SENIOR PROJECT APPROVAL PAGE

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INTRODUCTION

In the dairy industry there are many cost factors. Ever since cows have been domesticated the number one cost of operating a dairy is feed. For today's producer, feed cost is around 58% of cost of production. With the evolutionary change in the cattle breed producing greater amounts of milk production producers continue to strive to meet there growing nutrient requirements that the cow demands. Meeting these high demands increase the cost of feed but producer continue to use new innovations to minimize the cost. Each cow has a required individual diet based on different factors throughout her lactation. Producers are challenged based on how cattle should be grouped and feed to meet the requirements as a whole with maximizing profits for the producer. One way that producers have been able meet these nutrient demands of the cow is by grouping cows in pens and targeting the requirements of the individual cows and feeding the pens accordingly. The problem facing this issue is the order in which cow grouping should follow. Cattle have always been feed according to nonlactating and lactating cows. In this paper the discussion will focus on the order in which lactating cows should be grouped and feed to meet the nutrient requirements of the cow and still achieving maximum profit for a large commercial dairy herd. With the evolution of the Total Mixed Ration (TMR) producers are then allowed to go into more depth and detail in individualizing certain rations to meet specific dietary needs for lactating cows. A few of the groups under debate are fresh cows (first 60 days of lactation), High producing (usually early in lactation), First lactation and submissive cows, late lactation and older cows. Other systems of grouping are based on the cows reproduction, if the cow is open or pregnant, and have been grouped based on their body condition as well.

There are many advantage and disadvantage in grouping cows and separating TMRs, but the justification of this project is to provide substantial information leading to the greater advantage of feeding individualized rations for lactating dairy cattle. Grouping is a special problem because the manager neither controls nor is able to determine feed consumption by individual cows. To achieve maximum income above feed cost the rations should be consumed in large quantities, contain a high concentration of utilizable nutrients, contain sufficient fiber to avoid depressed milk fat percentage, and contain feed ingredients formulated on least cost. The advantages and limitations of feeding a single mix or feeding multiple mixes of feeds are discussed. Specifications for rations and sample ingredient mixes for various stages of lactation and yields of daily milk are presented. Much of the data collected will be from past studys researches as well as interviews with current nutrients and producer currently practicing group feeding.

LITERATURE REVIEW

The Basics of Grouping Cows

The trend over the past 15 years has been to feed a single TMR to the dairy herd. Higher producing cows have a greater dry matter intake and, therefore, receive more nutrients daily. Unfortunately, most feeding systems consequently over-feed lower producers to assure that higher producers receive enough feed of the correct concentration of nutrients. Feeds are usually inexpensive compared to the return generated by milk sales, and the results of this feeding practice were higher production at a moderate cost.

Surveys of milk production versus nutrient consumption done regionally around the United States have shown significant over-feeding of protein and phosphorus on dairy farms (10). Certainly, these high levels can be reduced through the choice of feed ingredients and more precise mineral feeding, however producers want assurance their cows have adequate nutrients for optimum milk production. There is a middle ground where producers can feed for optimum performance while meeting the demands of changing environmental constraints.

Dividing the herd into two or three feeding groups allows tailoring rations more closely to the production level and nutrient requirements of the group. By feeding more cows more closely to their requirements, a producer can reduce waste and the excretion of excess nitrogen and phosphorus.

Obviously, a dairy farm must have facilities so cows can be divided into multiple groups. The size of the groups are influenced by the size of the milking parlor, the barns or corrals available for housing the cows, other priority grouping currently done (dry cows, heifers), and the ability to deliver different rations to different groups of cows.

There are some important considerations when grouping cows for more efficient use of feed nutrients. It takes professional help to formulate rations for and to monitor the performance of different production groups. A nutritionist can also help monitor the quality of feed ingredients used in rations, this variable is most prone to large variations.

In summary, grouping cows can be part of a total feed management program to reduce waste and the excretion of unused nutrients. Grouping cows by production level or stage of lactation is most common but there are many other factors that lead to a variety of groups. In addition, grouping cows is beneficial for dairy producers because it helps control feed costs. It promotes feeding valuable nutrients to benefit cows at different stages of lactation and results in optimum efficiency, productivity, and profitability

Factors Leading to Different Groups

Dividing the milking herd into groups often allows for better herd management. Proper grouping can simplify cow movement, facilitate observation of cows, and allow rations to more closely match the requirements of each individual cow within the group. Several factors interact to determine the optimal group size of cows on any dairy herd. These factors include 1) feedbunk space and competition for feed, water, and free stalls, 2) social interactions among cows and how they are affected by group size, 3) space available to the cow, 4) size of holding area and capacity of milking parlor, 5) animal body size and age, 6) body condition, 7) Days In Milk (DIM), 8) stall size and equity, and 9) adequacy of ventilation (6). Stall equity means that every stall is equally comfortable and likely to be used by a cow. Rapid movement to and from the milking parlor, continuous availability of palatable feed, fenceline feeding rather than elevated feed bunks with cows eating around them (5) and relatively homogeneous cow characteristics can allow greater animal housing density without apparent stress problems (6).

A survey of the highest producing herds in the United States revealed that over 67% of producers used a TMR feeding system, and that these producers averaged 2.9 groups of cows that were fed 2.7 times daily (9). Several researchers have examined various grouping strategies and suggested that cows might best be grouped by nutrient requirements and compared seven grouping strategies using a simulation model that included required nutrients per kilogram of DMI, DIM, test-day milk, dairy merit, and merit weighted by DIM (7). Grouping systems based on nutrient concentrations were most effective in maximizing return over feed costs, whereas the method based only on test-day milk was least effective. Some producers group cows by days in milk or where they are in the production curve. This method is roughly equal to grouping by daily milk production, but some cows produce twice as much daily milk as other cows at the same point in the lactation cycle. Other farms group according to the cows' reproductive status. Higher producing, early lactation cows are in voluntary waiting period prior to breeding so putting them together in a group allows feeding for the higher production and for more efficient heat detection and artificial insemination when entering breeding phase. However, not all early lactation cows produce at the same level. The most successful way to group cows has been shown to be selecting cows based on the nutrients required per pound of feed; for example nutrients such as crude protein, starch, sugar, fiber, fat, vitamins, and minerals. While directly related to daily milk production, it is a more precise way to feed cows what they need without waste and over-excretion of nutrients.

Nutrition Requirements for the Dairy Cow

With genetic selection and progressive management, production has steadily risen in the last 100 years as seen in Figure 1. The modern high-producing dairy cow will produce about 40 to 50 kg of milk per day in early lactation; production as high as 60 kg/d is not uncommon. In fact, the current world-record Holstein produced >30,000 kg of milk in a year that's almost 90 kg/d on average. That is enough to feed more than 100 people (8). Certainly, genetics is a major reason for the rise in milk production per cow over the past 50 years, but proper nutrition and management are critical to enable the modern high-producing cow to meet her production potential. The major goal for most dairy farms is to maximize profits. Because feed accounts for up to half of all costs on a dairy farm, many farmers are tempted to lower feed costs, especially when feed prices are high. However, feed for lactating cows is obviously not a overseen expense but an investment. Good dairy farmers continually seek feed sources and regimes for seeking that cost less but yield the same returns. Often they are successful, but sometimes they are not, and without proper nutrition cows are unable to achieve their genetic potential for milk production. To properly organize a herd in substantial groups requires the organizer to provide the cow with her required nutrients. Cows require certain nutrients based on different factors. There is a minimal requirement for the basic cow.

