meaning that the feed must contain at least the guaranteed amount of these nutrients. Fiber is a maximum guarantee. Feeds that contain urea carry a statement following the protein guarantee as follows (this includes not more than ____% equivalent protein from non-protein nitrogen). It is important to recognize that this is not a guarantee for urea but rather a guarantee of the maximum amount of protein equivalent from urea. For example, one pound of feed grade urea contains .45 lb nitrogen which is the amount found in 2.81 lb of protein. (.45 x 6.25 = 2.81) To estimate the amount of urea in the feed, divide the protein equivalent by 2.81. Thus, if the tag guarantees "This includes not more than 4.5% equivalent protein from non-protein nitrogen", the feed contains about 4.5/2.81 = 1.6% urea.

Contrary to popular belief ingredients need not be listed in order of predominance in farm animal feeds although they frequently are. They may be listed as individual ingredients or as groups of ingredients using the officially designated collective terms. These collective terms are listed below with selected examples of the products covered. When they appear on a collective term tag, the feed must contain one or more of the products:

Animal Protein Products - Animal by-product meal, fish meal, meat and bone meal, dried whey, poultry by-product, dried whole milk, etc.

Forage Products - Alfalfa leaf meal, suncured alfalfa meal, ground grass, etc.

Grain Products - Barley, corn, oats, rice, wheat, etc. in any of the normal forms such as ground, cracked, rolled, crimped, etc.

Plant Protein Products - Soybean meal, linseed meal, cottonseed meal, sunflower meal, rapeseed (canola) meal, dried yeast, brewer's yeast, peanut meal, etc.

Processed Grain By-Products - Corn gluten feed, corn gluten meal, brewers dried grains, distillers' dried grains, malt sprouts, wheat bran, wheat middlings, etc.

Roughage By-Products - Dried citrus pulp, dried beet pulp, soybean hulls, oat hulls, rice mill by-product, etc.

Molasses Products - Beet molasses, cane molasses, molasses yeast condensed solubles, etc.

The reason the states permit the use of collective terms is that it removes the necessity of either printing new tags or keeping trace amounts of an ingredient in a feed just to conform with a tag requirement. For example, prior to the use of collective terms when a grain such as barley became available at a cost that made its use desirable, the manufacturer would have to change tags in order to use it even though the nutritional value of the feed was unchanged. If you are interested in the exact ingredients used in a feed, most manufacturers will be happy to supply the exact amounts of each.

In summary, feed tags are used to supply a guarantee to customers that the feed will contain the nutritional or feeding value they expect. It should be remembered, however, that some important nutrients such as energy are not guaranteed. This is because feed control officials do not want anything guaranteed which cannot be measured (verified) in the laboratory. At the present time there is no way of accurately measuring the net energy value of a feed in the laboratory. Some laboratories will estimate the energy value of concentrates but these predictions are too unreliable for guarantee enforcement purposes.

One of the major challenges facing feed control officials and farmers is that of taking representative samples. Because feeds have a strong tendency to separate with handling, it is important that care be taken to take multiple samples from different sections of the truck or bin and carefully mix before sampling. The uniform feed law requires that all "sampling and analysis be conducted in accordance with methods published by the Association of Official Analytical Chemists or in accordance with other generally recognized methods".

EXAMPLE 2. Formulation of a Mixture Containing a Specific Protein Percentage:

If we have corn-and-cob meal and we want to know what proportion of it and soybean meal should be used to obtain a 16% protein feed, set up the Pearson Square as follows:

(Soybean meal)	48.5%		8.5	(16 minus 7.5)
		16%		
(Corn-and-Cob Meal)	7.5%		32.5	(48.5 minus 16)
			41.0	(Total)

From the above, we can see that a 16% protein mix requires 32.5 parts of corn-and-cob meal and 8.5 parts of soybean meal, a total of 41 parts. Therefore, by the following calculations determine the percent of each ingredient required:

(8.5)/(41) x 100 = 20.7% Soybean meal

(32.5)/(41) x 100 = 79.3% Corn-and-cob meal

Therefore, the exact amount of each ingredient required for a ton mixture would be calculated as follows:

20.7%/100 x 2000 = 414 lb of soybean meal

79.3%/100 x 2000 = 1,586 lb of corn-and-cob meal

Total = 2,000 lb of a 16% mixture

COMMON BY-PRODUCT AND PROCESSED FEEDS

Alfalfa Meal - This product is obtained by grinding dehydrated alfalfa without any additives or removal of any leafy portion. It should be made from leafy hay of good quality and have an NDF content of not more than 46%. It is often made into pellets that analyze 13 to 17% protein. Because the alfalfa is finely ground, the fiber is not effective in maintaining fat test and digestibility will be lower than for hay.

