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## Introduction

The brood cow is the focal point in an efficient beef herd. Her function is to produce calves that are fed out for slaughter or that become future replacement animals for the herd. The maximum number of healthy, fast-gaining calves comes from well-grown heifers and productive cows. Net returns to the commercial beef herd are largely affected by the reproductive performance and winter feed costs of the herd. A good nutrition program is the cornerstone for optimizing reproductive efficiency and feed costs.

Feed costs can constitute up to 65% of the total cost of producing calves. To make good use of available feedstuffs, the cattle producer must recognize and satisfy the varying nutrient requirements of the beef cow during her annual production cycle (Fig. 1).

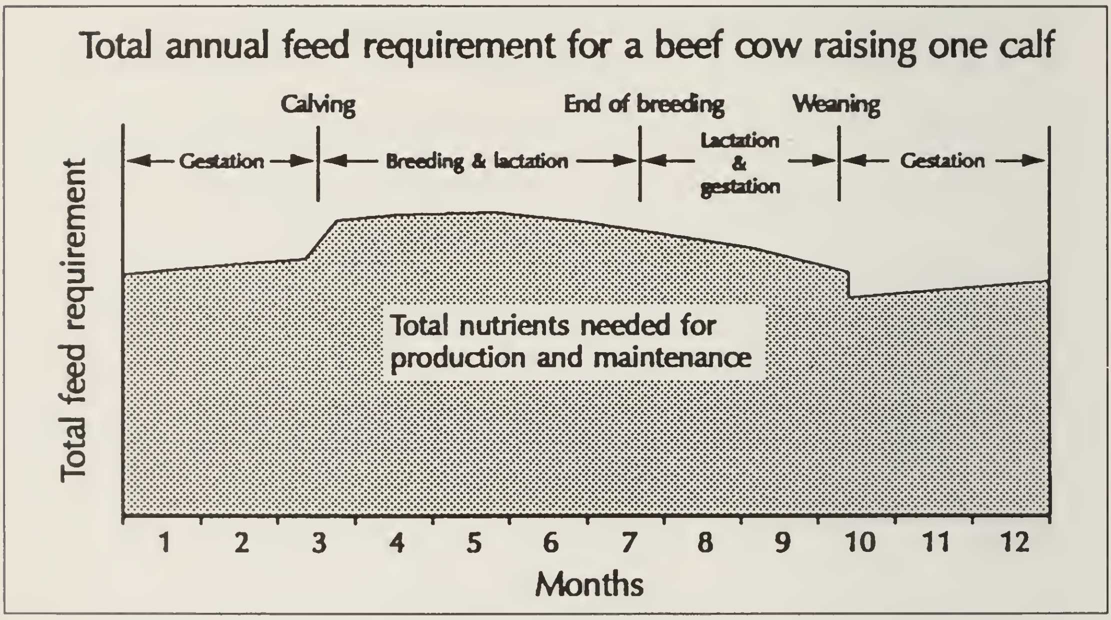


**Fig. 1 Total annual feed requirement for a cow raising one calf every 12 months.**

This publication provides information on feeding and managing cows and heifers to help beef cattle producers make efficient use of available feedstuffs. Although feeding is important, the success of the cattle producer depends upon attention to all aspects of management.

## Nutritional factors influencing lifetime production

The lifetime production of cows greatly influences the financial outcome of a cow–calf operation. Undoubtedly, the most important factor in lifetime productivity is the reproductive performance of the cow. The calf-crop percentage is a good measure of reproductive performance. This percentage is the number of calves weaned, expressed as a percentage of the number of cows and heifers exposed to breeding. A low calf-crop percentage means that the productivity of cows weaning calves must pay not only for the cost of their own maintenance but also for that of maintaining barren cows. This percentage significantly affects the cost of producing weaned calf gain (Table 1). Producers should set a goal of at least 90% for their calf-crop percentage, which is generally considered a sign of good management. Calf-crop percentages greater than 90% require intensive management, are labor intensive, and are generally obtained only in relatively small, purebred herds.

Table 1 Effects of calf-crop percentage on average weight of calf produced per cow and production cost per kilogram of weaned calf gain, assuming a cow maintenance cost of $125/year

| Calf-crop percentages | Weaning weight (kg) 250 | 225 | 205 | 180 | 160 |
|---|---|---|---|---|---|
| | Average weight (kg) of calf produced per cow | | | | |
| 100 | 250 | 225 | 205 | 180 | 160 |
| **90**[a] | **225** | **204** | **184** | **163** | **143** |
| 80 | 200 | 181 | 163 | 145 | 127 |
| 70 | 175 | 159 | 143 | 127 | 111 |
| 60 | 150 | 136 | 123 | 109 | 95 |
| | Production cost (dollars) per kg | | | | |
| 100 | 0.50 | 0.55 | 0.61 | 0.69 | 0.79 |
| **90**[a] | **0.56** | **0.61** | **0.68** | **0.77** | **0.88** |
| 80 | 0.63 | 0.69 | 0.77 | 0.86 | 0.98 |
| 70 | 0.72 | 0.79 | 0.88 | 0.98 | 1.13 |
| 60 | 0.84 | 0.92 | 1.02 | 1.15 | 1.31 |

a Practical optimum in a commercial herd.

As an example of the effect of calf-crop percentage on lifetime productivity, a breeding herd of 100 cows needs about 15–20 replacement heifers each year. If calves weigh an average of 200 kg at weaning, the weight of salable beef calves increases from 8 600 to 14 600 kg as the calf crop increases from 60 to 90%. This increase in salable beef is generally accomplished with only a small increase in cost.

Cows that are difficult to rebreed will likely not be pregnant in subsequent years. Offspring from these cows also are more likely to exhibit reproductive problems. Therefore, cull cows that are not pregnant prior to the winter feeding program because it is generally too costly to feed them. However, if poor nutrition is the cause of poor reproductive performance, then potentially valuable genetic material may be lost from the cow herd through unnecessary culling. For satisfactory reproductive performance cows must receive adequate levels of energy, protein, phosphorus (P), and vitamin A, as well as other nutrients. A deficiency in any one nutrient can lead to reproductive failure. Providing sufficient nutrients to the cow helps to ensure a high calf-crop percentage, but feeding above this level not only adds to feed costs but provides little or no benefit and may even reduce lifetime productivity (Table 2).

Table 2 Influence of level of winter supplementation on weight of weaned calves produced by cows maintained on native tall grass pastures

| | Winter feeding levels | | | | |
|---|---|---|---|---|---|
| Winter feed | Low | Moderate | High | Very high to moderate[a] | Very high |
| Supplemental feed per cow per year (kg) | 24 | 83 | 221 | 675 | 1 600 |
| Cows started on test | 30 | 30 | 30 | 30 | 30 |
| Cows remaining after seven calf crops (% of original) | 83 | 87 | 80 | 40 | 37 |
| Average calf birth weight (kg) | 34 | 35 | 36 | 35 | 34 |
| Total weight of weaned calves (kg) | 31 545 | 36 020 | 33 391 | 16 763 | 15 178 |

[a] Very high for three winters followed by moderate for five winters.

Source: Ludwig, C.; Ewing, S.A.; Pope, L.S.; Stephens, D.F. 1967. The cumulative influence of level of wintering on the lifetime performance of beef females through seven calf crops. Oklahoma State University Misc. Publ. 79:58–66.

*Nutrition and the reproductive cycle*

The early occurrence of estrus after calving is important if cows are to remain in the breeding herd. A cow's normal estrus cycle resumes about 6–10 weeks after calving. Inadequate nutrition during the pre- and post-calving periods delays estrus. With an average gestation of 285 days, a cow has only 80 days to become pregnant if her calving date is not to be delayed the next year. Even under ideal conditions, a cow is likely to have only two opportunities to become pregnant if she is to calve within the yearly cycle. Otherwise, calving will occur later each year, with the likelihood that she will at some time miss a breeding season.

Delays in breeding results in the offspring being smaller at weaning. For every day that breeding is delayed, the subsequent calf costs the producer about 1 kg of salable calf at weaning. If the breeding season continues beyond about 60 days to ensure that all cows are pregnant, calving is subsequently spread over an equally lengthy season. The resulting calves vary considerably in age and size. Because premiums are generally paid for uniform groups of calves, avoid an extended breeding season if all calves are to be weaned at the same time.

Poor nutrition during the last third of gestation has the greatest effect on the time of first estrus. It is difficult to compensate for precalving inadequacies in the early postcalving period, primarily because most nutrients are diverted to milk production rather than to reproduction. Postcalving malnutrition manifests itself in low pregnancy rates among cows bred. If the level of nutrition is too low or cows are in poor body condition, they may not exhibit estrus at all. Therefore, cows should gain weight during the last trimester of pregnancy to compensate for fetal growth. During the breeding season, unless they are already in good body condition, cows should gain slightly (up to 0.5 kg daily). But, weight gain for fat cows during this period actually may reduce conception rate. Specific deficiencies of vitamins A and E, selenium (Se), and P reduce conception rate if left uncorrected.

Cows that have calving difficulty (dystocia) or retained placenta often have a lower conception rate. Incidence of retained placenta is increased by deficiencies of Se and vitamins A and E. By far the most common cause of calving difficulty is the size of calf relative to the size of the cow. This relationship is controlled primarily by breed and individual sires selected. A common belief is that underfeeding the cow prior to calving reduces calf size and calving difficulty. In fact, numerous experiments have shown that overfeeding cows leads to a high incidence of dystocia and that underfeeding cows in the last trimester of pregnancy, although it indeed reduces calf birth weight, has no effect on calving difficulty. Additionally, underfed cows are likely to have weak, unthrifty calves that are susceptible to illness and have a high mortality rate. Poor nutrition affects milk production, which also increases calf mortality and decreases growth rate.

## Nutrient requirements

*Water*

The cow and calf must have an adequate supply of clean, fresh water. A shortage of water limits the amount of feed eaten and milk produced and reduces liveweight gain. Water intake ranges from about 6.5 L for each kilogram of feed dry matter consumed by calves to 3.5 L/kg of feed dry matter consumed by mature cows. Water intake approximately doubles as air temperature increases from 4 to 32°C. In general, water intake in winter is about 25% less than in summer. Milking cows need more water than dry cows.

Use heaters in winter to keep the temperatures of drinking water just above freezing. Cows are capable of eating enough snow to meet their water requirements, however, their success depends upon continuous access to sufficient fresh snow. It is not advisable to alternate between water and snow. Clean the water bowls or tanks regularly in summer because algae can be poisonous.

Cattle can tolerate water that is high in dissolved solids if the salt content of the diet is normal. However, when the level of salts in the water is above about 9000 parts per million (ppm), cattle reduce their water intake and may develop scours, which causes emaciation and weight loss. About 7000 ppm of dissolved mineral salts appears to be a practical maximum level. Calves are more sensitive than mature cattle to high levels of salts in water.

*Energy*

Most of the feed eaten by a cow is used to supply energy for body functions such as maintenance of the body, activity, growth of a fetus, milk production, and weight gain. Weight gain occurs only after other energy needs have been met.

The cow neither digests nor uses all the energy present in feedstuffs (Fig. 2). The greatest amount of feed energy is lost in the feces. Digestible energy (DE) is the energy remaining after energy in the feces is subtracted. DE is not directly measured in routine feed analyses. However, there is a high degree of association between digestibility and the amount of acid detergent fiber (ADF) in a feedstuff. Typically, DE is estimated from the ADF content in a particular feedstuff. Some feed-testing laboratories and older references refer to the amount of TDN (total digestible nutrients) in feeds. TDN and DE are roughly equivalent terms. TDN is expressed as a percentage of the total feed dry matter. DE is expressed as megacalories (Mcal) of energy per kilogram of feed. Estimated DE values are available for many feedstuffs and are used in this publication. Because 1 kg of typical cattle feed contains about 4.4 Mcal gross energy, TDN (%) is equivalent to 100 x DE/4.4 (Mcal/kg).