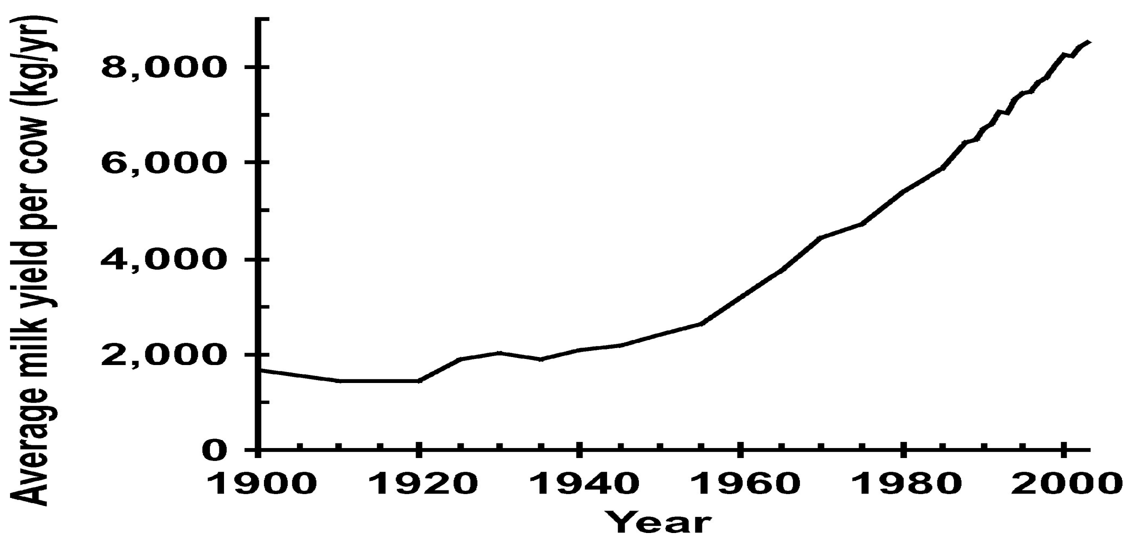

Figure 1. Milk production per cow in the United States over the past 100 yr. (8).

Dry matter intake. Dry matter intake (DMI) is an important criterion when formulating diets, especially for high-yielding dairy cows. Sometimes it is impossible to fulfill energy requirements within the DMI limits of high-producing cows, a problem that results in weight loss and, subsequently, lower milk yields. The amount of dry matter (DM) consumed by a cow depends on many variables including live weight, level of milk production, stage of lactation, environmental conditions, managerial and social factors, previous feeding history, body condition, and type and quality of feed ingredients, particularly forages. A review of the factors that affect the feed intake of food-producing animals has been published by the National Research Council (NRC, 1987a).

During early lactation cows do not consume as much feed as they do during later lactation, although their level of milk production may be the same. estimate that DMI is depressed 15 percent on the average during the first 3 weeks of lactation relative to later lactation. The greatest depression occurs during the first days of lactation shown in Figure 2 (8).

Figure 2 shows trends in milk production, DMI, live weight change, and energy balance during lactation. Milk production usually peaks between 4 and 8 weeks postpartum, yet maximum DMI usually occurs between 10 and 14 weeks postpartum. This rise in feed intake may not occur if the cow is fed a diet containing less-than-optimal amounts of dietary protein of lessthan-optimal degradability (9). The lag of maximum DMI behind peak milk yield causes a negative energy balance in early lactation.

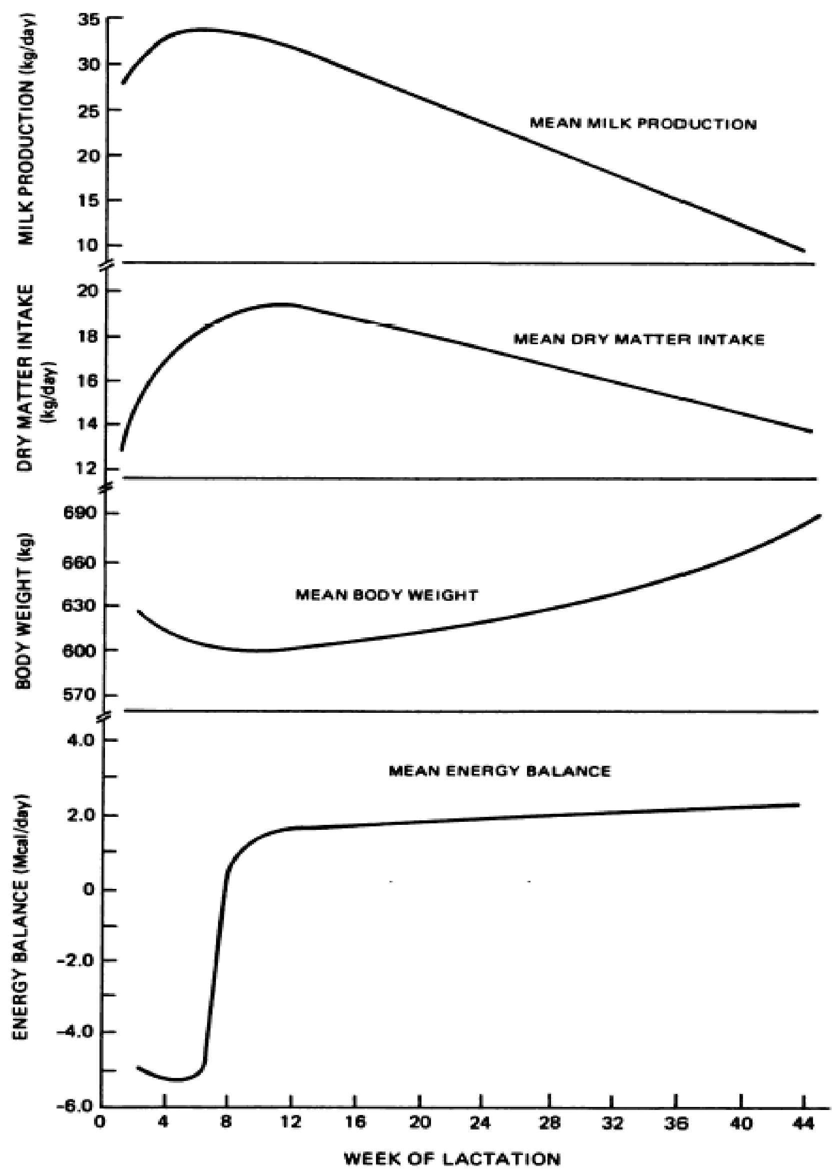

Figure 2. Trends in milk production, dry matter intake, body weight change, and energy balance during lacation (8).

mobilizes body tissues, particularly fat deposits, to overcome the energy deficit, which results in weight loss (Figure 2).