Beet Pulp - Dried beet pulp is a by-product of the sugar beet industry. It is palatable, bulky and a slightly laxative concentrate feed. It is low in protein, about 8%, and contains 53% NDF. It furnishes about the same total digestible nutrients as citrus pulp. It may be fed either wet or dry with other dry feed.

Canola Meal - Canola meal is obtained by drying the residue remaining after the mechanical and solvent extraction of most of the oil from the canola seed. The generic term "canola" applies to the seed, meal, oil, hulls or any other derivatives of the rapeseed varieties with less than 3 milligrams per gram normally measured glucosinotates and with 5% or less erucic acid. It contains 37% protein.

Citrus Pulp - Dried citrus pulp is a by-product of the citrus industry. It has about the same feeding value as beet pulp and many dairy producers claim it is just as palatable. However, it is lower in protein, about 6%, and is about 21% NDF. New England dairy producers have been liberal feeders of citrus pulp when the price was competitive.

Corn Distillers Dried Grains with Solubles - Distillers grains is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of the grain by condensing and drying the resultant whole stillage. It is a good source of protein, fat, energy and unknown nutrients. It is widely accepted as an excellent ingredient for dairy feeds. It contains about 26% protein.

Corn Gluten Feed - Corn gluten feed is that part of commercial shelled corn that remains after the extraction of the larger portion of the starch, gluten, and germ by the process employed in the wet milling manufacture of corn starch or syrup. Gluten feed is commonly used as a medium level protein source. It contains about 21% protein.

Corn Gluten Meal - Corn gluten meal is the dried residue from corn after the removal of the larger part of the starch and germ, and the separation of the bran by the process employed in the wet milling manufacture of corn starch or syrup. It has a characteristic golden color and contains about 60% protein.

Hominy Feed (Regular) - Hominy is a by-product consisting of a mixture of corn, bran, and the starchy portions of the kernel which is produced in the manufacture of pearl hominy, hominy grits, and table corn meal. It is high in energy and contains about 9% protein and 5% fat.

Hominy Feed (Solvent Extracted) - This product is produced similarly to regular hominy except more of the corn oil is extracted. It is lower in energy, is about 9% protein and only about 2 or 3% fat. The feeding value is probably less than corn. This is the predominant hominy produced today.

Liquid Whey - This is a by-product from cheese making. It contains only about 6.5% solids, but on the dry basis it is very high quality. It is corrosive and should be fed fresh each day.

Molasses - Cane molasses is the most common one available. It is an excellent conditioning feed and is very palatable. It is high in minerals and low in protein and an excellent source of energy usually available at a significantly lower cost than in other feeds.

Potatoes - Potato meal is a by-product of the potato processing industry. It's rather high fat content makes it a desirable ingredient for some rations. The density of potato meal is higher than many ingredients. Dried potato pulp was found palatable and nearly equal to hominy feed when forming 20% of the concentrate mixture. Cull potatoes are approximately equal to corn silage in feeding value. Potatoes should be chopped; maximum intake should be 30 pounds per head daily.

Soybean Meal - Soybean meal is a by-product of the extraction of oil from the soybean. It is an excellent source of protein and energy. Soybean meal is reasonably palatable, highly digestible, and provides a rich source of phosphorus. Dehulled soybean meal contains 49% protein and is usually a better buy than soybean meal with hulls.

Sweet White Lupin - This annual legume seed is being grown successfully in Maine. It has less than 0.3% alkaloids which improves its palatability over previous varieties. It contains about 36% protein.

Wheat Middlings - Wheat middlings is a popular by-product of the flour industry. It is palatable, rich in phosphorus, medium high in protein (16%) and pellets well; it has its greatest value when used to make up 20 to 25% of a feed mixture.