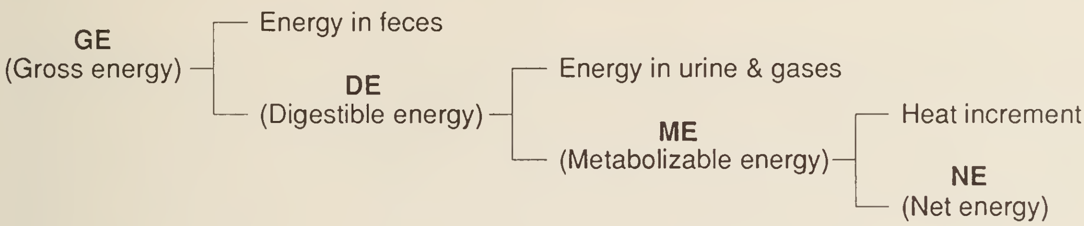


**Fig. 2 How cattle use the gross energy contained in feed.**

Most of the DE consumed by a cow is used to maintain her body; thus the greatest factor affecting this maintenance requirement is her size. The energy required for a cow's maintenance is directly related to her metabolic weight, which is expressed as $W^{0.75}$, where $W$ is the weight of the cow in kilograms. Thus, a cow weighing 600 kg has a metabolic weight of 120 kg, whereas a cow weighing 500 kg has a metabolic weight of 106 kg. Although the 600-kg cow is 20% larger, she requires only 14% more energy for maintenance than the smaller cow.

In Europe, metabolizable energy (ME) is used as a measure of animal requirements and feed quality. However, ME is difficult to measure directly and estimates for the ME content of feeds are usually derived from DE values. Therefore ME is seldom used in North America.

Digestible energy is used by the animal with different efficiencies, depending on whether the energy is used for maintenance or growth. Feeding standards based on the net energy of maintenance ($NE_m$) and gain ($NE_g$) are commonly used in preparing diets for feedlot cattle in North America. As most of the feed energy for beef cows is used to meet requirements for maintenance, using the net energy system offers no real advantage for the cow–calf operation.

Cows on pasture or range need more energy than those fed in pens or barns because of the energy used for grazing. A mature cow weighing 500 kg requires about 0.75 Mcal more DE for each kilometre traveled while grazing. Cows on pastures or ranges where grass is sparse need more energy than cows on heavily grassed fields because they must travel farther to get the same amount of feed.

Climatic conditions such as temperature and wind also influence energy needs. These factors are discussed in the section on "Influences of climate on energy requirements."

### *Proteins*

Proteins are nitrogen-containing compounds essential to life for all animals. Proteins are involved in forming and maintaining muscles, organs, bones, and milk, and in other biochemical activities in the body. Protein requirements of heifers and cows vary with the weight and stage of the production cycle (Appendixes 1 and 2). The need for protein is greatest in young, rapidly growing animals. In adult cattle, the need for protein increases during pregnancy, as the body of the fetus develops, and during lactation, as the calf grows. Cows that produce the most milk need the most protein in their diet. If the growing young animal receives insufficient protein to produce new tissue, its growth rate decreases. Feeding protein above the required amount is not harmful, but overfeeding is costly because protein is an expensive part of the diet.

Neither the amino acid composition nor quality of proteins influences their use by beef cows, because microorganisms in the rumen convert a large proportion of feed protein to microbial proteins that are digested and absorbed by cattle. These microbes also convert nitrogen from nonprotein nitrogenous (NPN) compounds, such as urea, into microbial protein. However, the portion of the total protein that cattle can obtain from NPN sources depends on the composition of the diet. If the diet is low in readily digestible energy, the NPN compounds are not used efficiently because the rumen microbes need the energy to produce protein from these sources. Energy from starch in grains is useful for this purpose. Energy from high-cellulose feeds, such as straws, corn stover, or low-quality hays, is not available rapidly enough to permit efficient conversion of supplemental NPN compounds to microbial protein. An adequate supply of a suitable energy source in the diet helps avoid the possibility of building up a toxic level of ammonia in the rumen when animals are fed NPN compounds.

The special nature of the rumen means that cattle have two protein requirements that must be met. The nonlactating cow fed at maintenance requires 6–7% protein in the diet to meet the needs of her body tissues. However, rumen bacteria require about 9% protein in the diet. If insufficient protein is provided to the rumen bacteria, digestion of the fiber in the rumen declines and potential DE is wasted. To maximize the use of nutrients, feed the greater of the two protein levels.

Take special care when feeding diets with a high urea content. Mix the diet carefully so that the cattle cannot get a large amount of urea at one time. Levels of urea higher than 0.5% of the diet may reduce palatability and intake. Cattle require 2–3 weeks to adapt to diets containing urea, so increase the urea level in the diet slowly over this period. Do not substitute fertilizer-grade urea for feed-grade urea. The size of the fertilizer-grade pellet is larger and is likely to separate from the rest of the feed, creating the potential for animals to get an overdose of urea.

Protein supplements that are inherently resistant to digestion by rumen bacteria, but are still digested by the animal, are referred to as bypass proteins because they bypass rumen fermentation. There is little benefit to feeding bypass proteins to beef cows unless their cost is competitive with alternative protein sources. However, incorporating bypass proteins in the creep feed of young calves and in the diets of rapidly growing crossbred yearling cattle generally improves growth rates of these animals.

### *Minerals*

Mineral elements of concern in feeding cattle are classified into major and trace minerals. The major minerals are calcium (Ca), phosphorus (P), sodium (Na), potassium (K), chlorine (Cl), magnesium (Mg), and sulfur (S). They are required in greater quantities than the trace minerals (Appendixes 1, 2, and 3). The trace minerals are cobalt (Co), iodine (I), copper (Cu), manganese (Mn), zinc (Zn), molybdenum (Mo), iron (Fe), and selenium (Se).

Cattle are poor judges at regulating their mineral intake to satisfy their needs. Therefore, it is best to mix minerals directly with the feed. In this way, the intake of the minerals can be controlled to prevent over- or under-consumption. If mixing them with feed is not possible, minerals may be fed free-choice in a mineral feeder. Commercial mineral mixes are generally designed to be consumed at a specific daily rate. Monitor the quantity of free-choice mineral mix that the cows consume over a few weeks because daily intakes by individual cows can fluctuate by severalfold. A safety margin is usually incorporated into the formulation of mineral mixes to ensure that the needs of all cows are met. However, if mineral intake is inadequate, individual cows may suffer symptoms of deficiency. Excess mineral intake results in a significant unnecessary cost, and occasionally, in toxicity from one or more of the trace minerals. The level of salt in the mineral mix can be adjusted to alter mineral intake.

*Major minerals* Both Ca and P are essential for normal growth, especially for bones. A lack of either mineral can result in poor bone growth, fragile bones, and reproductive problems. The ratio of Ca to P in the diet is also critical for the best use of these minerals. Ratios of Ca to P of between 1:1 and 4:1 are satisfactory, with ratios as high as 7:1 being acceptable for dry pregnant cows, as long as the requirement for P is met. However, for young growing animals and lactating cows, the maximum Ca to P ratio should not exceed 2:1. To increase Ca in the diet use legumes as pasture, hay, or silage. Because the P content of the forages decreases as the plants mature, P may be deficient in diets composed mainly of forages. The possibility of a P deficiency increases when cattle are grazed for long periods on mature forage in late summer or fall.

When legume hays or silages form the main portion of the diet, feed a mineral supplement containing 1 part Ca to 1 part P. Although this addition may result in a relatively high Ca to P ratio, supplemental sources of P alone are not only generally much more expensive than those containing both minerals but also often are not consumed. Feed a mixture containing 2 parts Ca to 1 part P with other types of diets. Mix these supplements in the diet at adequate levels or feed them free-choice, mixed in equal parts with cobalt-iodized salt. The salt helps to increase the intake of the other minerals.

High-concentrate diets usually contain adequate levels of P but require Ca supplementation. Mature forages, straws, and corn silage are low in Ca.

Adding 2% vegetable oil to the salt–mineral mix reduces crusting. The mix must be protected from the weather. Minerals commonly used to supply supplementary Ca and P in cattle diets are commercial supplements manufactured from bonemeal (29% Ca, 14% P), rock phosphate (30% Ca, 18% P), dicalcium phosphate (20% Ca, 20% P), and limestone (40% Ca, 0% P).

Salt provides cattle with Na and Cl, but they seldom consume enough to meet their needs if it is supplied only in blocks. Intake of loose salt is usually higher than from blocks. Salt and mineral intakes are low when the mineral content of the drinking water is high. A consumption level equivalent to 0.25% of the feed dry matter intake is usually adequate. However, depending on the minerals in the water, it may be necessary to induce consumption of minerals by mixing palatable feeds to ensure adequate intake of other required minerals. Cattle consume more salt when they are either on young rather than mature grass, or on silage rather than hay.

Most diets consumed by beef cattle contain enough Mg to meet the 12–30 mg/kg of body weight required per day. However, some lush pastures in early spring and summer do not contain enough Mg, or it may be unavailable because of high K levels, which results in grass tetany. Lactating cows are most susceptible to grass tetany. In problem areas, a daily supplement of 50–60 g of magnesium oxide prevents this condition.

Most diets normally contain at least 0.6% K, which meets the needs of beef cows and heifers. Some S is necessary for the normal synthesis of proteins by rumen microorganisms. When all-natural proteins are fed, S intake is usually adequate to meet the animal's needs. However, forages from some areas may be deficient in sulfur. If a NPN source such as urea is the major source of protein, supplemental S will be needed. The ratio of N to S in the total diet should be about 9:1. Add S to diets high in corn silage. Many of the other minerals are incorporated into mineral mixes in the sulfate form. If additional S is still required, then use either sodium sulfate or flowers of sulfur as a supplement.

*Trace minerals* Most cattle need supplemental Co and I. Some Co is necessary for the synthesis of vitamin $B_{12}$ by rumen bacteria, and I is needed for production of thyroxine by the thyroid gland. A deficiency of I often results in reproductive problems in cows, which may give birth to calves with enlarged thyroid glands. Use of cobalt-iodized salt will ensure that these two minerals are supplied adequately.

The need for other trace mineral supplements varies from region to region. The minerals most commonly found to be deficient in unsupplemented feedstuffs are Cu, Mn, Zn, and Se.

Feeds deficient in Cu are common. A high Mo content in forages grown in some areas may increase the possibility of Cu deficiency. Deficiency of Cu causes diahrrea, anemia, and loss of pigmentation in skin and hair. Deficiency of Mn results in impaired reproductive function through altered estrus cycles, sperm defects, and characteristic skeletal abnormalities in newborn calves. Deficiency of Zn results in dermatitis, reproductive failure, and general ill thrift.

Cattle need Se in tiny amounts relative to other trace minerals. The requirement is about 0.2 ppm in the feed. Unlike other trace minerals, the range between deficiency and toxicity is very narrow. Regular supplementation at levels 10 times the requirement may result in symptoms of chronic toxicity. This narrow range contrasts with other trace minerals where toxicities are not observed until the minerals are fed at 20–40 times the requirement. Too much Se produces a condition known as alkali disease, which can occur when cattle eat plants that accumulate high levels of Se. The cattle become lame, develop a roach back, lose weight rapidly, and are unable to move about freely to graze. Hoof deformities may develop as a result of prolonged intake of a moderately high level of Se. Cattle are more susceptible to Se toxicity when it occurs naturally in feeds than when it is supplemented as sodium selenite. The threshold toxic level seems to be lowered by deficiencies of P, vitamin A, and protein.

A deficiency of Se occurs most often when cattle graze vegetation from acidic, wet soils but may occur in other areas also. Calves deficient in Se grow slowly and may develop a condition known as white muscle disease. Cows may have lower fertility and increased incidence of retained placentas. Vitamin E can help to alleviate some of the Se requirement and adequate Se can compensate for insufficient vitamin E. Supplemental Se can be provided by intramuscular injection.