As DMI increases and milk production plateaus or begins to decline, weight change stabilizes and subsequently increases in mid- and late-lactation. The animal's weight continues to increase during the dry period. Much of this increase can be attributed to the development of the fetus and fetal membranes during the last trimester of gestation.

If cows do not consume as much dry matter as required (Table 2), and energy concentration is not increased, energy intake will be less than required. The result will be a loss of live weight, reduced milk yield, or both. If cows consume more DM than they need, as projected from Table 2, the energy concentration of the diet should be reduced or they may become overly fat. However, this is likely to happen only at lower milk yields.

The amounts of DM calculated from the table should be reduced by about 18 percent during the first 3 weeks of lactation to reflect the animal's reduced appetite and subsequent weight loss (rather than weight gain) in early lactation (3). Also, if fermented feeds constitute a major portion of the diet, the amount of DM should be reduced by 0.02 kg/100 kg of live weight for each 1 percent increase in diet moisture content above 50 percent (3). In both cases, reduced DMI is likely to result in live weight loss or reduced milk yields, or both, unless the cow's energy requirement can be fulfilled by increasing the energy concentration of the diet.

TABLE 1. Dry matter intake requirements to fullfill nutrient allowance for maintance, milk production and normal live weight gain during mid- and late

lactation (3).

Live Wt: (kg)	400	500	600	700	800
FCM (4%)[a] (kg)	% Live Wt[b,c]				
10	2.7	2.4	2.2	2.0	1.9
15	3.2	2.8	2.6	2.3	2.2
20	3.6	3.2	2.9	2.6	2.4
25	4.0	3.5	3.2	2.9	2.7
30	4.4	3.9	3.5	3.2	2.9
35	5.0	4.2	3.7	3.4	3.1
40	5.5	4.6	4.0	3.6	3.3
45	—	5.0	4.3	3.8	3.5
50	—	5.4	4.7	4.1	3.7
55	—	—	5.0	4.4	4.0
60	—	—	5.4	4.8	4.3

Energy. Ruminants need a daily supply of all nutrients required for maintenance and production: milk, meat, growth and pregnancy. Quantitatively any type of nutrient can limit performance levels, but the most likely to be in short supply are energy and protein, this is especially true for high and average yielding cows. Both energy and protein must be considered. For energy, the feeding system uses the metabolizable energy (ME) in the feed as a basis to formulate rations. The ME is the energy remaining in the digested foodstuffs after the loss in feces, urine, gases and body heat. The basic unit used to measure the energy content is the Megajoule (4).

There is considerable variation among diets fed to dairy cattle in the effect of the level of intake on nutrient and energy availability, but this effect is much greater with mixed diets than it is with diets consisting either of all forage or all concentrate (2). The decline in digestibility that occurs is greater with diets containing higher proportions of concentrate. Both the type and amount of cell wall influence the rate of change in digestibility that occurs with increasing intake. Other factors known to affect digestibility at high levels of intake include processing methods such as grinding to various degrees of fineness, pelleting, dry rolling, or steam flaking (2). The use of energy by dairy cattle depends to a large extent on the microbial fermentation that occurs in the rumen. The extent and type of fermentation determine the nature and amounts of the various metabolites that are absorbed from the digestive tract. These metabolites affect the efficiency of milk production, and they also influence the way energy is used. In general, diets that result in low ruminal acetate: propionate ratios (such as high concentrate diets) lead to increased body fat formation at the expense of milk fat synthesis. Such decreased milk fat synthesis occasionally may be accompanied by a modest increase in milk protein (3).

Protein. The digestible crude protein (DCP) is widely used to evaluate protein requirements, and it corresponds to the crude protein that remains after losses in the feces. However, a new system has been introduced which takes into account the degradability of the protein in the ration during digestion. It is a better system to calculate requirement levels, especially for high-yielding cows which have been shown to benefit from protein that escape microbial degradation in the rumen and is absorbed as amino-acids in the small intestine. Following this approach crude protein can be split into Rumen Degradable Nitrogen (RDN) and Undegraded Dietary Nitrogen (UDN). Fish meal is considered as a good source of UDN (10).

TABLE 2. Daily nutrient requirements of a lactating cow (10).

Live Weight (kg)	Energy NEL (Mcal)	ME (Mcal)	DE (Mcal)	TDN (kg)	Total Crude Protein (g)	Minerals Ca (g)	P (g)	Vitamins A (1,000 IU)	D (1,000 IU)
Maintenance of Mature Lactating Cows[a]									
400	7.16	12.01	13.80	3.13	318	16	11	30	12
450	7.82	13.12	15.08	3.42	341	18	13	34	14
500	8.46	14.20	16.32	3.70	364	20	14	38	15
550	9.09	15.25	17.53	3.97	386	22	16	42	17
600	9.70	16.28	18.71	4.24	406	24	17	46	18
650	10.30	17.29	19.86	4.51	428	26	19	49	20
700	10.89	18.28	21.00	4.76	449	28	20	53	21
750	11.47	19.25	22.12	5.02	468	30	21	57	23
800	12.03	20.20	23.21	5.26	486	32	23	61	24
Milk Production—Nutrients/kg of Milk of Different Fat Percentages									
(Fat %)									
3.0	0.64	1.07	1.23	0.280	78	2.73	1.68	—	—
3.5	0.69	1.15	1.33	0.301	84	2.97	1.83	—	—
4.0	0.74	1.24	1.42	0.322	90	3.21	1.98	—	—
4.5	0.78	1.32	1.51	0.343	96	3.45	2.13	—	—
5.0	0.83	1.40	1.61	0.364	101	3.69	2.28	—	—
5.5	0.88	1.48	1.70	0.385	107	3.93	2.43	—	—
Live Weight Change During Lactation—Nutrients/kg of Weight Change[c]									
Weight loss	−4.92	−8.25	−9.55	−2.17	−320	—	—	—	—
Weight gain	5.12	8.55	9.96	2.26	320	—	—	—	—

Inorganic nitrogen sources from plants as well as other non-protein nitrogen, such as urea, are completely degraded by microbes in the rumen. Hence, the RDN is broken down by rumen microbes and used for their protein synthesis by the microbes. Later in the digestion process the microbes are themselves digested and the microbial protein becomes available to the animal Nevertheless this microbial synthesis is only optimal when the animal receives sufficient energy supplements. Therefore, if sufficient RDP is not available, the rate of digestion of fibrous as well as concentrate rich diets will be reduced. This leads to a reduction in intake, lower energy supply and reduced milk production (10).