Whole Cottonseed - Most cottonseeds are not de-linted well and therefore resemble pussy willows in appearance. Cottonseeds are difficult to handle but they are excellent nutritionally averaging about 22% protein, 19% fat and 29% ADF. Maximum amount should be about 6 to 7 lbs/cow/day.

Wet Brewers Grains - Wet brewers grains (a by-product of the beer industry) provide a succulent feed of relatively high protein. Because it is perishable, deliveries should be made once a week in the winter but during the summer, deliveries should be made every two or three days. Heat encourages fermentation and the wet brewers grains will ferment, sour and spoil.

On the farm wet brewers should be stored under a roof and in an enclosure that traps potential run-off because juice will ferment producing a strong odor. In feeding the wet grains, the mangers should be kept clean and free from any spoiled material. To avoid the possibility of off flavor in milk, the wet grains should be fed after milking and stored outside of the milking area to avoid any fermenting odors reaching the milk.

Wet brewers grains, as indicated by their name, are quite wet containing from 77 to 87% moisture. Because of this great variation in dry matter content, dairy producers need to check carefully on the water content and the price paid. Special consideration should be given to the price paid in accordance with the moisture content (feed value) of the brewers grains. If the price quoted is at the plant, then add your cost of transportation including a truck with a tight body. Also consider the cost of handling the wet grains on the farm.

When feeding wet brewers grains, decreases in milk production may occur when the amount fed is more than 25 to 35 lbs per cow. This is because the grains are high in moisture and relatively low in energy. Furthermore, as the total ration increases in moisture content, dry matter consumption decreases. For cows in early lactation total ration dry matter should be above 50%.

Wet brewers grains fit particularly well in rations with low protein roughages such as corn silage and grass hays. However, if much alfalfa hay is fed, then the amount of brewers should be reduced some and/or a lower protein grain fed depending upon the quality of the alfalfa. The real value of brewers grains is in protein, not energy; feeding protein above the needs of the animal usually is not economical and may adversely affect conception rate.

Don't begin feeding wet brewers grains until you are sure of a continuous fresh supply as needed. Once you decide to feed wet brewers, start on it gradually and continue to make changes gradually. Watch the cow's body weight. Cows may lose weight because of the lower energy content of brewers compared to other protein sources.

RELATIVE FEED COSTS

It isn't the price you pay for feed that really counts but rather the price you pay for the nutrients that are in it. Most dairy producers grow nutrients in silage and/or hay at a lower cost than they can purchase nutrients in a concentrate mixture. Then, it is a question of balancing out the cow's needs using the feeds that supply the nutrients at the lowest cost. If one is short on roughage and has on hand enough mixed grass and legume silage, then one should look for a feed that supplies energy at low cost. Likewise, if corn silage is the major forage, then a good high protein feed is needed at a low cost per pound of protein. If one has little homegrown roughage on which to build, then the buyer should recognize the cow's needs for fiber and consider the possible substitution of some high fiber by-products to supplement the forage. But consideration must be given to the balance of the total ration.

We can lower feed costs and still provide dairy cattle with the nutrients they need by feeding by-product concentrates and roughage. A certain combination of feeds might be the cheapest during one year and the most expensive another year. Some of the more common by-product feeds available in New England are listed on Page 51.

The ration must be balanced using all the information available. Consider the cow's requirements for fiber and all known nutrients, the feeds available on the farm and the alternatives that can be purchased. Use of a computer regularly would insure correct calculations, but accurate information including forage analysis is a must.

To facilitate your decision about which feed is the best buy, you can easily calculate the cost per Mcal for any feed as follows:

Cost per ton/Mcal per ton = cost per Mcal.

For example, if hominy was available for $125/T, in Appendix Table 1, hominy has an NE_L value of 0.96 Mcal/lb of DM and it is 91% DM. Therefore:

2000 x 91%/100 = 1820 lb DM
1820 lb DM x 0.96 = 1747 Mcal
$125/1747 Mcal = $0.072 per Mcal

If beet pulp was available for $115/T, would it be a better buy? The calculation would be:

2000 x 91%/100 = 1820 lb DM
1820 x 0.77 = 1401 Mcal
$115/1401 Mcal = $0.082 per Mcal

In this example, hominy is the better buy because it costs less per Mcal. At times when a protein source is needed, similar calculations can be made substituting the amount of protein obtained in a ton for the Mcal in the above example.