If problems with any minerals are suspected, send samples of feedstuffs to a laboratory for analysis. Provincial extension specialists can provide information on the locations of laboratories.

*Vitamins*

Vitamin A is the vitamin most likely to be deficient in beef cattle diets under most feeding programs. The requirements of cows and heifers for vitamin A (see Appendix 4) can be met by carotene if their diets contain high-quality forages. Cattle can convert the beta-carotene to vitamin A. Cattle grazing green grass can store sufficient vitamin A in their livers for about 3 months. Provide supplementary vitamin A to animals grazing on mature grasses or feeding on low-quality stored forages.

All forages lose carotene when stored and the rate of loss increases as temperature and exposure to air and sunlight increase. Some losses of carotene and vitamin A also occur when diets are processed with steam or pressure, or when they contain oxidizing materials, such as certain minerals or organic acids. Ensiling forages reduces the carotene content, particularly if the forage is wilted first or contains high levels of nitrates. It is important, therefore, to supply a vitamin A supplement when diets contain a high proportion of silage.

A cow deficient in vitamin A during late pregnancy may give birth to a weak calf that is susceptible to pneumonia and scours. Vitamin A deficiency in cows also can increase the incidence of retained placenta. Adequate vitamin A after calving meets the needs of the cow for early rebreeding and for producing milk with adequate vitamin A content for the calf. Calves with low vitamin A intake are susceptible to scours, and very deficient calves may be night-blind or totally blind.

Because cattle can store vitamin A in the liver, this vitamin can be fed at weekly or monthly intervals. Add it directly to the diet prior to feeding, incorporate it into a mineral mix, or administer it by intramuscular injection. Vitamin A is relatively inexpensive so supplementation above requirements is often done to ensure that subclinical deficiencies do not occur.

When a vitamin A deficiency occurs, feed intake is erratic; cows lose weight and develop other symptoms, such as dermatitis, watery eyes, night blindness, or total blindness. They also are susceptible to general unthriftiness and infectious diseases, especially those of the respiratory system.

Vitamin D, which is important in the intestinal absorption of Ca, is normally supplied by sunlight or sun-cured roughages. Animals confined under a roof for long periods and eating diets high in grain or silage may need additional vitamin D. Supplemental vitamin D can be stored by the liver and is commonly added to commercial supplements along with vitamin A. Vitamin E is an essential vitamin but the level required and its role in the body are unclear. Vitamin E can work synergistically with Se, to prevent white muscle disease and retained placenta. About 400 IU per day should be sufficient for cows. Additional vitamin E can be provided if deficiency-associated problems are common within the herd. Vitamin E is usually provided along with vitamin A in commercial supplements. Unlike vitamin A, vitamin E is expensive and extra supplementation may be an uneconomical luxury unless deficiency symptoms are a potential problem.

## Influences of climate on energy requirements

Full protection against the weather is neither practical nor economical for most beef cattle operations, especially in western Canada. Beef cattle in Canada will be exposed to both cold and heat stress at different times throughout the year. Because winter feed costs are the largest costs incurred by beef producers, cold stress has a greater effect on cow nutrition than heat stress. However, heat stress does affect overall animal performance.

Although the ways in which cattle respond to the weather cannot be measured precisely, they must be understood to determine what level of shelter and protection to provide.

*Heat loss*

The rate of heat loss from an animal depends on environmental conditions, as well as the ability of the animal to prevent heat flow from its body. Temperature alone is not always sufficient to describe the effective coldness of an environment. Wind, moisture (rain or humidity), snow, and radiation also determine the level of cold stress. Wind chills express the combined effects of wind and temperature in terms of equivalent calm-air temperatures (Table 3). Wind protection helps to reduce heat loss.

In cold weather, rain or snow evaporating from an animal's coat can cause a serious heat drain and cold stress. Wind increases the rate at which moisture evaporates and also reduces the insulation of the hair coat.

During the cloudless winter nights that are common in most of western Canada, radiant heat loss from the animal's body can be substantial. This heat loss can be reduced by providing shelter, such as a shed, or by natural tree cover.

Table 3 Wind chill expressed as the equivalent calm-air temperature in dry conditions

| Wind (km/h) | Temperature (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| Calm | 0 | – 5 | –10 | –15 | –20 | –25 | –30 |
| 10 | –4 | –9 | –13 | –19 | –25 | –29 | –35 |
| 20 | –10 | –16 | –22 | –26 | –32 | –36 | –42 |
| 30 | –13 | –21 | –28 | –35 | –43 | –50 | –57 |
| 40 | –15 | –24 | –31 | –38 | –49 | –53 | –62 |
| 50 | –18 | –27 | –33 | –41 | –51 | –58 | –66 |

Adapted from National Oceanic and Atmospheric Administration. 1980. *Heed the wind chill factor.* NOAA News 5:4.

*Heat gain*

Unless artificial sources of heat are provided, heat gained by an animal arises from body metabolism and from radiant energy absorbed from the sun. Heat from the sun in cold environments is usually not significant. Thus metabolic heat must be relied upon as the major source of heat gain by beef cattle during the winter.

The animal's body is continually producing heat by burning food and using it for normal body functions. If this heat production is not sufficient to keep up with the rate of heat loss during cold weather and if the rate of heat loss cannot be reduced, then the animal must increase its rate of heat production. Shivering, increased muscular tone, and metabolic acclimatization are used to increase heat processes in the animal; these develop after exposure to cold for an extended time. Heat produced by shivering and other means is necessary for an animal to maintain its body temperature. However, the energy used for these processes is drawn from additional food supplies or from body energy stores, which leaves less energy for other functions, such as growth of a fetus, milk production, growth, or fattening. Under extreme or extended periods of cold stress, large amounts of energy are diverted to maintain body temperature. Productivity and body energy reserves are depleted unless food intake is increased.

*Animal adjustments*

Normally, an animal attempts to avoid unfavorable weather by seeking shelter. Provide natural or artificial windbreaks or simple shed structures to help cattle reduce heat loss during inclement weather.

Thermal insulation is provided by the hair coat and the air that it traps, the skin, and the subcutaneous tissues. The thicker and deeper the hair coat, the greater is the thermal insulation. However, the insulation value of the hair coat is largely destroyed by wind, moisture, snow, or mud. The skin and underlying tissues, particularly the subcutaneous fat layer, provide good insulation against heat loss. Animals in poor condition have little or no subcutaneous fat and therefore lose more heat when exposed to cold. (Refer to the section on "Body condition and nutrient requirements" for further information.)

If cold stress persists, adaptive morphological and physiological changes (acclimatization) occur so that cattle can better withstand persistent cold or acute cold stress. Appetite increases in the cold but extra feed is not always available. Also, the ability of cattle to digest feed is somewhat reduced. Thus, during cold stress when demands for feed energy are increased, the availability of digestible energy is often reduced. If sufficient energy cannot be obtained from food sources, then body stores (fat deposits) are drawn upon and the animal loses weight. The metabolic changes caused by prolonged exposure to cold increase an animal's capacity to produce heat rapidly during sudden severe cold stress, whereas an unacclimatized animal may not be able to produce sufficient heat to maintain its body temperature.

*Practical application*

Two effects are important when considering the influence of winter conditions on cows and heifers:

- the acute effect of a sudden change in the weather, such as a cold snap, storm, or blizzard
- the more general, long-term effect of winter and the changes that occur as cattle acclimatize.

In coping with acute cold, producers try to minimize stress and prevent frostbite and animal loss. The lower critical temperature is the temperature below which body heat production must be increased to maintain body temperature. Critical temperatures of cattle are not constant and are affected by breed, age, body condition, previous exposure to cold, and windspeed. If the critical temperature for the animal is less than the adjusted temperature of the environment (Table 3), after the effects of moisture and radiation have been allowed for, there is no direct cold stress on the animal. However, when the adjusted temperature is lower than the animal's critical temperature, the animal suffers cold stress. The amount of the stress is proportional to the difference in temperatures. Ensuring good body condition and providing wind shelter result in reduced feed requirements.

Healthy cows and heifers in reasonable body condition are usually subject to subcritical temperatures for only 20–50 days each winter in western Canada, and this exposure increases the average daily winter feed requirements by less than 0.5 Mcal DE. Subcritical temperatures, therefore, require an increase in nutrient intake for short periods to prevent suffering and loss of animals that do not have enough body reserves or stamina to resist acute cold stress.

Table 4 Effect of acclimatization to cold on the maintenance energy requirements of beef cows and heifers

| Average effective temperature (°C) | Resistance to cold stress: Low | Average | High |
|---|---|---|---|
| | % increase in feed requirement | | |
| 10 | 10 | 5 | 0 |
| 0 | 20 | 12 | 5 |
| –10 | 35 | 25 | 15 |
| –20 | 50 | 35 | 25 |
| –30 | 65 | 50 | 40 |

Acclimatization, although important for the survival of animals during acute stress, affects animals during the entire winter period even when conditions are mild. It takes time for the animal to develop and lose winter acclimatization. The overall effect of acclimatization on digestive function and metabolism increases the winter maintenance requirements of cattle by about 10% for each 10°C lowering of average effective temperature. The effect on animals with low resistance to body cooling (low thermal insulation) is greater than on those with high resistance (Table 4).

Acclimatization to cold also lowers the upper critical temperature for an animal. Thus, when the effective temperature rises suddenly, as occurs during "chinooks" in southern Alberta, cattle can suffer heat stress in the middle of winter. Heat stress does not have a significant effect on feed requirements. However, try to reduce other stresses and to avoid unnecessary activity that may add to the animal's heat production.

## Feedstuffs

Feedstuffs supply variable amounts of energy, protein, minerals, and vitamins (Appendix 5). For example, grains are good sources of DE and are often referred to as high-energy feeds. Feedstuffs rich in protein are known as protein supplements. Except for mineral supplements, most feedstuffs supply some energy and protein as well as minerals and vitamins. In formulating diets, consider DE requirements first and protein second. After the requirements for DE are met, the diet is balanced to meet the requirements for protein, minerals, and vitamins (Appendix 6). Also, feed composition is expressed as a percentage of the total feed, whereas the animals' requirements are for actual megacalories of DE, grams of protein, and milligrams of minerals. If cows are fed a high-energy diet at a maintenance level (reduced total dry matter intake), the percentage of protein, minerals, and vitamins in the diet will have to be increased so that the correct amount of each nutrient will be provided.

During the grazing period, when energy consumption may exceed requirements, cows convert the extra energy into body fat. Continuous feeding of excess energy reduces the productive life of the cow and is wasteful. Protein, minerals, and vitamins may be provided above the requirement levels generally without harmful effects. In fact, it may be profitable to feed these nutrients above the requirement levels to take advantage of a feed that provides energy at a relatively low cost. For example, alfalfa hay, beet tops, and pea vines all provide more protein than is required by mature cows when fed at a level to meet their energy requirements.

*Grains and oilseed meals* When these feeds make up a large portion of the diet, limit the amount fed so that DE intake is not excessive.

Grains normally contain enough protein to meet the cow's needs and may even be used to supplement low-protein feeds such as straw. Although grains are often looked upon as fattening feeds, they may be fed as the primary ingredient of a maintenance diet if restricted in amount and supplemented with Ca and vitamin A. Ensure that enough protein is consumed when the grains are fed at a restricted level. Grains should not make up more than 70% of the dry matter fed to pregnant beef cows. Otherwise, metabolic and reproductive disorders such as birth of weak and immature calves and retained placenta may occur. Grains infested with smut or rust have slightly lower nutritional value than normal grains but are safe to feed. Frozen grains can be fed to cattle, except frozen flax, which may be toxic. Do not allow pregnant cattle to feed on grains that contain ergot or to graze ergot-infested forage because these feeds cause abortion.