On the other hand, some protein nitrogen can resist microbial breakdown in the rumen and can pass directly to the cows intestine. This feed protein fraction is called by-pass protein which is especially profitable for high-yielding cows. At a low level of productivity a cow can meet her protein requirements entirely from microbial protein and the diet only needs to contain degradable protein (10). This explains why such a cow can be fed with urea or chicken manure instead of high quality protein can meet the protein requirements. It is therefore important to have the optimum balance of UDP and RDP in the diet. Appendix Table 1. shows the required UDP and RDP needed by the lactating cow.

Minerals and Vitamins. Mineral elements that have been shown to be essential for animals and if underfeed will lead to signs of deficiency. Mineral are generally divided into two groups: macrominerals and trace minerals. Macrominerals—those required in greater quantities and present in animal tissue at higher levels—include calcium, phosphorus, sodium, chlorine, potassium, magnesium, and sulfur. The trace minerals, which are required in smaller amounts and are generally present in tissues at lower levels, include cobalt, copper, iodine, iron, manganese, molybdenum, selenium, and zinc. (5) Under practical feeding conditions, it is usually necessary to provide supplemental sources of several of these elements to meet the dietary requirements of dairy cattle. Several other elements including fluorine, chromium, silicon, vanadium, arsenic, nickel, lead, and tin have been shown to be essential for one or more species of animals. Currently, however, these elements are not considered to be of practical importance in the feeding of dairy cattle (5).

Cows need some of these essential mineral elements for use as structural components of body organs and tissues or as components of metalloenzymes and as cofactors in enzyme and hormone systems. Others serve as constituents of body fluids and are involved in the maintenance of osmotic pressure, acid-base balance, membrane permeability, and nerve transmission.

In excessive dietary concentrations, all nutrients, including all essential mineral elements, can have detrimental effects in animals. The National Research Council's *Mineral Tolerance of Domestic Animals (2),* describes signs of toxicosis in animals as a result of excess concentrations of many mineral elements. The tolerance level for a particular element depends on several factors including the animal species, the form of the element, other dietary aspects, and the length of exposure to the element. The maximum tolerable level for a mineral element has been defined as that dietary level that, when fed for a limited period, will not impair animal performance and should not produce unsafe residues in human food derived from the animal. It is important not to exceed safe tolerances for dietary mineral elements in feeds, and it is good nutritional practice to maintain mineral intakes at the required levels, which are generally well below the tolerance levels listed in Appendix Table 2 . The toxicity of several essential mineral elements including fluorine, selenium, molybdenum, and copper can be a problem under some practical feeding situations. Other mineral elements including lead, cadmium, and mercury are also of practical concern because of their potential toxicity (8).

Vitamins are classified as fat soluble or water soluble. The fat-soluble vitamins include vitamins A, D, E, and K; the water-soluble vitamins include the B vitamins and vitamin C. Because vitamins are essential for the optimum performance and health of dairy cattle, the sections that follow present the pertinent scientific literature and major findings for each individual vitamin.

Dairy cattle have a physiological requirement for the fat-soluble vitamins A, D, E, and K. Generally, dairy cattle of all ages require a dietary source of vitamins A and E. Vitamin D must either be synthesized in the skin under the influence of ultraviolet radiation or be included in the diet. Rumen microbes synthesize adequate amounts of vitamin K to meet the needs of most dairy cattle with the exception of young calves.

Under most feeding conditions, there should be few problems with deficiencies of fat-soluble vitamins in dairy cattle. High-quality forages contain large amounts of vitamin A precursors and vitamin E. Vitamin D is found in large quantities in sun-cured forages. In addition, cattle can store adequate reserves of the fatsoluble vitamins to meet their needs for several months (8). Yet, as producers feed more ensiled forages and expose cattle to less sunlight, additional vitamins will probably be needed under many dietary conditions for the optimum health and performance of the high-producing cow. The goal of the producer is to provide intakes of vitamins that are adequate to prevent deficiencies yet that are below the maximum tolerable levels.

Grouping Strategies

There are a variety of ways farmers have grouped cattle to meet the required needs of that group. Each grouping style has showed positive results but the farmer first must formulate a strategy based on the facility and equipment as well as other factors that will allow of the grouping to properly function. Listed below are a few grouping protocols but these groupings can be altered, combined, and manipulated to meet to needs of dairy.

Grouping based on Lactation*.* Nutrient requirements for lactating dairy cows vary with the stage and level of lactation, growth rate and stage of gestation. Grouping cattle based on stage of lactation allows producers the opportunity to feed cows according to their level of production and to manage the amount and quality of feed that the cow is consuming. Figure 3 shows the relationship and lactation curves for milk production, dry matter intake and body weight. Based on these curves, three distinct feeding phases for lactating cows can be defined. Phase 1 is early lactation (0 to 70 days after calving), which includes peak milk production for most animals and increasing dry matter intake. Phase 2 is peak dry matter intake and declining, but high milk production (70 to 140 days after calving).

Phase 3 is mid and late lactation (140 to 305 days or longer with declining milk production after calving (10)

If all cows are fed the same amount of feed, some cows will be overfed, which will increase feed costs. Overfeeding also leads to cows that are too fat, indicating that the feed is not utilized most efficiently. Other cows will be underfed, which will not allow them to optimize their level of production and may also deplete body reserves to the point that it affects reproduction and general health.

Grouping Based on Milk Yield. Organizing the lactating cattle into groups based on the amount of the milk produced and targeting the nutrient requirements has been the most popular way of grouping pens. This allows for the dairymen to challenge his high producing cows, as well as target low producing cows for non wasted nutrients. High milk production is almost always more important for high profitability than is low feed cost. Level of milk production of a cow is determined by 1) the ability of the mammary gland to produce milk, 2) the ability of the cow to provide the mammary gland with nutrients, and 3) the ability of the farmer to manage and care for the cow (7). The way this groping should take place is by targeting the highest average group. The average milk