Frequently it would be better to be able to compare feeds on the basis of both protein and energy and estimate the value of the feed in question in relation to its market price and other feeds that are available. Table 18 provides information that makes this possible.

TABLE 18. Factors for evaluating selected feeds on the basis of the cost of corn and soybean meal

Feed	Corn Factor[1]	44% Soybean Meal Factor[1]
Barley	.908	.093
Malt Sprouts	.376	.423
Dried Brewers Grains	.374	.464
Beet Pulp	.931	-.051
Corn Gluten Feed	.456	.434
Corn Gluten Meal	-.322	1.287
Distillers Grains	.710	.350
Hominy	1.043	.012
Cottonseeds	.656	.303
Soybeans	.352	.746
Wheat	.875	.125
Wheat Middlings	.683	.258

[1]From Morrison, Feeds and Feeding.

To use this information, multiply the energy factor for the feed in question by the market price for corn. Multiply the protein factor for the feed in question by the market price for 44% soybean meal. Add these values together; the result is the relative dollar value of the feed in question compared to current prices for corn and soybean meal.

For example, if the current market price for corn is $125 per ton and soybean meal is $230 per ton and you are considering the purchase of barley, your calculations are: (.908 x 125) + (.093 x 230) = $134.89. In other words, you could afford to pay $134.89 per ton for barley based on the current market for corn and soybean meal. If barley costs more than $134.89 per ton, you would be better off using a mixture of corn and soybean meal.

Software is now available for microcomputers to formulate least-cost rations. These programs consider all nutrients in various alternative feeds as well as the cost. Nutrition specifications of the ration can be set including minimum and maximum levels of nutrients and of individual ingredients. Care must be exercised in developing ration constraints to maintain a least-cost ration as well as one that will be palatable under conditions existing on a particular farm.

Most dairy farms have their own forage supply and perhaps some homegrown grain. Therefore, software to calculate least-cost rations probably is unnecessary. On the other hand, a simple spread sheet program on a commercial ration balancing program could be very helpful. Since this field is changing so rapidly, you may want to consult with your extension agent or state university before buying computer software.