Oilseed meals are generally used as protein supplements even though their DE content is similar to grains. They are commonly used to supply the protein required to balance low-protein roughages such as straw or native range. Cattle that graze dried mature grasses generally require supplemental protein to use this forage efficiently. This supplement can be fed twice a week rather than daily.

*Protein supplement* Choose the supplement on the basis of convenience and the price per unit of nitrogen (protein equivalent) that it contains. Urea may safely form up to 6% of a commercial protein supplement, but high levels are toxic. Therefore, urea-containing supplements must be mixed with other feeds so that total urea intake is below 1% of the diet. Grain supplies DE in addition to protein and is especially useful when the supply of forage is limited. One kilogram of grain may replace about 1.5 kg of hay as an energy source.

*Legume hays* Hays such as alfalfa, clover, and sainfoin are good sources of DE, protein, and minerals. Because the leaves are the most nutritious part of the plant, take special care when harvesting and handling them to conserve as many leaves as possible. Alfalfa has a high level of Ca and therefore complements grains and straw well because these feeds are deficient in Ca. Cows allowed free access to legume hays or legume–grass mixtures generally consume more than they require for maintenance.

*Grass hays* Grass hays are generally lower in protein and mineral content than legume hays but only slightly lower in DE content if harvested at or prior to the plant heading out. About 8 kg/day of a grass or grass–legume hay supplies the energy and protein required by a 500-kg cow for maintenance.

*Cereal hays* Cereal hays cut in the soft to mid-dough stage have slightly higher DE contents than alfalfa or grass hays but less protein. About 7 kg/day can be fed to a mature 500-kg cow to meet its requirements for DE and protein. Provide a mineral supplement containing about 30% Ca and 10% P with cereal hays to balance the Ca–P intake.

*Silages* Ensiled corn, cereals, alfalfa, clovers, beet tops, and pea vines make valuable feeds. Because silages vary widely in moisture content, their composition and feeding recommendations should be expressed on a dry matter or air-dry (90% dry matter) basis. Silages generally contain a higher DE content (dry matter basis) than hay and at least sufficient protein to meet the requirements of a cow allowed free access to the feed. The protein content of corn silage may be increased by adding urea or ammonia when ensiling; this enrichment would be unnecessary for feeding mature cows but is desirable for feeding young heifers. Make available some dry grass hay to cows consuming cereal or corn silage because cows may become too fat during the winter.

*Beet tops* Beet tops are moderately rich in DE and protein. Although they have moderately high levels of Ca, they also contain oxalic acid, which combines with some of the Ca and makes it unavailable to the cow. To avoid a Ca deficiency, add 1% limestone to wet beet tops when ensiling or at feeding.

*Potatoes* Potatoes contain about 22% dry matter. They are highly digestible, contain sufficient protein, and may form a large part of the diet. Because potatoes are low in Ca and P, these minerals must be supplemented to meet the cow's requirements. Potatoes should be chopped into small enough pieces to avoid choking, which can occur if they become lodged in a cow's throat. Potato wastes are similar to potatoes in nutrient content and also require mineral and vitamin supplementation. For information on feeding potatoes and potato wastes, refer to Agric. Can. Publ. 1527, *Guidelines for feeding potato processing wastes and culls to cattle*. Potatoes that have turned green because of exposure to sunlight may contain solanin, a toxic compound, and therefore should not be fed to animals.

*Liquid protein supplements* Supplements containing molasses, phosphorus, and urea may be self-fed using a lick-wheel mechanism to limit intake. A mineral mixture and vitamins must be supplied to meet the requirement for these nutrients if they are not included in the liquid supplement. Although expensive, liquid supplements are an effective, convenient way to supplement low-quality forage.

*Low-quality roughages* Use these roughages, such as cereal straws, corn stover, and low-quality hays, whenever they are available; their costs are generally low. Although they may be used to some extent in the diets of most beef cattle, they are best used for maintaining mature pregnant cows. These feedstuffs are comparatively low in digestible energy, digestible protein, minerals, and vitamins. They are used primarily as a source of DE and require supplementation with protein, minerals, and vitamins. Inadequate protein intake reduces intake of roughages, which causes loss of weight and possible abomasal impaction.

*Low-quality hays* Hays either cut when they are mature or allowed to weather in the field after cutting lose quality. The protein content is often adequate for mature cattle but not for the young. If there is doubt about the protein content, have a sample analyzed by a feed-testing laboratory. The P and vitamin A content of these hays is low.

*Sedge meadow hays* These hays usually contain adequate protein for mature cows but are deficient in P and vitamin A.

*Cereal straws* Straws may provide a major portion of the winter maintenance diets for mature cows. They must be supplemented with protein, Ca, P, and vitamin A. The voluntary intake of straw is low, the maximum intake being only 4–5 kg/day. Abomasal impaction is often a problem with high intake of straw and low intake of protein, especially when cows are thin and the weather is cold. Increase straw intake by providing extra protein and energy in the form of good-quality hay or grain. Diets containing about 50% straw in a hay–straw diet or 80% straw in a concentrate–straw diet with a minimum of 9–10% protein prevent impaction.

*Corn stover* This feed is normally grazed in the field, although it can be ensiled if moisture is added. Pregnant mature cows may be able to maintain weight for short periods on corn stover if they have access to a high-P mineral supplement containing trace minerals and vitamin A. Cows on corn stover should receive about 0.2 kg of crude protein equivalent per day if they are to gain weight. Supplements containing mainly natural protein sources, such as soybean meal or canola meal, usually give better results with stover diets than supplements with NPN sources, such as urea.

## Processing feeds

Process concentrate feeds to maintain a coarse particle size. Cattle often refuse dusty or fine-particle feeds, which, if consumed, may lead to digestive disorders such as bloat. Pelleting reduces dust and prevents separation of ingredients, but pelleted feeds are generally more costly and composed of fine-particle material, which may cause bloat if fed in large quantities. When concentrate feeds form a substantial portion of the diets, temper the grain by adding water before rolling to maintain coarse-particle size (for further information, refer to Agric. Can. Publ. 1591, *Feedlot finishing of cattle*).

Usually, it is too expensive to cut or grind and pellet roughages for cows. Although cutting low-quality roughage reduces wastage and increases its intake, cows generally consume enough for their needs in long form.

## Feeding heifers and cows

### *Developing heifers to first breeding*

Heifers must reach puberty and be bred by 14–15 months of age if they are to calve for the first time by 2 years of age. Sexual maturity depends on both body size and age. Therefore, heifers must be fed properly if they are to reach the body weight at which they become sexually mature. The desired weight at first breeding varies with the breed. For instance, the larger breeds, such as Charolais, should weigh 325–350 kg at first breeding, whereas 280–310 kg is adequate for medium-sized breeds such as Hereford and Angus.

Because first-calf heifers are subject to more difficult labor than mature animals, some producers believe that heifers should calve for the first time as 3-year olds. This timing can be recommended only for extensive, low-input management systems. Lifetime production of weaned calves is similar for cows from their 3rd year onward regardless of age at first calving. Thus the cost of raising replacement heifers can be amortized over one extra calf in the 2-year-old system. Additionally, the 3-year-old system generally has higher costs for raising the replacement heifers.

A growth rate of 0.5–0.7 kg/day, from weaning to breeding, produces heifers with good skeletal size and adequate fleshing but without excessive fat. Excessively fat heifers have more difficulty calving, produce less milk, and have a lower lifetime production of calves than heifers with moderate to good flesh cover.

Energy and protein requirements of heifers can be met by various feedstuffs or combinations thereof. Compared with more mature animals, young growing heifers have limited rumen capacities and must consume feeds that are more concentrated sources of energy and protein to grow at a proper rate. From weaning to about 15 months of age, feed heifers some concentrate along with good-quality roughage, either as hay or silage, to meet their energy and protein needs for growth. After 15 months of age, most heifers can grow adequately on an all-forage diet as long as the quality of the forage is sufficiently high. The protein requirement for growing heifers is greater than that for mature cows. As the digestible energy density of the diet increases, less total feed is required, but a higher protein content is required in the diet.

Provide heifers with trace-mineralized salt and Ca–P supplements at all times. For further information on mineral and vitamin requirements of heifers, see the section entitled "Nutrient requirements."

*Pregnant heifers*

Heifers must continue to develop during pregnancy to ensure that they calve without difficulty, produce adequate levels of milk, and return to estrus quickly after calving. For easy calving and a thrifty calf, the properly fed heifer, of normal size at weaning (about 7 months of age), should double her body weight by first calving. If the pasture is of excellent quality, heifers may reach this required weight by the time they are removed from fall pasture as yearlings. In this situation, the winter feeding level needs only to maintain this weight until calving. If this weight has not been reached, the feeding level must be increased to attain the required weight gain. It is important to provide enough feed without getting the heifers too fat at calving time.

*Lactating heifers*

Producing milk is by far the most demanding of biological processes for animals. Within the animal's body, the nutrient demands for milk synthesis takes precedence over other metabolic processes. Therefore, nutrient deficiencies during lactation generally have adverse effects on reproduction and growth.

After calving, heifers need more energy and protein than mature cows (Appendix 2) to meet their needs for both milk production and body growth. If good-quality pasture or range is not available at calving time, then provide supplementary feed until sufficient grass is available. A heifer's needs for energy and protein nearly double following calving, to meet the additional demands of milk production. Failure to supply sufficient energy after calving results in a loss of body condition, delayed return to estrus, and failure to rebreed in the normal breeding season. Young cows should gain weight after weaning their first calf and weigh 50–60 kg more at second calving than they did at first calving. Insufficient protein intake decreases milk yield, reduces calf weaning weight, and delays growth of the lactating heifer.

*Wintering mature cows*

The nutrient requirements of beef cattle are lowest for mature cows in mid gestation. Therefore producers can reduce winter feed costs by wintering cows on rangeland or grain stubble and providing supplemental feed as necessary. The amount of supplemental feed depends on cow condition, length of feeding period, and environmental conditions.

Divide the cow herd into at least two groups during the winter feeding period. Keep bred yearling heifers and 2-year-old cows that have weaned their first calf in the first group. If only two groups can be accommodated, include older cows, which may be unable to compete with other cows, with the first group. If possible, feed these older cows and other cows in poor condition separately so that they can be offered additional feed to improve their body condition. The remainder of the mature cows can be grouped together. If there are sufficient numbers of fat cows, feed them separately. Restrict their energy intake to reduce their body condition to a healthier state. However, remember that their requirement for protein, minerals, and other nutrients does not change. Therefore, increase the *concentration* of these nutrients in the total diet.

Cows should enter the winter feeding period in good condition (see "Body condition and nutrient requirements"). After second calving, cows in good to excellent condition may lose up to 10% of their fall weight during the following winter. This loss allows for the level of feeding to be reduced during mid pregnancy. This restriction does not adversely affect birth weights of calves. In addition to lower feed costs and a longer productive life, cows in good condition that lose some weight in mid pregnancy often require fewer services per conception, have fewer calving problems, and produce more milk than overfed, fat cows. Although cows can be fed at a reduced level in mid pregnancy, cows must gain weight and stay on an increasing plane of nutrition during the final third of gestation. Feeding cows at levels below their energy needs for too long reduces their lifetime productivity. Cows fed fewer nutrients than they need during late pregnancy and lactation produce calves that are more susceptible to scours, have greater death losses to weaning, and are lighter at weaning than calves from adequately fed cows. Underfed cows also return to estrus later after calving and produce less milk. The energy needs of a pregnant cow increase rapidly during the last 3 months before calving, because the fetus is growing rapidly at this stage. Cows should gain about 0.5 kg/day during this period to compensate for the growth of fetal tissues.