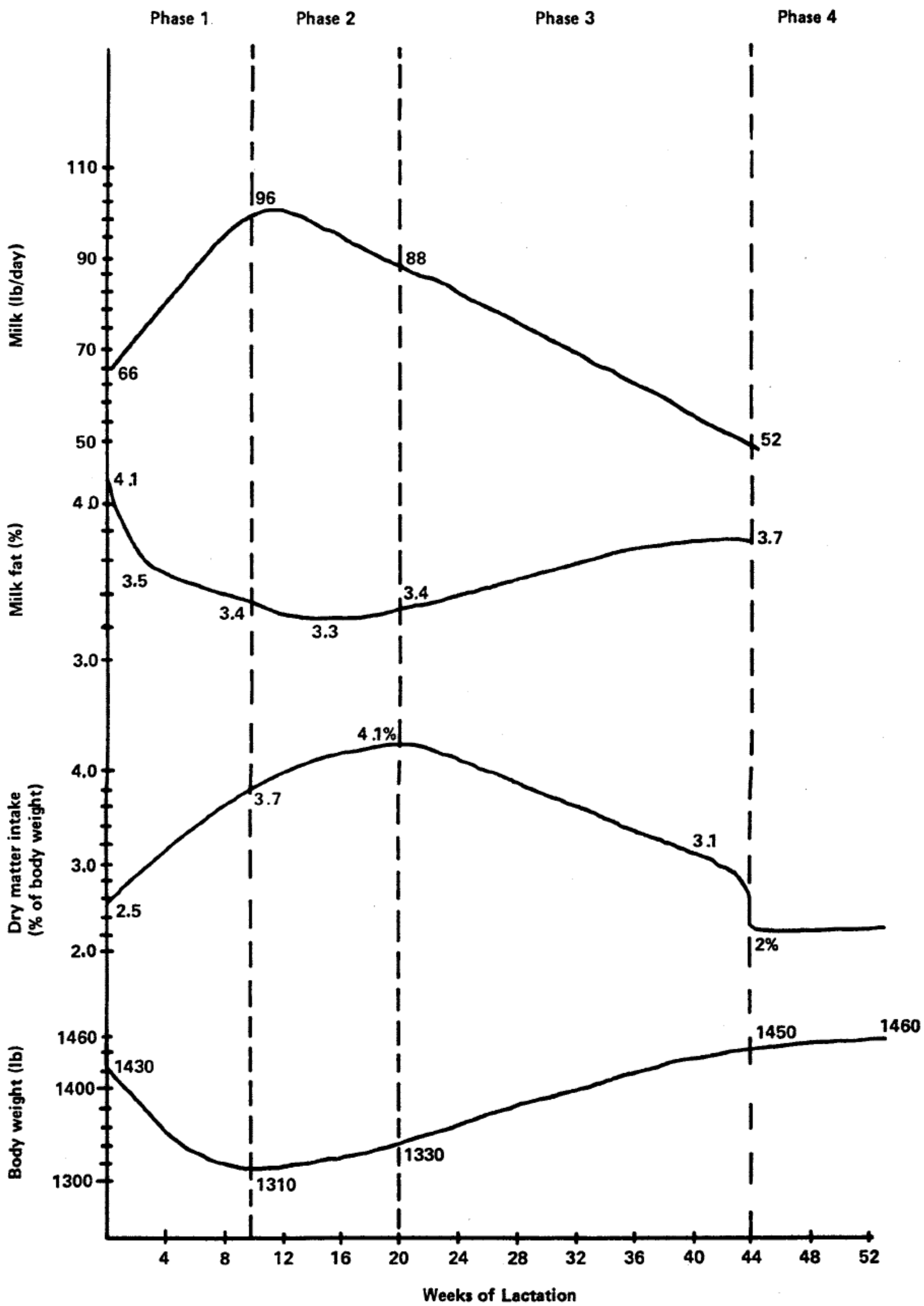

Figure 3. Lactation cycle phases with corresponding changes in milk production, milk fat percentage, dry matter intake and body weight (5).

production for cows on DHI has surpassed 9,000 kg in some states. Individual dairy herds are producing >14,000 kg of milk per year per cow (4). Development of feeding programs for these high producing herds can be a challenge. Herd managers expect and demand nutrition programs that support high milk production while they still control feed cost per unit of milk produced. At the same time, cow health and reproductive performance parameters must be considered in the formulation process. Traditionally, nutrition programming has been based on nutrient requirements derived from research trials.

When feeding groups of cows, nutrients are provided to the average daily production of the group. The average cow in each of three groups is closer in production to her group-mates than the average cow is to the entire herd. However, by feeding the average cow in the group, rations will be inadequate for the higher producing cows in the group. Higher dry matter intake will make up for some of the shortage, but most managers will “lead feed” the group to supply necessary nutrients to the top half of the group. Lead feeding factors have been developed through trial and error and by research using commercial dairy herds. One rule of thumb to lead feeding was to feed the average cow plus one standard deviation of the variation in the group. If the average for a group is 70 pounds/cow-day and the standard deviation in the group is 5 pounds; the herd would be fed for 75 pounds per day (7). This works when production variation is small due to many production groups. When feeding two or three groups, researchers in VPI have developed lead factors as shown in Table 3.

Table 3. Optimum ration lead factors for energy and protein proposed by The Ohio State University and those proposed by McGilliard et al. at V. P. I.

		Lead factors		
Number of Groups	Group #	NE_1%	CP%	VPI %
1 Group		133	126	132
2 Groups	1 Highs	119	113	117
	2 Lows	130	125	123
3 Groups	1 Top	115	111	114
	2 Middle	121	117	110
	3 Lows	129	124	121

Notice two things: 1.) Lead factors are different for protein and energy in the Ohio work, (7) The level of lead feeding over the entire herd can be reduced when feeding more production groups. In a three group dairy, the top string would be fed 115% of the average nutrient requirement based on energy in the Ohio system or 114% of average in the VPI system.

Grouping Based on Reproduction. Often farmers are plagued with the reality of poor reproductive performance in dairy herds. Heat detection generally is the single greatest reason for poor reproductive performance in dairy herds today. But what about those farms that are out three times a day watching for heats? Why is their reproductive program still failing? The answer may lie in nutritional deficiencies or imbalances. Outside of diseases or poor management a close look at a farmer's nutritional program might be the key to better reproductive performance.

The number one nutritional reason for poor reproductive performance is the lack of energy. At the start of lactation, cows are in negative energy balance. This is where they are putting more energy into their milk than they can consume from feed. In order to compensate for this deficiency, cows must rely on their body stores of fat. The more energy you can get into the ration, the sooner they will come out of negative energy balance. Those cows that lose a large amount (over one body condition score) will take longer to have their first estrus and ovulation. This in turn can lead into longer breed back intervals and more days open (1). Data today suggest that energy balance is a key in controlling the development of the eggs (1).

Protein is the next big factor in a cow's diet that needs to be monitored. The lack of crude protein in a ration will cause an increase in non-detectable heats as well as a lower conception rate. But most of the time, a protein deficiency is not the problem with a milking herd. It is overabundance of protein, especially degradable protein which causes most problems. The most visible affect with excess of degradable protein is an increase in number of services per conception and more days open. But the hidden affect is the conversion of excess degradable protein to blood urea nitrogen which as been linked to a major decrease in fertility.

The final area to evaluate is the role and importance of vitamins and minerals. Though these are the cheapest and easiest nutritional elements to control, they often go unchecked. There are two main minerals, four trace minerals, and one main vitamin that affects reproductive performance. Calcium deficiency can cause a whole host of problems such as uterus not returning to normal size after calving. The incidence of dystocia (trouble calving) and prolapsed uterus can increase with the improper amount of calcium. Phosphorus has an adverse affect on fertility and feed intake that may lead to energy deficiencies. As far as the trace minerals are concerned, selenium plays a key role in preventing retained placentas. Lack of selenium also may play a role in early embryonic deaths. Copper also plays a role in early embryonic death as well as reduced estrus activity. Zinc can cause many fetal abnormalities, and finally cobalt plays a role in a delayed onset of puberty. Vitamin A is the most common vitamin deficient in cows. Vitamin A is a key in healthy epithelial tissue that lines the reproductive tract. Without enough vitamin A, these tissues become inflexible and crack. This leads to an increased incidence of infections and abnormalities in the reproductive tract (1).