APPENDIX TABLE I

Feedstuff	Dry Matter	Crude Protein	Sol N	Rumen Degrad.[1]	ADF	NDF	Ca	P	K	Mg	S	TDN	NEL
	DRY MATTER BASIS												
	%	%	%N	%	%	%	%	%	%	%	%	%	Mcal
CONCENTRATES													
Alfalfa Meal (dehyd. ground)	93	16.3	22.9	38	35	45	1.43	.52	2.68	0.39	0.21	61	0.63
Animal fat	99	--	--	--	--	--	--	--	--	--	--	225	2.45
Bakery product (dehyd)	92	11.9	40.0	50	--	--	0.07	0.26	0.91	0.35	--	89	0.94
Barley	89	13.8	16.8	79	7	19	0.09	0.47	0.63	0.14	0.15	84	0.88
Beet pulp (dehyd)	91	8.0	3.9	80	33	54	0.75	0.11	0.23	0.30	0.22	74	0.77
Beet pulp w/molasses (dehyd)	92	9.9	4.0	80	25	44	0.61	0.11	1.78	0.14	0.42	76	0.79
Brewers grains (dehyd)	92	26.0	2.8	50	24	46	0.29	0.54	0.09	0.15	0.34	68	0.73
Brewers grains (wet)	24	26.0	3.0	55	23	42	0.29	0.54	0.09	0.15	0.34	68	0.73
Brewers dried yeast	93	48.3	25.0	50	5	--	0.14	1.54	1.85	0.25	0.41	79	0.83
Citrus pulp (dehyd)	90	6.9	25.7	80	22	23	2.07	0.13	0.77	0.16	0.07	82	0.86
Corn, cracked	89	10.0	12.0	50	3	34	0.03	0.31	0.35	0.13	0.14	80	0.84
Corn, ground (corn meal)	89	10.0	12.0	50	3	34	0.03	0.31	0.35	0.13	0.14	85	0.90
Corn & cob meal	87	9.3	16.0	50	12	28	0.05	0.26	0.56	0.17	0.22	83	0.87
Corn cobs (ground)	90	2.8	2.2	20	35	89	0.12	0.04	0.84	0.07	0.47	49	0.50
Corn gluten feed	90	25.6	31.8	65	11	41	0.33	0.86	0.67	0.32	0.24	83	0.87
Corn gluten meal (41%)	91	46.2	7.2	45	9	37	0.11	0.44	0.03	0.06	0.44	86	0.90
Corn gluten meal (60%)	91	65.9	7.2	45	5	14	0.18	0.51	0.03	0.05	0.44	89	0.94
Cottonseed meal (solvent)	93	44.8	7.2	70	19	26	0.17	1.31	1.53	0.61	0.23	80	0.84
Cottonseeds (whole)	93	24.9	8.0	65	29	39	0.15	0.73	1.21	0.35	0.26	96	1.01
Distillers grains (dehyd)	92	29.5	3.2	45	15	43	0.10	0.40	0.21	0.07	0.46	86	0.90
Distillers grains (dehyd w/sol)	92	29.8	17.4	45	13	44	0.16	0.79	0.50	0.07	0.32	88	0.93
High-moisture ear corn	68	9.3	45.0	65	13	28	0.04	0.45	0.61	0.17	0.10	80	0.84
High-moisture shelled corn	72	10.2	40.0	65	4	13	0.03	0.36	0.30	0.13	0.10	88	0.92
Hominy feed (yellow)	91	11.8	22.9	40	12	50	0.06	0.58	0.59	0.26	0.03	92	0.96
Linseed Meal (solvent)	91	38.6	50.8	70	19	25	0.43	0.91	0.66	1.52	0.44	78	0.81
Liquid protein supplement (32%)	65	50.8	100.0	100	--	--	0.62	2.31	2.31	0.31	--	77	0.80
Liquid protein supplement (65%)	65	100.0	100.0	100	--	--	0.62	3.08	2.31	0.31	--	55	0.60
Malt sprouts (dehyd)	92	27.2	48.5	50	21	50	0.22	0.76	0.23	0.20	--	63	0.63
Molasses (sugarcane)	75	4.3	90.0	99	--	--	1.19	0.11	3.17	0.47	0.46	72	0.75
Oats	89	13.6	25.8	60	16	32	0.07	0.39	0.42	0.19	0.38	77	0.80
Oat mill feed	92	3.8	16.8	50	29	56	0.27	0.22	0.61	0.08	0.23	37	0.39
Oat hulls	93	3.9	16.8	50	42	78	0.10	0.11	0.52	--	--	32	0.35
Peanut meal (solvent)	92	54.2	40.0	75	14	--	0.22	0.71	1.29	0.04	0.32	77	0.80
Potato (process resid., dehyd)	91	8.4	42.5	50	--	--	0.16	0.25	--	--	--	90	0.95
Potato tubers (dehyd)	88	8.0	38.6	50	--	--	0.08	0.22	2.15	0.12	0.09	81	0.85
Rapeseed meal (canola meal)	94	39.6	39.0	77	17	26	0.69	1.04	0.90	0.54	--	74	0.77
Soybean (seeds, heat processed)	90	41.7	22.0	80	11	42	0.28	0.66	1.89	0.23	0.24	94	0.99
Wheat grain	86	11.5	29.7	70	4	14	0.07	0.36	0.46	0.13	0.16	89	0.93
Wheat bran	89	17.1	34.3	60	15	51	0.13	1.38	1.56	0.60	0.25	70	0.73
Wheat middlings	90	18.7	39.1	70	11	37	0.13	0.99	1.13	0.40	0.19	83	0.87
Whey (dehyd)	93	14.2	41.4	80	--	--	0.92	0.82	1.23	0.14	1.12	81	0.85
Whey (liquid)	7	12.8	100.0	99	--	--	0.92	0.82	1.23	0.14	1.12	81	0.85
Urea	99	281.0	100.0	100	0	0	0	0	0	0	0	0	0

[1] Percent of protein degraded in the rumen.