Allow animals to graze stubble, headlands, and other noncropped areas to provide as much of their feed as is practical. When necessary, provide supplemental feed to meet the cows' nutrient requirements. If straw is the basic feed, a protein supplement is necessary to meet their needs and to prevent ruminal impaction. Impaction can occur when an animal tries to consume too much low-quality roughages to compensate for their low DE content. If the rate of intake exceeds the rate at which the feed can be digested, the rumen or abomasum fills up with undigested feed until the animal stops eating and eventually starves to death. Supplemental protein helps to prevent this problem.

Keep the minimum protein content at 9% of the total diet. Provide protein in the form of grain, hay, or protein supplements. Legume hay in baled, cubed, or pelleted form is a good source of protein, as well as DE. When the predominant feeds are low in protein (i.e., straw or chaff), a high-protein supplement may be the most economical way to meet the cows' requirements. If grain is inexpensive, it can provide up to 70% of the required DE requirement, as well as supplemental protein. Grain is also a good source of the readily available energy that is necessary when feeding supplements containing nonprotein nitrogen (NPN) compounds.

Liquid protein supplements provide a convenient way to supplement cows with protein and some minerals. They contain molasses, which supplies the readily digestible energy needed for cattle to make efficient use of the NPN compounds. The intake of liquid supplements is usually limited mechanically. Thus a protein supplement can be fed with a small amount of labor. Check the equipment regularly to ensure proper function and adequate supplement intake. Follow the supplier's instructions carefully when introducing cattle to liquid protein supplements. Do not allow hungry animals free access to liquid supplements because they may overeat and consume toxic levels of NPN compounds. Feed cattle hay before allowing them access to the liquid supplement feeder.

*Body condition and nutrient requirements*

Body condition can have a great effect on the energy requirements of beef cows. Fat cows are more resistant to the stress of winter and require less DE per unit body weight than thin cows. The layer of subcutaneous fat acts as insulation. In addition, the extra fat can serve as a valuable reservoir of energy, thus reducing the feed requirements needed during the winter feeding period.

Body condition is most commonly estimated by palpating cows along the backbone, ribs, and tailhead and assigning a linear body condition score between 1 (emaciated) and 5 (excessively fat) (Table 5). Details on how to score cows for body condition are available in the publication *Body condition: implications for managing beef cows*, Alberta Agriculture, Agdex No. 420/40-1.

Table 5 Body condition scoring criteria

| Score | Description |
|---|---|
| 1 | Individual short ribs fairly sharp to touch; no fat around tail head. Hip bones, tail head, and ribs visibly prominent. |
| 2 | Short ribs identifiable individually when touched, but feel rounded rather than sharp. Some tissue cover around tail head and over hip bones and flank. Individual ribs no longer obvious. |
| 3 | Short ribs can only be felt with firm pressure. Areas on either side of tail head now have a degree of fat cover that can be easily felt. |
| 4 | Fat cover around tail head is evident as slight rounds, soft to touch. Short ribs cannot be felt even with firm pressure. Folds of fat developing over animal's ribs and thighs. |
| 5 | Bone structure no longer noticeable; animal presents a "blocky" appearance. Tail head and hip bones almost completely buried in fat; folds of fat apparent over ribs and thighs. Short ribs completely covered by fat; animal's mobility impaired by large amounts of fat carried. |

Source: after Alberta Agriculture. 1988. *Body condition: implications for managing beef cows*. Agdex 420/40-1.

To maximize reproductive efficiency, cows should have a body condition score of 2.5–3 at calving and 2–2.5 at breeding. Monitor the cows' condition at the beginning of the winter feeding period and at intervals during the winter to allow for adjustments that optimize the use of feed during the winter. Each unit of body condition lost in late pregnancy contributes 800 Mcal DE, whereas 1500 Mcal DE are required for each unit of body condition gained. Cows in good condition (greater than 2.5) can be fed less DE than their requirement, whereas thin cows must be fed more DE than they would normally require. Factors for adjusting DE requirements based on body condition are given in Table 6. Note that body condition has a greater effect on winter feed requirements than the mature body weight of the cow.

Table 6 Effect of cow size and condition on the DE requirements of beef cows

| | Body weight (kg) | | | | | |
|---|---|---|---|---|---|---|
| Condition score | 400 | 450 | 500 | 550 | 600 | 650 |
| | Mcal/day | | | | | |
| 1 | 10.8 | 11.8 | 12.7 | 13.7 | 14.7 | 15.6 |
| 1.5 | 9.5 | 10.4 | 11.1 | 12.0 | 12.9 | 13.7 |
| 2 | 8.4 | 9.2 | 9.9 | 10.6 | 11.4 | 12.1 |
| 2.5 | 7.5 | 8.2 | 8.8 | 9.5 | 10.2 | 10.8 |
| 3 | 7.1 | 7.8 | 8.4 | 9.0 | 9.7 | 10.3 |
| 3.5 | 6.8 | 7.4 | 7.9 | 8.6 | 9.2 | 9.7 |
| 4 | 6.4 | 7.0 | 7.5 | 8.1 | 8.7 | 9.3 |
| 4.5 | 6.1 | 6.7 | 7.2 | 7.7 | 8.3 | 8.8 |
| 5 | 5.8 | 6.3 | 6.8 | 7.4 | 7.9 | 8.4 |

Cows in good condition may lose about 10% of their body weight in winter. However, excessive loss of weight may result in a "downer cow." This condition occurs most often as calving approaches and is characterized by paralysis and low body temperature (about 35°C). If a cow "goes down" and calves within 1 day, it is likely to recover, but a cow that is down for more than 1 day is unlikely to recover. The condition can be prevented by feeding adequate energy. If the condition does occur, an intravenous treatment of 200 mL of 25% calcium borogluconate within 4 h is at least partly effective.

*Winter drylot feeding*

Drylot feeding of beef cows and heifers is usually carried out during winter when open grazing areas are not available. During this period, use low-cost feeds, such as straw, to keep feed costs down. Because low-cost feeds are generally low in DE, protein, P, and vitamin A supplements must be added.

Provide enough bunk space to allow each animal its share of the feed (Appendix 7). Cows confined to a paved lot should have 5–9 $m^2$ per cow. Increase the allotment to at least 14–19 $m^2$ per cow on soil lots. Open sheds or windbreaks are desirable in most areas. Ensure that fresh water is available at all times. Provide 75 cm of linear open-water tank space or one automatic water bowl for each 25 animals. Prevent water from freezing in cold weather.

*Year-round drylot feeding*

Year-round drylot feeding may be useful where the amount of land available is limited or where the producer wants to obtain maximum calf production from each cow. This feeding system also permits greater flexibility in calving dates. Drylot feeding requires a great deal of work and the 4–5 t of feed dry matter needed each year by a cow and her calf usually cost more when fed in a drylot than on pasture or range. However, because feed intake is controlled, the operator can feed each cow for maximum production and avoid under- or over-feeding. In some long-term trials on drylot production of calves, operators have encountered problems because of inadequate intakes of protein, P, or vitamin A. The effects of these deficiencies did not appear in some cows until they had been in the drylot for a long period.

Amounts of feed to be given each day must be estimated with a knowledge of the desired weight and condition for the breed of cows being raised. Estimate feed requirements using Appendixes 1 and 2 given in this publication when the desired weights and rates of gain are established. Because the animals move around less in confinement, the requirements for DE may be slightly lower than given in the tables. If cows are gaining too much weight, restrict the quantity of DE supplied to each cow. Pay special attention to providing enough vitamin A because the hay and silage may not provide enough.

Overcrowding and dirty bedding increase calf scours. Dusty yards increase respiratory problems, particularly in calves. Muddy areas may increase the incidence of foot rot. Supply additional supplemental copper or organic iodide at levels prescribed by veterinarians to remedy this problem.

*Summer feeding on range*

Grazing cows and heifers on rangeland for the longest possible time during the year usually minimizes costs of production. However, be careful not to overgraze the range forage. The best use of the total forage available on a range depends on the even distribution of the grazing cattle. Their distribution is determined by topography, availability of water and salt supplies, palatability of forages, and fencing. Because cattle generally graze close to water supplies, adequate distribution of watering places encourages more uniform grazing than a single location for water. Watering places need to be closer together in hilly or mountainous country than on the plains. Locating salt away from water encourages uniform grazing.

Employ techniques of sustainable range management at all times. When making decisions on managing beef cows on range, pay attention to the carrying capacity of the range. Carrying capacity varies with the type of forage and the rainfall (Table 7). Within a general range type, the carrying capacity varies with climate, soil topography, grazing intensity, precipitation, and temperature. For more detailed information on range management, refer to Agric. Can. Publ. 1589/E, *Management of prairie rangeland.*

In areas where the conditions are suitable, reseeding of range with productive grasses can increase carrying capacity (Table 7). Base any decision about reseeding on sound knowledge of the soil, climate, and economic requirements. It is helpful to consult a range management specialist who is familiar with the situation. Use reseeded pastures of crested wheatgrass or fall rye for early spring grazing. Extending the fall grazing period with pasture forages such as Russian wild ryegrass, spring-seeded fall rye, or corn can add several months to the productive grazing season.

The quality of range forage decreases as the grazing season progresses. In late summer, levels of protein, P, and vitamin A in range grasses are low. Protein levels in the forage can decrease from about 20% in spring to 8% in July and as low as 4% in September. Calves depend increasingly upon grazed forage as the season progresses. Because calves generally require feeds higher in protein and DE than cows, daily gains of calves often decrease to 0.2 kg or less in the fall. This gain is commonly at the expense of the dam's body condition, particularly for cows with a high potential for milk production. Consider options such as early weaning and supplementation of the cows or calves, or both, when calf prices are high or grain prices are low.

Table 7 Average carrying capacities of native and reseeded ranges in western Canada

| Type of range and area | Condition of range | | | |
|---|---|---|---|---|
| | Excellent | Good | Fair | Poor |
| | hectares/animal unit•month[a] | | | |
| **Native** | | | | |
| British Columbia | | | | |
| Big sagebrush–bluebunch wheatgrass | 0.9 | 1.2 | 1.9 | 4.9 |
| Bluebunch wheatgrass–Sandberg's bluegrass | 1.0 | 1.2 | 1.5 | 1.9 |
| Bluebunch wheatgrass–rough fescue | 0.5 | 0.6 | 0.7 | 0.9 |
| Lodgepole pine–pinegrass | 2.0 | 4.0 | 6.0 | 8.0 |
| Reseeded clearcut | 1.0 | 1.2 | 1.6 | 2.0 |
| Foothills | | | | |
| Rough fescue | 0.5 | 0.7 | 1.0 | 1.3 |
| Prairies | | | | |
| Needle-and-thread–blue grama | 1.4 | 1.7 | 2.3 | 3.5 |
| Needle-and-thread–blue grama–western wheatgrass | 1.1 | 1.3 | 1.7 | 2.5 |
| Western porcupinegrass–western wheatgrass | 0.8 | 1.0 | 1.3 | 1.7 |
| Parkland | 1.1 | 1.3 | 1.7 | 2.3 |
| Bush pastures | 1.6 | 2.0 | 2.4 | 3.4 |
| **Reseeded** | | | | |
| Prairies | | | | |
| Crested wheatgrass | – | 0.5 | – | – |
| Russian wild ryegrass | – | 0.6 | – | – |
| Bromegrass | – | 0.2 | – | – |
| Intermediate wheatgrass | – | 0.2 | – | – |
| Pubescent wheatgrass | – | 0.2 | – | – |
| Timothy | – | 0.2 | – | – |

[a] An animal unit is one mature 455-kg cow, with or without an unweaned calf, and is based on an average daily forage consumption of 11.8 kg of dry matter. Weaned calf = 0.50 animal unit; yearling heifers and steers = 0.67 animal unit; bull = 1.30 animal units.