In conclusion, proper nutritional balance is just one aspect for an optimum reproductive program. To ensure cows are being bred on a timely basis, all aspects of a reproduction management program are important. These aspects include timely heat detection and insemination. At the same time, proper vaccination protocols need to be in place to prevent diseases. Don’t try to target just one area and expect to see an improvement. Only a well-rounded program that includes all of these aspects will truly increase your reproductive program.

Feeding Management and Protocol

As the farmer takes a certain approach to the style of grouping, the most important factor is the ability to manage the procedure to the strategy's full potential. Poor management will cause a greater overall loss. The feed manager must consitely formulate rations that meet the required needs of the specific group.

First the producer must decided on how many groups. A minimum of two and preferably three production groups should be arranged. In small herds, where three or even two groups are not feasible, computerized concentrate feeders (magnet feeders or other feeding device) can theoretically provide a separate feeding group. Some grain feeding in the parlor can, in effect, make grouping possible, but this practice is losing popularity.

Shifting cows is an important management skill. It is important to move cows in groups. Move cows at feeding and active times and regular intervals. One strategy is to increase grain levels three to five lbs. for a week after moving to increase nutrient level (9). It is also important to move cows before peak dry matter intake has occurred for certain grouping protocols. Monthly intervals are frequent enough, preferably using the Dairy Herd Improvement (DHI), or similar test report as reference for shifting. Use judgment, on an individual cow basis, based on your knowledge of time in lactation, physical condition, level of production, pregnancy, temperament, age, etc., before shifting (9).

Formulate the ration is another important management skill. Formulate for each group using the average production, size and fat test for each group. Keep feed in the manger for the cows at all times. This is especially important for the higher-producing groups and where manger space may be inadequate to allow all cows to eat at one time. Reformulate the rations whenever a change in forage quality occurs. Test the forages at least monthly and more frequently if type or quality of silage changes. An accurate measurement in pounds of hay eaten per cow per day is essential for accurate calculation and reformulation of rations. The frequency of feeding is also important. Feeding the groups two or more feedings daily encourage cows to eat more frequently. Once a day may be sufficient for low-producing groups during cool weather. Regardless of frequency of feeding, providing adequate bunk volume for free-choice feeding at all times is very important.

Grouping size must also be taken into factor. The upper limit of group size is dictated practically by parlor size and time spent in the holding pen. Cows should spend no longer than 45 min to 1 h waiting to be milked with 2 or 3 times per day milking. A good generalization for maximum group size in herds with herringbone and parallel parlors is 4.5× the parlor size (9). For example, groups for a double-10 parlor should contain 90 cows or fewer. Realistically, management of feeding and housing facilities will determine how large a group can be within the constraint imposed by parlor size. Limited time in the holding area enhances cow comfort and well-being because it minimizes crowding, time away from feed, water, and resting areas.

Results and Discussion

Grouping cows according to their required dietary needs provides an opportunity to lower feed cost and target the group to meet the required needs with no wasted nutrients. The three group system has been the most successful. Each bite consumed contains the required level of nutrients (energy, protein, minerals and vitamins) needed by the cow in Table 4. (7)

Table 4. Nutrient specifications for three group system (100% dry matter basis) 1300 lb cow. (7)

	Production Level		
	High[2]	**Medium**	**Low**
Milk production (lbs)	Over 75	55-75	Under 55
Dry matter intake/day (lbs)[3]	48	40	34
NE_L Mcal/lb	0.78	0.74	0.70
ADF (% dry matter)	19	20	21
NDF (% dry matter)[4]	25	28	28
Protein (% ration DM)	18	17	15
Calcium (% ration DM)[5]	0.8	0.7	0.5
Phosphorus (% ration DM)[5]	0.5	0.4	0.4

[1] Based on nutrient requirements of dairy cattle of NRC (1989)
[2] Some type of fat source (i.e. sunflower seeds) may be used
[3] Estimated dry matter intake will depend on body size and milk production.
[4] This is only appropriate when not feeding high fiber concentrates, such as corn gluten. If high fiber concentrates are fed, these values should be increased to 35, 38, and 41, respectively.
[5] Increase 30% when fed fat supplements (e.g. sunflower seeds).

There are many advantages to the grouping system The producer has more control over the feeding program. Grouping the cows permits greater flexibility in feeding exact amounts of nutrients to more nearly nourish cows for their particular stage of lactation and level of milk yield. Grain mixtures can be liberally fed to grouped high producers without over-feeding the late-lactation or lower-producing cows, resulting in more efficient use of feeds (Table 4).

There are disadvantage of grouping cows. Grouping cows is not feasible in small herds (less than 50 cows). Grouping protocols takes consistently good management and if poor management exists then a great economical effect will concur. Special equipment is needed for feeding and mixing the proper ration.

Table 5 is a study done where a producer mixed the first lactation heifers with the rest of the herd which shows eating time, meals per day, DMI, lying time, milk production, and fat test being lower compared to when the producer separated the first lactation heifers. (10)

Table 5.Grouping First Lactating Heifers Separate from Older Cows (10).

	Mixed (all animals)	Separate
Eating Time (min/day)	184	205
Meals per day	5.9	6.4
Dry Matter Intake (lb./day)	39.1	44.4
Lying time (min/day)	424	461
Milk Production (lb/day)	40.4	43.9
Milk Fat test (%)	3.92	3.97

CONCLUSION

Organizing cows in groups has been a debate since the evolution of the Total Mixed Ration (TMR). Feed cost is the number one expense for the dairy producer and is a consistent battle to reduce those cost. Grouping cows is beneficial for dairy producers because it helps control feed costs. It promotes feeding valuable nutrients to benefit cows at different stages of lactation and results in optimum efficiency, productivity, and profitability (9). Reviewed research that evaluated optimal group numbers on a dairy farm. Shifting a herd from one to two groups of cows increased FCM production by 1 to 3% (10).

Moving to three groups improved FCM production by up to 2% versus two groups, but shifting to four groups from three only resulted in a 0 to 1% increase in FCM. Overall, marginal return to additional groups declined beyond three. Most researchers have concluded that the milking herd should be divided into three groups with three different diets for optimal efficiency (10). The actual grouping system selected will depend on herd size, facilities available, and other specifics of the farm situation. There are many schemes for deciding which cows to group together.

It appears that feeding in three groups produces higher income over feed costs than feeding two groups and group feeding in two groups results are better than one group feeding (10). A California survey showed feeding three groups reduced nitrogen excretion by 15% over herds feeding a one-group TMR (10).