Feedstuff	Dry Matter	Crude Protein	Sol N	Rumen Degrad.[1]	ADF	NDF	Ca	P	K	Mg	S	TDN	NEL
		··········· DRY MATTER BASIS (MOISTURE FREE) ···········											
	%	%	%N	%	%	%	%	%	%	%	%	%	Mcal
FORAGES													
Corn silage	30	8.5	45.5	75	28	58	0.22	0.18	0.95	0.18	0.10	70	0.72
Legume silage	35	17.0	50.0	80	32	49	1.20	0.27	2.30	0.27	0.25	62	0.65
Mixed mostly legume silage	35	14.0	52.0	80	38	55	1.10	0.26	2.10	0.20	0.25	61	0.62
Mixed mostly grass silage	35	12.0	54.0	80	40	64	0.81	0.23	1.90	0.18	0.24	58	0.60
Grass silage	35	10.0	54.0	75	40	70	0.63	0.23	1.90	0.17	0.13	56	0.58
Legume hay	90	18.0	25.0	75	32	48	1.20	0.27	2.20	0.22	0.25	62	0.65
Mixed mostly legume hay	90	15.5	25.0	70	38	54	1.10	0.26	2.10	0.20	0.25	61	0.62
Mixed mostly grass hay	90	12.5	22.0	70	40	64	0.71	0.20	1.70	0.16	0.23	58	0.60
Grass hay	90	10.5	21.0	70	40	66	0.64	0.20	1.70	0.16	0.20	56	0.58
MINERALS													
Dicalcium phosphate	99	--	--	--	--	--	22.00	19.30	0.07	0.59	1.14	--	--
Limestone	99	--	--	--	--	--	37.00	0.02	0.12	2.06	0.04	--	--
Magnesium oxide	99	--	--	--	--	--	--	--	--	56.20	--	--	--
Monoammonium phosphate	99	68.8	100.0	--	--	--	--	24.00	0.01	0.46	1.46	--	--
Monosodium phosphate	99	--	--	--	--	--	--	25.39	--	--	--	--	--
Sodium sulfate	99	--	--	--	--	--	--	--	--	--	9.95	--	--
Sodium tripolyphosphate	99	--	--	--	--	--	--	25.00	--	--	--	--	--
Trace mineral salt	99	--	--	--	--	--	--	--	--	0.10	0.04	--	--
COMMERCIAL CONCENTRATES													
12% Dairy concentrate	89	13.5	25.0	[2]	7	17	1.50	0.70	1.00	0.30	0.25	85	0.88
16% Dairy concentrate	89	18.0	25.0	[2]	9	26	1.50	0.70	1.00	0.30	0.25	82	0.85
20% Dairy concentrate	89	22.5	25.0	[2]	9	26	1.50	0.70	1.00	0.30	0.25	82	0.85
24% Dairy concentrate	89	27.0	25.0	[2]	9	26	1.50	0.70	1.00	0.30	0.25	81	0.84
30% Dairy concentrate	89	33.7	25.0	[2]	8	19	1.80	1.30	1.00	0.30	0.25	79	0.82
40% Dairy concentrate	89	45.0	25.0	[2]	7	19	2.40	1.70	1.00	0.30	0.25	78	0.81

[1] Percent of protein that is degraded in the rumen.

[2] Commercial concentrates vary in protein degradability depending on the ingredients used; check with the manufacturer for information regarding the degradability of a specific feed.

APPENDIX TABLE 2: ESTIMATION OF NE_L (1978) OF FEEDS

We are in a period of transition regarding the estimation of productive energy (NE_L, TDN, etc.) of feeds from their chemical constitutents. Often "book" values for concentrate ingredients adequately describe energy density (NE_L/DM) of mixed concentrates; these should be available from your feed supplier's nutritionist. But homegrown forages and high-moisture grains vary widely due to differences in length of growing season, stage of maturity at harvest, botanical composition, methods of harvest and of storage, etc.; this variability necessitates efficient (representative) sampling and accurate laboratory analysis. A recommended procedure is to sample each load of fresh forage to be ensiled and then combine these (frozen) samples into well-mixed composites for testing. The following equations can be used to estimate composition of silo "outgo" from analysis of silo "input" (J. Dairy Sci. 66:1403, 1983).