*Summer feeding on irrigated pastures*

Properly managed, irrigated pastures supply high-quality feed. These pastures provide grazing earlier in the spring and later in the fall than native range. Part of the forage produced in the summer can be harvested as silage or hay for feeding in the winter. For maximum carrying capacity and maintenance of the forage stand, be sure that the grazing system and stocking rate are suited to the climate, soil, type of forage grown, and irrigation method used.

Graze forages so that they do not mature and go to seed. The forage quality of irrigated pastures remains more constant throughout the grazing season than dryland ranges. Actively growing grasses or legumes contain adequate levels of protein and DE for all classes of beef cattle. Provide a mineral mix of about 9% Ca and 9% P combined with 50% cobalt-iodized salt at all times and protect the feeders from the weather. Good-quality water must be available. Give cattle access to some form of shade during hot weather. Use caution if cattle graze pasture containing legumes that can cause bloat, such as alfalfa or birdsfoot trefoil, especially if the forage is more than 50% legume. Bloat is not a concern if nonbloating legumes such as sainfoin or cicer milkvetch are grazed.

Beef cows with calves grazing highly productive irrigated pastures may consume more nutrients than they require. In this situation, graze the fields first with yearling cattle, for which rapid gains are desired, and then follow with cows and calves. Further information on grazing irrigated pastures is available in Agric. Can. Publ. 1862/E, *Irrigated pastures in western Canada.*

## Fall calving

Fall calving allows the operator options to use forage and other feedstuffs more efficiently. At weaning in the spring, put the cows onto lower-quality range and the calves onto improved or irrigated pastures for maximum gains. More intensive management of the herd is possible with fall calving than with spring calving when cows and calves are on the range together. It is easier to creep-feed calves, supplement the cows, or wean the calves early. Calving areas are often drier in fall, which can reduce calf diseases. Feed can be used more efficiently by feeding it directly to an early weaned calf than by feeding it to the cow to produce milk for the calf. However, feeding and management of the early weaned calf (45 days) requires special attention to produce normal growth.

With fall calving, the winter feeding program must be changed from that used for spring-calving cows. Pregnant cows require more feed in the fall both in the last 6 weeks before calving and after calving for milk production. Cows supporting milk production need a higher-quality, more-expensive stored forage than do dry, pregnant cows. Supplement with high-energy feeds as needed during lactation.

## Creep-feeding calves

Creep-feeding can provide additional nutrients for calves when adequate nutrients are not available from either the dam's milk or grazing. Creep-feeding generally results in higher weaning weights. The economic advantage to creep-feeding is quite variable. Where the cows are good milk producers and good grazing on native ranges or pastures is available, the cost of supplementation may be too high to justify the additional gains. However, if there is a premium for large, fleshy weaned calves, creep-feeding may be profitable. In other situations where the cow's milk production declines greatly late in the lactation, and grazing is limited, some creep-feeding may be desirable. Calves from large breeds with a greater genetic potential for growth usually benefit most from creep-feeding. Calves from small breeds may have a low postweaning rate of gain if they are creep-fed. Dams of creep-fed calves often are in better body condition at weaning. Therefore winter feed requirements can be reduced by creep-feeding. Creep-fed calves can be weaned and put on full feed with less stress and sickness than calves off the range. Creep-feeding may not be desirable in a herd where cows are selected for milk production because creep-fed heifer calves may have excessive fat, which can restrict future milk production.

The calves from cows of average milk-producing ability consume creep feed at about 0.25 kg/day at 2 months of age. This rate increases to about 3 kg/day at 6–7 months of age. When the consumption of creep feed exceeds 1.5 kg/day, the consumption of forage decreases. Limit the calves' intake of creep feed by supplying only a certain amount each day or by adding salt or fat, or both, to a self-fed creep feed diet. The level of salt or fat required to limit feed intake varies widely with the feeding situation and requires some experimentation to establish. Diets containing up to 5% fat or 20% salt have been used successfully. If high-salt diets are used, the supply of water must be adequate at all times.

Oat is a palatable feed that makes a good creep feed. Because calves on pasture may have an irregular pattern of feed intake, grains such as barley and wheat, which contain higher levels of energy, may produce more digestive upsets than oat. Calves will chew grains enough that whole grain can be used. However, it is difficult to keep other ingredients adequately mixed if whole grains are used. Molasses can be used to alleviate separation problems. The creep feed should contain 16–20% protein. Use protein supplements that are low in ruminal degradability (bypass proteins), such as fishmeal, meat and blood meal, and brewers' grains. These protein sources are generally more expensive than canola meal, soy meal, or urea, but the additional calf growth rate compensates for the added cost.

## Additional reading

### Agriculture Canada publications

Agriculture Canada publications are available from
Communications Branch, Agriculture Canada
Ottawa, Ont. K1A 0C7

*Minerals and vitamins for dairy cows.* Agric. Can. Publ. 1450/E.

*Beef production from the dairy herd.* Agric. Can. Publ. 1456/E.

### Other publications

*Some physiological costs of cold climates.* 1975. Special Report 175. Agricultural Experiment Station, University of Missouri, Columbia, Miss.

*United States–Canadian tables of feed composition.* 1969. Publ. 1684. U.S. National Research Council, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C.

*Nutrients and toxic substances in water for livestock and poultry.* 1974. U.S. National Research Council, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C.

*Applied animal nutrition.* 1969. 2nd ed. E.W. Crampton and L.E. Harris. W.H. Freeman and Company, San Francisco, Calif.

*Digestive physiology and nutrition of ruminants, volume 2: nutrition.* 1984. 3rd ed. D.C. Church et al. O and B Books Inc., 1215 N.W. Kline Place, Corvallis, Oreg.

*Digestive physiology and nutrition of ruminants, volume 3: practical nutrition.* 1984. D.C. Church et al. Oregon State University Book Stores Inc., Box 489, Corvallis, Oreg.

*Feeds and nutrition.* 1978. M.E. Ensminger and C.G. Olentine, Jr. The Ensminger Publishing Co., 3699 East Sierra Ave., Clovis, Calif.

# Appendix 1

## Daily dietary requirements of beef heifers

| Avg weight for feeding period (kg) | Daily gain (kg) | Minimum dry matter consumption[a] (kg) | Roughage[a] (%) | Total protein (kg) | DE[a] (Mcal) | Ca (g) | P (g) |
|---|---|---|---|---|---|---|---|
| **Growing heifers (medium frame)** | | | | | | | |
| 150 | 0.4 | 3.6 | 70–80 | 0.41 | 9.8 | 16 | 9 |
| | 0.6 | 3.7 | 50–60 | 0.48 | 11.3 | 22 | 11 |
| 200 | 0.4 | 5.4 | 70–80 | 0.46 | 14.4 | 17 | 10 |
| | 0.6 | 5.1 | 50–60 | 0.52 | 15.6 | 22 | 13 |
| 250 | 0.4 | 6.1 | 70–80 | 0.50 | 16.4 | 17 | 12 |
| | 0.6 | 6.0 | 50–60 | 0.56 | 18.6 | 22 | 14 |
| 300 | 0.4 | 6.5 | 70–80 | 0.55 | 17.4 | 18 | 13 |
| | 0.6 | 6.6 | 50–60 | 0.60 | 19.8 | 22 | 14 |
| 350 | 0.4 | 7.6 | 70–80 | 0.59 | 20.3 | 18 | 13 |
| | 0.6 | 7.8 | 50–60 | 0.64 | 23.5 | 22 | 14 |
| 400 | 0.0 | 7.1 | 100 | 0.50 | 16.4 | 17 | 12 |
| | 0.2 | 7.8 | 100 | 0.55 | 19.1 | 18 | 13 |
| | 0.4 | 8.3 | 70–80 | 0.63 | 22.3 | 20 | 14 |
| | 0.6 | 8.5 | 50–60 | 0.67 | 25.6 | 22 | 16 |
| **Growing heifers (large frame or compensating medium frame)** | | | | | | | |
| 150 | 0.4 | 3.8 | 70–80 | 0.43 | 9.9 | 16 | 9 |
| | 0.6 | 4.0 | 50–60 | 0.50 | 11.3 | 22 | 10 |
| 200 | 0.4 | 5.2 | 70–80 | 0.48 | 14.7 | 18 | 11 |
| | 0.6 | 5.5 | 50–60 | 0.55 | 15.6 | 22 | 12 |
| 250 | 0.4 | 6.2 | 70–80 | 0.53 | 16.4 | 18 | 12 |
| | 0.6 | 6.6 | 50–60 | 0.60 | 18.6 | 23 | 13 |
| 300 | 0.4 | 6.6 | 70–80 | 0.58 | 17.4 | 18 | 13 |
| | 0.6 | 7.0 | 50–60 | 0.64 | 19.8 | 23 | 14 |
| 350 | 0.4 | 7.7 | 70–80 | 0.62 | 20.3 | 19 | 14 |
| | 0.6 | 8.3 | 50–60 | 0.68 | 23.5 | 24 | 15 |
| 400 | 0.0 | 7.1 | 100 | 0.56 | 16.4 | 17 | 12 |
| | 0.2 | 8.3 | 100 | 0.58 | 19.1 | 18 | 14 |
| | 0.4 | 9.0 | 70–80 | 0.67 | 22.3 | 20 | 16 |
| | 0.6 | 9.0 | 50–60 | 0.72 | 25.6 | 24 | 17 |

*(Continued)*

**Appendix 1** *(Concluded)*

| Avg weight for feeding period (kg) | Daily gain (kg) | Minimum dry matter consumption[a] (kg) | Roughage[a] (%) | Total protein (kg) | DE[a] (Mcal) | Ca (g) | P (g) |
|---|---|---|---|---|---|---|---|
| **Pregnant yearling heifers (last 3–4 months of pregnancy)** | | | | | | | |
| 325 | 0.4 | 7.1 | 100 | 0.59 | 17.0 | 19 | 17 |
| | 0.6 | 7.3 | 90–100 | 0.65 | 19.0 | 23 | 18 |
| | 0.8 | 7.3 | 80–90 | 0.70 | 20.4 | 27 | 19 |
| 350 | 0.4 | 7.5 | 100 | 0.62 | 18.0 | 20 | 18 |
| | 0.6 | 7.7 | 90–100 | 0.67 | 20.0 | 24 | 19 |
| | 0.8 | 7.8 | 80–90 | 0.72 | 21.8 | 27 | 20 |
| 375 | 0.4 | 7.8 | 100 | 0.64 | 18.7 | 21 | 18 |
| | 0.6 | 8.1 | 90–100 | 0.70 | 21.1 | 25 | 20 |
| | 0.8 | 8.2 | 80–90 | 0.74 | 23.0 | 27 | 21 |
| 400 | 0.4 | 8.2 | 100 | 0.66 | 19.7 | 22 | 18 |
| | 0.6 | 8.5 | 90–100 | 0.72 | 22.1 | 25 | 21 |
| | 0.8 | 8.6 | 80–90 | 0.76 | 24.1 | 28 | 22 |
| 425 | 0.4 | 8.6 | 100 | 0.69 | 20.6 | 23 | 21 |
| | 0.6 | 8.8 | 90–100 | 0.74 | 22.9 | 26 | 22 |
| | 0.8 | 8.9 | 80–90 | 0.79 | 24.9 | 28 | 23 |

[a] Dry matter consumption and allowance of digestible energy (DE) based on the general type of diet indicated in the roughage column. Most roughages contain DE at 2.3—2.7 Mcal/kg dry matter, and 90—100% concentrate diets are expected to have DE at 3.6—4.0 Mcal/kg dry matter. (See Appendix 4 for vitamin A requirements.)

Source: Adapted from *Nutrient requirements of beef cattle. Number 4.* 1984. 6th ed. Revised. U.S. National Research Council, National Academy of Sciences, Washington, D.C.; and *The nutrient requirements of farm livestock. Number 2: ruminants.* 1980. Agriculture Research Council, London, England.