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APPENDIX

Appendix A. Daily nutrient requirements for lactating cows using absorbable

Live Weight (lb)	Fat (%)	Milk (lb)	Live Weight Change (lb)	Dry Matter Intake (lb)	Energy NELDM (Mcal/lb)	Energy NEL (Mcal)	Energy TDN (lb)	Protein UIP (lb)	Protein DIP (lb)	Minerals Ca (lb)	Minerals P (lb)
Intake at 100% of the Requirement for Maintenance, Lactation, and Weight Gain											
900	4.5	14.0	0.495	20.79	0.64	13.39	13.07	0.98	1.50	0.085	0.056
900	4.5	29.0	0.495	27.42	0.68	18.73	18.20	1.51	2.25	0.137	0.087
900	4.5	43.0	0.495	32.76	0.72	23.71	22.94	1.92	2.95	0.185	0.117
900	4.5	58.0	0.495	37.86	0.77	29.04	28.00	2.29	3.72	0.237	0.149
900	4.5	74.0	0.495	44.54	0.78	34.73	33.45	2.81	4.52	0.292	0.183
900	5.0	14.0	0.495	21.26	0.64	13.70	13.37	1.01	1.54	0.088	0.058
900	5.0	29.0	0.495	28.13	0.69	19.36	18.80	1.55	2.34	0.144	0.092
900	5.0	43.0	0.495	33.70	0.73	24.65	23.84	1.97	3.09	0.195	0.124
900	5.0	58.0	0.495	38.98	0.78	30.31	29.19	2.34	3.90	0.251	0.158
900	5.0	74.0	0.495	46.61	0.78	36.35	35.00	2.94	4.74	0.310	0.194
900	5.5	14.0	0.495	21.73	0.64	14.01	13.66	1.05	1.59	0.092	0.060
900	5.5	29.0	0.495	28.84	0.69	20.00	19.41	1.59	2.43	0.151	0.096
900	5.5	43.0	0.495	34.62	0.74	25.59	24.73	2.01	3.23	0.206	0.130
900	5.5	58.0	0.495	40.49	0.78	31.57	30.41	2.43	4.08	0.265	0.166
900	5.5	74.0	0.495	48.68	0.78	37.96	36.56	3.08	4.97	0.328	0.205
1,100	4.0	18.0	0.605	24.62	0.64	15.86	15.47	1.11	1.86	0.102	0.067
1,100	4.0	36.0	0.605	32.01	0.68	21.87	21.25	1.71	2.70	0.160	0.103
1,100	4.0	55.0	0.605	38.77	0.73	28.21	27.29	2.23	3.60	0.221	0.140
1,100	4.0	73.0	0.605	44.45	0.77	34.22	32.98	2.65	4.46	0.279	0.176
1,100	4.5	91.0	0.605	54.13	0.78	42.22	40.65	3.39	5.58	0.359	0.225
1,100	4.5	18.0	0.605	25.23	0.64	16.25	15.86	1.16	1.91	0.107	0.070
1,100	4.5	36.0	0.605	32.89	0.69	22.65	22.00	1.76	2.81	0.169	0.108
1,100	4.5	55.0	0.605	39.95	0.74	29.41	28.43	2.29	3.77	0.234	0.149
1,100	4.5	73.0	0.605	45.92	0.78	35.81	34.49	2.72	4.69	0.297	0.187
1,100	4.5	91.0	0.605	54.13	0.78	42.22	40.65	3.39	5.58	0.359	0.225
1,100	5.0	18.0	0.605	25.74	0.65	16.65	16.24	1.19	1.97	0.111	0.072
1,100	5.0	36.0	0.605	33.76	0.69	23.44	22.75	1.81	2.92	0.177	0.113
1,100	5.0	55.0	0.605	41.11	0.74	30.61	29.57	2.35	3.95	0.248	0.157
1,100	5.0	73.0	0.605	47.97	0.78	37.41	36.02	2.85	4.92	0.314	0.198
1,100	5.0	91.0	0.605	56.68	0.78	44.20	42.56	3.55	5.86	0.381	0.239
1,300	3.0	23.0	0.715	27.80	0.64	17.91	17.47	1.21	2.16	0.115	0.076
1,300	3.0	47.0	0.715	36.40	0.68	24.87	24.17	1.94	3.13	0.181	0.116
1,300	3.0	70.0	0.715	43.53	0.72	31.55	30.53	2.51	4.07	0.244	0.155
1,300	3.0	93.0	0.715	49.90	0.77	38.22	36.85	3.01	5.02	0.306	0.194
1,300	3.0	117.0	0.715	57.94	0.78	45.19	43.52	3.67	6.00	0.372	0.234
1,300	3.5	23.0	0.715	28.58	0.64	18.41	17.96	1.27	2.23	0.121	0.079
1,300	3.5	47.0	0.715	37.55	0.69	25.90	25.15	2.00	3.27	0.192	0.123
1,300	3.5	70.0	0.715	45.05	0.73	33.08	31.98	2.59	4.29	0.261	0.165
1,300	3.5	93.0	0.715	51.70	0.78	40.25	38.77	3.09	5.32	0.329	0.208
1,300	3.5	117.0	0.715	61.21	0.78	47.74	45.97	3.88	6.36	0.400	0.251
1,300	4.0	23.0	0.715	29.25	0.65	18.91	18.45	1.31	2.30	0.127	0.083
1,300	4.0	47.0	0.715	38.68	0.70	26.92	26.13	2.07	3.42	0.204	0.130
1,300	4.0	70.0	0.715	46.53	0.74	34.60	33.43	2.67	4.52	0.277	0.176
1,300	4.0	93.0	0.715	54.22	0.78	42.28	40.72	3.24	5.61	0.351	0.221
1,300	4.0	117.0	0.715	64.49	0.78	50.29	48.43	4.09	6.72	0.428	0.269
1,500	3.0	26.0	0.825	31.23	0.64	20.12	19.63	1.32	2.48	0.132	0.087
1,500	3.0	52.0	0.825	40.51	0.68	27.66	26.88	2.10	3.53	0.203	0.130
1,500	3.0	78.0	0.825	48.58	0.73	35.21	34.07	2.75	4.60	0.274	0.174
1,500	3.0	104.0	0.825	55.76	0.77	42.76	41.22	3.31	5.67	0.345	0.218
1,500	3.0	130.0	0.825	64.50	0.78	50.30	48.44	4.03	6.73	0.416	0.262
1,500	3.5	26.0	0.825	32.11	0.64	20.69	20.18	1.39	2.56	0.138	0.091
1,500	3.5	52.0	0.825	41.79	0.69	28.80	27.97	2.18	3.69	0.215	0.138
1,500	3.5	78.0	0.825	50.27	0.73	36.91	35.69	2.84	4.84	0.292	0.186
1,500	3.5	104.0	0.825	57.77	0.78	45.02	43.36	3.40	6.01	0.370	0.233
1,500	3.5	130.0	0.825	68.14	0.78	53.14	51.17	4.26	7.13	0.447	0.281
1,500	4.0	26.0	0.825	32.83	0.65	21.25	20.73	1.43	2.64	0.144	0.094