Corn silage	R^2
% CP out = 2.77 + .748 (% CP in)	.80
% ADF out = 60.54 - 2.94 (% DM in) + .044 (% DM in)^2 + .58 (% ADF in)	.75
% CF out = 15.04 - .244 (% DM in) + .68 (% CF in)	.79

Haycrop silage	
% CP out = 10.78 - .190 (% ADF in) + .731 (% CP in)	.85
= 11.89 - .22 (% CF in) + .648 (% CP in)	.84
= 3.62 + .736 (% CP in)	.81
% ADF out = 45.7 - .53 (% CP in) - 1.203 (% DM in) + .0142 (%DM in)^2 + .657 (% ADF in)	.86
% CF out = 44.55 - .31 (% CP in) - 1.16 (% DM in) + .0139 (% DM in)^2 + .48 (% CF)	.69

Hay should be sampled by setting aside 1 or 2 bales from each load and core sampling these before making a well-mixed composite be sent for analysis.

Fiber of forages is composed of cellulose, hemicellulose and lignin. Cellulose and hemicellulose are partially digested by ruminants while lignin is virtually indigestible. Crude fiber (CF) analysis includes variable amounts of these three fibrous components, depending upon degree of lignification (maturity) and botanical source of the fiber. Many feed testing laboratories have dropped CF in favor of ADF (acid detergent fiber) which accounts for (traps) cellulose and lignin but not hemicellulose. A few feed testing labs now analyze for NDF (neutral detergent fiber) which accounts for all three components. Fiber is negatively correlated with NE_L or TDN content of forages, and this relationship is strongest for NDF. In order to develop equations to predict NE_L or TDN from NDF, a large data base is required in which both NDF and either NE_L or TDN were experimentally measured on a wide-range of forage types and qualities. In practice, it is easier and less costly to measure NDF and TDN of single-forage diets fed to non-lactating cows, heifers, or steers and develop predictions of TDN from NDF. Then standard conversions can be used to predict NE_L from TDN.

Unfortunately, very few scientifically-based data are available relating NDF or ADF to TDN or NE_L, and consequently we are skeptical of the accuracy of the numerous prediction equations currently in use in the Northeast. Some of this uncertainty would disappear if prediction equations were accompanied by "R^2" values which indicate the proportion (0.00 to 1.00) of variability of NE_L

accounted for by knowing percentages of NDF or ADF in the feedstuff. In addition, computerized infrared reflectance is being used in place of "wet lab" chemical methods to estimate the content of certain chemical constituents of certain classes of feedstuff. Following are equations currently used by NYDHIC forage testing laboratory to predict NE_L and TDN from measured ADF:

ALL VALUES* ON MOISTURE-FREE BASIS
(NE_L, Mcal/lb DM; TDN, % DM; ADF; % DM)

Grasses:
$NE_L = 1.085 - .015$ (% ADF) $\qquad$ TDN = 92.51 - .7965 (% ADF)

Mixed Grass Legume:
$NE_L = 1.044 - .0131$ (% ADF) $\qquad$ TDN = 87.84 - .6956 (% ADF)

Legumes:
$NE_L = 1.044 - .0123$ (% ADF) $\qquad$ TDN = 85.24 - .6531 (% ADF)

Corn Silage:
$NE_L = .94 - .008$ (% ADF) $\qquad$ TDN = 81.3 - .4248 (% ADF)

Generalized Equation (1978 NRC):
$NE_L = -.0544 + .01111$ (% TDN)

---

*Adapted from NYDHIC, 1/85.

Caution needs to be used in balancing rations for dairy cows based on feed analyses. An error in sampling forages or in analysis of samples may have a profound impact on the ratio of concentrate to forage computed to constitute a balanced diet. Feed analysis data should be checked for reasonableness against "book" values and levels found for previous tests. For this reason it is desirable to keep a permanent, bound notebook copy of forage test results identified by date, type of forage, etc., with notes on maturity, weather damage, field from which it was harvested and other relevant factors.