# Appendix 2

**Daily dietary requirements of mature beef cows**

| Avg weight for feeding period (kg) | Daily gain (kg) | Minimum dry matter consumption[a] (kg) | protein (kg) | Total DE[a] (Mcal) | Ca (g) | P (g) |
|---|---|---|---|---|---|---|
| **Dry pregnant cows[a] (middle third of pregnancy)** | | | | | | |
| 350 | 0 | 6.8 | 0.48 | 14.5 | 15 | 15 |
| 400 | 0 | 7.5 | 0.53 | 15.8 | 16 | 16 |
| 450 | 0 | 8.2 | 0.57 | 17.6 | 19 | 19 |
| 500 | 0 | 8.8 | 0.61 | 18.9 | 21 | 21 |
| 550 | 0 | 9.5 | 0.66 | 20.2 | 22 | 22 |
| 600 | 0 | 10.1 | 0.70 | 21.6 | 24 | 24 |
| 650 | 0 | 10.7 | 0.74 | 22.9 | 26 | 26 |
| **Dry pregnant cows[ab] (last 90 days of pregnancy)** | | | | | | |
| 350 | 0.4[b] | 7.4 | 0.61 | 18.0 | 24 | 18 |
| 400 | 0.4 | 8.2 | 0.66 | 19.4 | 26 | 19 |
| 450 | 0.4 | 8.9 | 0.70 | 21.1 | 27 | 21 |
| 500 | 0.4 | 9.5 | 0.75 | 22.4 | 30 | 24 |
| 550 | 0.4 | 10.2 | 0.79 | 23.7 | 31 | 25 |
| 600 | 0.4 | 10.8 | 0.83 | 25.1 | 33 | 27 |
| 650 | 0.4 | 11.5 | 0.87 | 26.4 | 36 | 30 |
| **Cows nursing calves[a] (average milking ability[c] in first 3–4 months postpartum)** | | | | | | |
| 350 | 0 | 7.7 | 0.82 | 20.2 | 27 | 22 |
| 400 | 0 | 8.5 | 0.86 | 21.6 | 30 | 25 |
| 450 | 0 | 9.2 | 0.91 | 23.3 | 31 | 26 |
| 500 | 0 | 9.9 | 0.96 | 24.6 | 33 | 28 |
| 550 | 0 | 10.6 | 1.00 | 26.0 | 35 | 30 |
| 600 | 0 | 11.2 | 1.04 | 27.3 | 37 | 32 |
| 650 | 0 | 11.9 | 1.09 | 29.0 | 39 | 34 |
| **Cows nursing calves[d] (superior milking ability[e] in first 3–4 months postpartum)** | | | | | | |
| 350 | 0 | 7.4 | 1.01 | 22.4 | 40 | 29 |
| 400 | 0 | 8.2 | 1.10 | 26.0 | 41 | 30 |
| 450 | 0 | 9.6 | 1.19 | 28.1 | 43 | 31 |
| 500 | 0 | 10.8 | 1.26 | 29.9 | 45 | 33 |
| 550 | 0 | 11.6 | 1.30 | 31.2 | 48 | 36 |

*(Continued)*

**Appendix 2** *(Concluded)*

| Avg weight for feeding period (kg) | Daily gain (kg) | Minimum dry matter consumption[a] (kg) | protein (kg) | Total DE[a] (Mcal) | Ca (g) | P (g) |
|---|---|---|---|---|---|---|
| 600 | 0 | 12.4 | 1.35 | 33.0 | 49 | 37 |
| 650 | 0 | 13.0 | 1.39 | 34.3 | 50 | 39 |

[a] Based on diets of 100% average-quality roughage containing DE at about 2.3–2.4 Mcal/kg dry matter.

[b] Weight gain of about 0.4 ± 0.1 kg/day over the last third of pregnancy is accounted for by the products of conception.

[c] Milk produced at 5.0 ± 0.5 kg/day.

[d] Based on diets of 100% good-quality roughage containing DE of at least 2.4–2.5 Mcal/kg dry matter.

[e] Milk produced at 10.0 ± 0.5 kg/day.

(See Appendix 4 for vitamin A requirements.)

Source: Adapted from *Nutrient requirements of beef cattle. Number 4.* 1984. 6th ed. Revised, U.S. National Research Council, National Academy of Sciences, Washington, D.C.; and *The nutrient requirements of farm livestock. Number 2: ruminants.* 1980. Agriculture Research Council, London, England.

## Appendix 3
**Mineral requirements of beef cows**

| Element | Suggested level | Range | Possible toxic levels[a] |
|---|---|---|---|
| Sodium, % | 0.08 | 0.06–0.10 | 6 |
| Magnesium, % | 0.10 | 0.05–0.25 | 0.40 |
| Potassium, % | 0.65 | 0.5–0.7 | 3 |
| Sulfur, % | 0.10 | 0.08–0.15 | 0.40 |
| Iodine, ppm | 0.5 | 0.2–2.0 | 50 |
| Iron, ppm | 50 | 50–100 | 1000 |
| Copper, ppm | 8 | 4–10 | 115 |
| Cobalt, ppm | 0.10 | 0.07–0.11 | 5 |
| Manganese, ppm | 40 | 20–50 | 1000 |
| Zinc, ppm | 30 | 20–40 | 500 |
| Selenium, ppm | 0.20 | 0.05–0.30 | 2 |

[a] The level of mineral that is toxic is at best an estimate and depends upon such factors as length of intake, availability of the mineral in the feedstuff or compound, and levels of other minerals.

Note: Refer to Appendices 1 and 2 for Ca and P requirements.

Source: Adapted from *Nutrient requirements of beef cattle. Number 4.* 1984. 6th ed. Revised, U.S. National Research Council, National Academy of Sciences, Washington, D.C.

## Appendix 4
**Daily amounts of vitamin A for cows and heifers**

| Animal | Daily gain (kg) | Body weight (kg) 250 | 350 | 400 | 500 | 600 |
|---|---|---|---|---|---|---|
| | | IU per head per day | | | | |
| Growing heifer | 0.6 | 18 000 | 24 000 | 27 000 | – | – |
| Pregnant heifer and cow | 0.0 | – | 19 000 | 20 000 | 25 000 | 30 000 |
| | 0.4 | – | 22 000 | 23 000 | 28 000 | 33 000 |
| | 0.6 | – | 25 000 | 28 000 | 31 000 | – |
| | 0.8 | – | 28 000 | 30 000 | – | – |
| Pregnant cow, last 3 months | 0.4 | – | – | 30 000 | 35 000 | 40 000 |
| Cow nursing calf | – | – | – | 50 000 | 55 000 | 60 000 |

## Appendix 5
### Composition of common feeds

| Feed | Dry matter (%) | Dry matter basis Protein (%) | ADF (%) | DE (Mcal/kg) | Ca (g/kg) | P (g/kg) |
|---|---|---|---|---|---|---|
| **Hays** | | | | | | |
| Alfalfa, early bloom | 90 | 18 | 35 | 2.56 | 14.8 | 2.2 |
| Alfalfa, late bloom | 90 | 14 | 44 | 2.20 | 13.4 | 2.4 |
| Red clover | 90 | 16 | 30 | 2.43 | 11.4 | 1.6 |
| Bromegrass | 89 | 10 | 36 | 2.40 | 4.2 | 2.0 |
| Oat | 88 | 10 | 32 | 2.43 | 2.2 | 2.0 |
| Prairie | 92 | 6 | 31 | 1.95 | 4.2 | 0.7 |
| Sainfoin, early bloom | 90 | 16 | 32 | 2.71 | 6.4 | 3.1 |
| Sainfoin, late bloom | 90 | 13 | 30 | 2.35 | 7.6 | 1.6 |
| Timothy, midbloom | 88 | 9 | 38 | 2.51 | 3.6 | 4.1 |
| Slough grass | 91 | 9 | 30 | 1.95 | 5.1 | 1.5 |
| Sedge meadow | 90 | 10 | 29 | 1.95 | 6.0 | 1.5 |
| **Silages (dry matter basis)** | | | | | | |
| Corn (early dent) | 100 | 8 | 31 | 3.09 | 3.7 | 2.2 |
| Sorghum (dough stage) | 100 | 8 | 29 | 2.65 | 2.9 | 1.6 |
| Barley (dough stage) | 100 | 11 | 33 | 2.45 | 4.6 | 3.5 |
| Oat (dough stage) | 100 | 10 | 34 | 2.38 | 4.7 | 3.3 |
| Rye (dough stage) | 100 | 11.5 | 35 | 2.34 | 4.0 | 2.3 |
| Faba bean | 100 | 20 | 36 | 2.49 | 9.0 | 2.8 |
| Pea vine | 100 | 13 | 49 | 2.51 | 1.3 | 0.2 |
| Sweetclover | 100 | 13.5 | 35 | 2.56 | 11.8 | 2.2 |
| Alfalfa | 100 | 18.5 | 29 | 2.56 | 19.1 | 2.4 |
| **Straws** | | | | | | |
| Barley | 91 | 5 | 47 | 1.75 | 3.3 | 0.9 |
| Oat | 91 | 5 | 47 | 1.87 | 3.0 | 0.9 |
| Wheat | 91 | 4 | 49 | 1.70 | 1.5 | 0.7 |
| **Grains** | | | | | | |
| Barley | 90 | 12 | 6 | 3.70 | 0.7 | 4.0 |
| Corn | 87 | 10 | 3 | 4.16 | 0.4 | 2.7 |
| Oat | 90 | 11 | 4 | 3.42 | 0.9 | 3.3 |

*(Continued)*

**Appendix 5** *(Concluded)*

| Feed | Dry matter basis | | | | | |
|---|---|---|---|---|---|---|
| | Dry matter (%) | Protein (%) | ADF (%) | DE (Mcal/kg) | Ca (g/kg) | P (g/kg) |
| **Grains** *(continued)* | | | | | | |
| Rye | 90 | 14 | 3 | 3.70 | 0.7 | 3.7 |
| Wheat | 90 | 16 | 7 | 3.92 | 0.4 | 4.0 |
| **Oil meals** | | | | | | |
| Linseed | 91 | 38 | 17 | 3.62 | 4.4 | 8.4 |
| Canola | 92 | 38 | 6 | 3.35 | 6.8 | 11.7 |
| Soybean | 91 | 46 | 9 | 3.75 | 2.6 | 6.4 |
| **Miscellaneous** | | | | | | |
| Beet pulp (dried molasses) | 92 | 9 | 31 | 3.35 | 5.5 | 0.9 |
| Beet tops (dry matter basis) | 100 | 14 | 14 | 2.25 | 9.9 | 2.2 |
| Bran | 89 | 16 | 14 | 2.75 | 1.4 | 11.7 |
| Brewers' grain (dried) | 92 | 26 | 22 | 2.91 | 2.6 | 5.1 |
| Distillers' corn grain (dried) | 92 | 27 | 18 | 3.88 | 0.9 | 3.7 |
| Flax (whole seed) | 92 | 24 | 7 | 4.76 | 2.6 | 5.5 |
| Meat meal | 94 | 53 | 2 | 3.00 | 79.1 | 40.3 |
| Molasses (beet) | 80 | 8 | 0 | 3.48 | 0.4 | 0.2 |
| Pea (seed) | 91 | 22 | 7 | 3.84 | 1.7 | 5.0 |

Note: This table contains average values for nutrients that have been derived from a large number of samples. However, because the values may vary under different production and feeding situations, analysis of specific feeds used may be necessary.

# Appendix 6

## Formulating diets for beef cows and heifers

Beef cows and heifers are fed a variety of grains and roughages ranging from agricultural by-products, such as straw or chaff, to high-energy or high-protein concentrates, such as barley grain or canola meal. Specific diets depend on

- quantity and quality of home-grown feeds
- prices of commercial feeds
- weight and body condition of the animals
- environmental conditions
- level of performance desired.

Send representative samples of home-grown feeds to a feed-testing laboratory for analysis. If you provide adequate information about the cattle and management program, diet recommendations may be provided by the laboratory.