Appendix B. Ration Summary for a average lactating cow

Cow Wt (kg)	Fat (%)	Wt Gain (kg/d)	Lactating Cow Diets: Milk Yield (kg/d)				
400	5.0	0.220	7	13	20	26	33
500	4.5	0.275	8	17	25	33	41
600	4.0	0.330	10	20	30	40	50
700	3.5	0.385	12	24	36	48	60
800	3.5	0.440	13	27	40	53	67

	Lactating Cow Diets (7/8/10/12/13 kg/d)	(13/17/20/24/27 kg/d)	(20/25/30/36/40 kg/d)	(26/33/40/48/53 kg/d)	(33/41/50/60/67 kg/d)	Early Lactation (wks 0–3)	Dry, Pregnant Cows	Calf Milk Replacer	Calf Starter Mix	Growing Heifers and Bulls[a] 3–6 Mos	Growing Heifers and Bulls[a] 6–12 Mos	Growing Heifers and Bulls[a] >12 Mos	Mature Bulls	Maximum Tolerable Levels[b,c]
Energy														
NEL, Mcal/kg	1.42	1.5[illegible]	1.62	1.72	1.72	1.67	1.25	—	—	—	—	—	—	—
NEM, Mcal/kg	—	—	—	—	—	—	—	2.40	1.90	1.70	1.58	1.40	1.15	—
NEG, Mcal/kg	—	—	[illegible]	—	—	—	—	1.55	1.20	1.08	0.98	0.82	—	—
ME, Mcal/kg	2.35	2.53	2.71	2.89	2.89	2.80	2.04	3.78	3.11	2.60	2.47	2.27	2.00	—
DE, Mcal/kg	2.77	2.95	3.13	3.31	3.31	3.22	2.47	4.19	3.53	3.02	2.89	2.69	2.43	—
TDN, % of DM	63	67	71	75	75	73	56	95	80	69	66	61	55	—
Protein equivalent														
Crude protein, %	12	15	16	17	18	19	12	22	18	16	14	12	10	—
UIP, %	4.4	5.2	5.7	5.9	6.2	7.0	—	—	—	8.9	5.4	3.2	—	—
DIP, %	7.8	8.7	9.6	10.3	10.4	9.7	—	—	—	4.5	6.2	7.0	—	—
Fiber content (min.)[d]														
Crude fiber, %	17	17	17	15	15	17	22	—	—	13	15	15	15	—
Acid detergent fiber, %	21	21	21	19	19	21	27	—	—	16	19	19	19	—
Neutral detergent fiber, %	28	28	28	25	25	28	35	—	—	23	25	25	25	—
Ether extract (min.)	3	3	3	3	3	3	3	10	3	3	3	3	3	—
Minerals														
Calcium, %	0.43	0.51	0.58	0.64	0.66	0.77	0.39[e]	0.70	0.60	0.52	0.41	0.29	0.30	2.00
Phosphorus, %	0.28	0.33	0.37	0.41	0.41	0.48	0.24	0.60	0.40	0.31	0.30	0.23	0.19	1.00
Magnesium, %[f]	0.20	0.20	0.20	0.25	0.25	0.25	0.16	0.07	0.10	0.16	0.16	0.16	0.16	0.50
Potassium, %[g]	0.90	0.90	0.90	1.00	1.00	1.00	0.65	0.65	0.65	0.65	0.65	0.65	0.65	3.00
Sodium, %	0.18	0.18	0.18	0.18	0.18	0.18	0.10	0.10	0.10	0.10	0.10	0.10	0.10	—
Chlorine, %	0.25	0.25	0.25	0.25	0.25	0.25	0.20	0.20	0.20	0.20	0.20	0.20	0.20	—
Sulfur, %	0.20	0.20	0.20	0.20	0.20	0.25	0.16	0.29	0.20	0.16	0.16	0.16	0.16	0.40
Iron, ppm	50	50	50	50	50	50	50	100	50	50	50	50	50	1,000
Cobalt, ppm	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	10.00
Copper, ppm[h]	10	10	10	10	10	10	10	10	10	10	10	10	10	100
Manganese, ppm	40	40	40	40	40	40	40	40	40	40	40	40	40	1,000
Zinc, ppm	40	40	40	40	40	40	40	40	40	40	40	40	40	500
Iodine, ppm[i]	0.60	0.60	0.60	0.60	0.60	0.60	0.25	0.25	0.25	0.25	0.25	0.25	0.25	50.00[j]
Selenium, ppm	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	2.00
Vitamins[k]														
A, IU/kg	3,200	3,200	3,200	3,200	3,200	4,000	4,000	3,800	2,200	2,200	2,200	2,200	3,200	66,000
D, IU/kg	1,000	1,000	1,000	1,000	1,000	1,000	1,200	600	300	300	300	300	300	10,000
E, IU/kg	15	15	15	15	15	15	15	40	25	25	25	25	15	2,000

NOTE: The values presented in this table are intended as guidelines for the use of professionals in diet formulation. Because of the many factors affecting such values, they are not intended and should not be used as a legal or regulatory base.

[a]The approximate weight for growing heifers and bulls at 3–6 mos is 150 kg; at 6–12 mos, it is 250 kg; and at more than 12 mos, it is 400 kg. The approximate average daily gain is 700 g/day.

[b]The maximum safe levels for many of the mineral elements are not well defined and may be substantially affected by specific feeding conditions. Additional information is available in *Mineral Tolerance of Domestic Animals* (NRC, 1980).

[c]Vitamin tolerances are discussed in detail in *Vitamin Tolerance of Animals* (NRC, 1987b).

[d]It is recommended that 75 percent of the NDF in lactating cow diets be provided as forage. If this recommendation is not followed, a depression in milk fat may occur.

[e]The value for calcium assumes that the cow is in calcium balance at the beginning of the dry period. If the cow is not in balance, then the dietary calcium requirement should be increased by 25 to 33 percent.

[f]Under conditions conducive to grass tetany (see text), magnesium should be increased to 0.25 or 0.30 percent.

[g]Under conditions of heat stress, potassium should be increased to 1.2 percent (see text).

[h]The cow's copper requirement is influenced by molybdenum and sulfur in the diet (see text).

[i]If the diet contains as much as 25 percent strongly goitrogenic feed on a dry basis, the iodine provided should be increased two times or more.

[j]Although cattle can tolerate this level of iodine, lower levels may be desirable to reduce the iodine content of milk.

[k]The following minimum quantities of B-complex vitamins are suggested per unit of milk replacer: niacin, 2.6 ppm; pantothenic acid, 13 ppm; riboflavin, 6.5 ppm; pyridoxine, 6.5 ppm; folic acid, 0.5 ppm; biotin, 0.1 ppm; vitamin B_{12}, 0.07 ppm; and choline, 0.26 percent. It appears that adequate amounts of these vitamins are furnished when calves have functional rumens (usually at 6 weeks of age) by a combination of rumen synthesis and natural feedstuffs.