Normal diets for beef cows and heifers consist mainly of forages, but energy or protein supplements may be added where the supply or voluntary intake of forage is insufficient to meet the animals' needs. To decide what diet should be fed, assess the requirements of the animals and the feedstuffs available.

*Beef cows*

The following examples illustrates how to formulate a diet for a beef cow.

The average weight of cows in a herd is 500 kg. During the middle third of pregnancy, the cows require daily 18.9 Mcal of digestible energy (DE), 0.61 kg of protein, 21 g of Ca, 21 g of P (Appendix 2), and 35 000 IU of vitamin A (Appendix 4) for maintenance. The following feeds (average analyses from Appendix 5) are available:

| Feedstuff | Dry matter (%) | Protein (%) | DE (Mcal/kg) | Ca (g/kg) | P (g/kg) |
|---|---|---|---|---|---|
| Bromegrass hay | 89 | 10.0 | 2.40 | 4.2 | 2.0 |
| Alfalfa hay (early bloom) | 90 | 18.0 | 2.56 | 14.8 | 2.2 |
| Oat straw | 91 | 5.0 | 1.87 | 3.0 | 0.9 |

*Digestible energy*

Calculate how much feed is needed to meet energy requirements. Note that animals normally consume 1.5–3.0 kg of feed per 100 kg of body weight, depending on feed type and quality. The animal requires 18.9 Mcal of DE.

**REMEMBER: The following calculations are based on dry matter intake. Adjust actual intake upward to compensate for the moisture in the feed.**

*Example 1* Bromegrass hay contains DE at 2.4 Mcal/kg. Therefore, 18.9 ÷ 2.4 = 7.9 kg of bromegrass hay dry matter is required. Bromegrass contains 89% dry matter, therefore 7.9 ÷ 0.89 = 8.8 kg of bromegrass must be provided.

*Example 2* Assume that enough alfalfa is available to supply dry matter daily at 5.0 kg/head. How much straw is required to provide the additional energy?

5.0 kg (alfalfa) x 2.56 Mcal/kg = 12.8 Mcal
A further 18.9 – 12.8 = 6.1 Mcal is required.

Because oat straw contains DE at 1.87 Mcal/kg, the amount of straw that must be fed daily = 6.1 ÷ 1.87 = 3.3 kg.

Thus, a ration of 5.0 kg of alfalfa hay dry matter and 3.3 kg of oat straw dry matter supplies 18.9 Mcal of DE. Correcting for the moisture in the feeds, 5.0 kg ÷ 0.90 = 5.5 kg of alfalfa and 3.3 kg ÷ 0.91 = 3.6 kg of oat straw are needed on an as-fed basis.

These same calculations could be carried out using metabolizable energy (ME) values for each feed. ME values can be estimated for most feeds by multiplying the DE values by 0.82.

*Protein*

Determine if the calculated rations supply sufficient protein. The animal requires 0.61 kg of protein. Because protein content is expressed as a percentage of dry matter, it is not necessary to correct for the moisture in the feed in this example.

*Example 1* Bromegrass hay contains 10.0% protein. Therefore, protein supplied per kilogram of feed = 7.9 x 0.10 = 0.79 kg. Thus, protein requirements are met. However, if the bromegrass contained only 6% protein, the amount of protein supplied would be only 0.47 kg, which is 0.14 kg less than the requirements and supplemental protein would be needed.

*Example 2* Alfalfa contains 18.0% protein and oat straw contains 5.0% protein. The amount of protein supplied is (alfalfa: 5.0 kg × 0.18) + (oat straw: 3.3 kg × 0.05) = 1.06 kg. Thus, protein requirements are exceeded.

These are only two of many rations that might be used. In example 2, because the amount of protein supplied is much greater than needed, more straw and less alfalfa could be used. Because straw is normally much less expensive than alfalfa, maximizing the amount of straw in a ration usually results in lower feed costs. Diets consisting of straw plus a concentrate mixture are also satisfactory if properly formulated. Refer to the section on feedstuffs for limitations on feeding straw.

### *Minerals and vitamins*

Requirements for minerals and vitamins must be met. The animal requires 21 g of Ca and 21 g of P.

*Example 1* The calculated ration (7.9 kg) of bromegrass hay supplies 33.2 g of Ca (i.e., 7.9 kg × 4.2 g) and 15.8 g of P (i.e., 7.9 kg × 2.0 g). Ca requirement of the animals (21 g) is exceeded but the P requirement (21 g) is not met. Provide free-choice mineral supplement containing at least 12% each of Ca and P to make certain that sufficient P is consumed by the animal.

*Example 2* The amounts of Ca and P supplied in the calculated ration of alfalfa and oat straw are 74.0 g and 11.0 g, respectively. Again, feed a free-choice mineral supplement such as that prescribed for example 1 to guarantee an adequate supply of P.

Vitamin A may be supplied by carotene in green hays and silages. However, because the amount, stability, and availability of carotene are not always known, use synthetic vitamin A to ensure that the cows receive sufficient quantities. Vitamin A can be fed daily as part of the diet or, if this is not convenient, a 14- or 28-day supply can be fed every 2 or 4 weeks in, for example, 1 kg of grain. If the dry synthetic vitamin A containing 10 000 IU/g is used, a total of 49 g would be required each 14 days to supply an animal with 35 000 IU/day. Vitamin A injections also can be used, providing that they are given at least every 2 months.

### *Heifers*

Heifers need diets that are somewhat higher in digestible energy, protein, Ca, and P than those required by cows because they are expected to grow rather than simply to maintain their body weight. A pregnant heifer weighing 400 kg and gaining 0.4 kg/day requires 19.7 Mcal of DE, 0.66 kg of protein, 22 g of Ca, 18 g of P (Appendix 1), and at least 23 000 IU of vitamin A (Appendix 4). A ration consisting of 2 kg of alfalfa hay (early bloom) and 6.1 kg of bromegrass hay would easily meet these energy, protein, and Ca requirements, but would not supply enough P. Provide a mineral supplement containing at least 12% of each of Ca and P, as well as a vitamin A supplement.

Analyze the feedstuffs before the feeding program is established. Provincial and federal departments of agriculture and private industry provide assistance in planning a feeding and management program.

## Appendix 7
### Minimum accommodation for beef cattle

| Accommodation | Cows and bred heifers | Yearlings | 225-kg calves |
|---|---|---|---|
| **Feedlot (without shed)** | | | |
| Hard-surfaced | 7 $m^2$ | 4 $m^2$ | 4 $m^2$ |
| Soil | 28 $m^2$ | 24 $m^2$ | 14 $m^2$ |
| **Feedlot (with shed)** | | | |
| Hard-surfaced | 5 $m^2$ | 2 $m^2$ | 2 $m^2$ |
| Soil | 28 $m^2$ | 23 $m^2$ | 14 $m^2$ |
| **Shed area** | | | |
| Floor area | 3 $m^2$ | 2 $m^2$ | 1 $m^2$ |
| Clear height | 3 m | 3 m | 3 m |
| **Slotted floors** | | | |
| Space per animal | 3 $m^2$ | 2 $m^2$ | 1 $m^2$ |
| **Maternity pens** | | | |
| Additional area | 1 pen/20 cows 3 x 3 m (not slotted) | | |
| **Water** | | | |
| Surface area | 0.1 $m^2$/ 25 head | 0.1 $m^2$/ 25 head | 0.1 $m^2$/ 30 head |
| **Bedding storage** (except for slotted floors) | | | |
| Daily amount | 2.3 kg/head | 1.4 kg/head | 1.4kg/head |
| **Feed bunk** (length per head) | | | |
| Simultaneous feeding | 66 cm | 51 cm | 46 cm |
| Full feeding | | | |
| Roughage | 20 cm | 20 cm | 5 cm |
| Mill feed | 8 cm | 8 cm | 5 cm |
| Height at throat | 46 cm | 46 cm | 46 cm |
| Max. reach[a] | 96 cm | 76 cm | 61 cm |

[a] Top of throat board to bottom inside corner

Source: *Canadian Farm Building Code*, NRCC No. 13992. 1975. National Research Council of Canada, Ottawa.

## Appendix 8
**Guide to common nutrition-related ailments**

| Symptoms | Cause or predisposing factors | Nutritional treatment or preventive measures |
|---|---|---|
| Downer cow | Energy deficiency | Provide pregnant cows with adequate energy (Appendix 2); provide shelter and bedding to reduce heat loss |
| Retained placentas | Vitamin A deficiency | Provide vitamin A at 90 000 IU/day as a corrective measure |
| | Se deficiency | Provide feeds containing adequate Se (1 mg/day) |
| Poor conception | Energy deficiency in late pregnancy and early lactation | Provide sufficient energy (Appendices 1 and 2) |
| | Vitamin A deficiency | Provide vitamin A at 90 000 IU/day as a corrective measure |
| | P deficiency | Provide P supplement |
| | Ca:P imbalance | Provide Ca or P or both to make Ca:P balance between 1.4:1 and 7:1 |
| | Iodine deficiency | Feed iodized salt (loose) |
| Dull coat and failure to shed winter coat in spring | Vitamin A or copper deficiency | Provide vitamin A (Appendix 4) or a trace-mineral supplement containing copper |
| Night blindness | Vitamin A deficiency | Provide adequate vitamin A (Appendix 4) |
| Sudden nervousness | Ca deficiency caused by feed that is high in oxalic acid, e.g., beet tops | Feed 0.1 kg limestone per head per day with grain |

*(Continued)*

**Appendix 8** *(Continued)*

| Symptoms | Cause or predisposing factors | Nutritional treatment or preventive measures |
|---|---|---|
| Internal bleeding | Sweetclover poisoning, due to consumption of moldy or spoiled hay or silage | Alternate sweetclover and other forage at 2-week intervals |
| Grain overload | Too much grain at one time | Limit cattle unaccustomed to grain to a maximum of 1% of body weight; if more is fed, increase at rate of 0.1% of body weight per day |
| Grass tetany, staggering | Magnesium deficiency; usually in milking cows on lush pasture | Give 50–60 g magnesium oxide per day |
| Stiff legs | Ca:P imbalance on high-concentrate diets | Add about 1% limestone to concentrate |
| Impaction | High straw intake | Replace straw with hay or grain to provide additional energy |
| | Protein deficiency or cold, stressful weather | Provide protein supplement so that protein forms at least 7% of the daily intake of feed |
| Chewing wood and bone | P, cobalt, or copper deficiency | Provide a P supplement, cobaltized salt (loose), or trace-mineral supplement containing copper |
| White muscle in calves | Se or vitamin E deficiency or both | Provide Se daily at 1 mg per cow or Se supplement prescribed by veterinarian |

*(Continued)*

**Appendix 8** *(Concluded)*

| Symptoms | Cause or pre-disposing factors | Nutritional treatment or preventive measures |
|---|---|---|
| Bloat | Fine particle feed | Steamroll or temper and roll grain; reduce speed of hammer mill, do not hammer hay; adjust Ca:P ratio to about 2:1 |
| | Consumption of diets high in legume | Remove legume hay from diet; feed mixed straw or grass hay with legume hays; remove barley and legume combination diet; temporarily feed 4% salt in diet |
| Poisoning | High Se intake; over-grazing that causes consumption of Se accumulator such as certain milk vetches | Do not overgraze pastures; supplement pastures to avoid consumption of SE accumulator plants |
| | Nitrates consumed in high-nitrate forages | Analyze forages whose growth has been halted abruptly by hail, frost, or drought for nitrate content; if forage has a high nitrate content, limit daily intake to nontoxic level (less than 0.5% in the feed) |
| | Poisonous plants consumed when forages are in limited supply | Avoid pasturing areas containing poisonous plants. For further information, refer to Agric. Can. Publ. 1842/E, *Poisonous plants of Canada* (1990) |

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