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The members of the committee selected to undertake this project and prepare this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. Responsibility for the detailed aspects of this report rests with that committee.

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PREFACE

This report is one of a series issued under the direction of the Committee on Animal Nutrition, Board on Agriculture and Renewable Resources, National Research Council. It was prepared by the Subcommittee on Sheep Nutrition, and it replaces Publication 1693, *Nutrient Requirements of Sheep*, issued in 1968.

This edition differs from the previous one in these respects:

- Where symptoms of deficiency are known, descriptions of the symptoms accompany the statements of nutrient requirements.
- Nutrient requirements and feed-composition data are expressed on a dry matter basis.
- Protein requirements for lactation have been increased on the basis of new experimental data.
- Weight increments and gains have been substantially increased and nutrient requirements adjusted accordingly. This change is due to the fact that, in general, sheep grow faster and reach greater weights at maturity than they did in 1945, when publication of this series began.
- A new section on the energy measurement concept of net energy for maintenance plus gain (NE_{m+g}) has been included to stimulate additional research in this area.
- A section on requirements of early-weaned lambs has been included, even though experimental data to substantiate such requirements are limited.
- A table of toxic levels of trace minerals is included to present the latest data available for sheep.
- A graph depicting daily and cumulative weight changes of a 60-kg ewe is included.

The Subcommittee wishes to express appreciation to Dr. R. J. Emerick, South Dakota State University, for preparing the section on urinary calculi; to Dr. Peter Rattray, Ruakura Agricultural Research Centre, New Zealand, and the University of California, Davis, for contributing to the section on energy requirements; and to Dr. D. C. Church, Oregon State University, for helping to assemble photographs depicting symptoms of deficiency and toxicity.

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INTRODUCTION

The major nutrient requirements of sheep are presented in Tables 1 and 2. The requirements are expressed as amounts per animal per day in Table 1 and as concentration in the diet dry matter in Table 2. Yearly dry matter, energy, and protein requirements of a 60-kg ewe are given in Table 3.

The nutrient requirements stated here are the values considered necessary for maintenance, optimum production, and prevention of all signs of nutritional deficiency. The values are designed to meet above-average requirements. Thus, they provide a margin of safety for animals whose requirements are average or below.

Most of the values given in Tables 1 and 2 are based on experimental evidence. Where values from several comparable experiments were available, the subcommittee entered in the tables the average, or the approximate average, of those values. The various weight increments for replacement lambs and yearlings are considered to be the result of growth, not of improved body condition.

These two tables imply that if nutrients are supplied in stated amounts, certain gains in weight can be expected. The data on nutrients and gains are based on the assumption that feeds of average composition, digestibility, and quality will be used. An adjustment should be made if feeds above or below average are used. For example, if the hay being fed has nutritional values lower than those indicated in the feed-composition table (Table 16), additional amounts should be fed. Statements on amounts of feed refer to amounts actually consumed, not merely to amounts offered to the animals.

Although some calculations and interpolations were necessary before experimental results could be used in the tables of nutrient requirements, values have not been intentionally increased.

Feed manufacturers and sheep feeders may find it desirable to increase the concentration of labile nutrients when transportation and storage conditions are likely to cause deterioration or when the feeds available are below average in quality. Likewise, under conditions of stress (e.g., bad weather, shipment, disease, or parasitism), a greater quantity of nutrients may be beneficial.

Statements on nutrient requirements of sheep must be related to the size of the animals and to stages of production. In practical feeding, however, it is not possible to have all the sheep in a flock the same size or in exactly the same stage of production, and it is not possible to know at each feeding the exact composition of the feed. Therefore, it should be understood that the data presented here are intended as useful guides to adequate nutrition, not as standards to be rigidly followed. Moreover, these requirements are not to be interpreted as recommendations for every area of sheep production. Recommendations should be given by proper authorities on a local basis.

NUTRIENT REQUIREMENTS AND SYMPTOMS OF DEFICIENCY

ENERGY

Insufficient energy probably limits performance of sheep more than any other nutritional deficiency and may result from inadequate amounts of feed or from feed of low quality.

Supplies of feed may be inadequate as a result of overgrazing, drought, or snow covering. Available feed may be of such low quality and digestibility that sheep cannot obtain enough energy to meet requirements. Poorly digested low-quality forage also leads to reduced feed intake. Forage may also be so high in water content that energy intake is limiting.

Symptoms of Deficiency

Energy deficiency, depending on severity, will cause slowing or cessation of growth, loss of weight, reduced fertility or reproductive failure, lowered milk production and shortened lactation period, reduced wool quantity and quality, including breaks in the fiber, and eventually increased mortality. Sheep suffering from energy deficiency have lowered resistance to infection by internal parasites. Energy deficiency may be complicated by protein, mineral, and/or vitamin deficiencies.

Factors Affecting Requirements

In addition to size, age, pregnancy, lactation, and growth, covered in the requirement tables, and their relationship to nutrients such as protein, which must be supplied in adequate amounts, other considerations can affect energy requirements.

Environment Temperature, humidity, and wind may increase or decrease energy needs, depending upon relative values in relation to the zone of thermal neutrality.

Shearing Shearing decreases insulation and may increase energy losses.

Stress Stress of any kind appears to increase energy requirements.

Feed Availability

The maintenance requirements of sheep on pasture or range are 10 to 100 percent higher than those fed indoors. The size of the increase depends on the availability of feed and water, nature of the terrain, and distance traveled daily.

DE or ME in the Diet

Energy concentration in the diet may be expressed as Metabolizable Energy (ME) per kilogram, Digestible Energy (DE) per kilogram, or Total Digestible Nutrients (TDN) per kilogram. Good-quality roughage furnishes about 2 Mcal ME/kg. As concentrates are mixed with roughage, the energy increases to 2.5 Mcal ME/kg or more for early-weaned and finishing lambs (Table 2). The efficiency with which ME is utilized for both maintenance and gain usually increases with increasing levels of ME in the diet.

Energy Requirements

Energy requirements for the various classes of sheep in Tables 1 and 2 are expressed as TDN, DE, and ME. The assumption is made that 1 kg TDN equals 4.4 Mcal DE, which is utilized for ME at 82-percent efficiency. ME requirements and values of feeds are not included in the major tables, but are discussed at the end of this section. Table 1 presents the estimated requirements per sheep per day, while Table 2 presents the estimated requirements per kilogram of dry matter in the diet. For example, ewes on maintenance and ewes in the first 15 weeks of gestation are assumed to be receiving an all-roughage diet containing 2.4 Mcal of DE/kg dry matter, while ewes suckling twins in the first 8 weeks of lactation are assumed to be receiving a higher concentrate diet containing 2.9 Mcal DE/kg.

In practical feeding situations, depending on the desired response of the animals, their body condition, the appetite of the sheep, and environmental conditions, the amount of feed fed may be varied from the levels recommended in Tables 1 and 2. If diets fed are more concentrated than those indicated in Table 2, the level of dry matter fed may be reduced accordingly.

Requirements for Maintenance

Previous editions of sheep requirements have based the estimate for kilocalories of DE for maintenance on the interspecies generalization of $2 \times 70\ W_{kg}^{0.75}$. Recent research has demonstrated that the maintenance requirement of the adult sheep is 10 to 20 percent less than previously assumed. The values in Tables 1 and 2 are calculated from the following formulas:

$$DE = 119\ W_{kg}^{0.75}$$

$$ME = 98\ W_{kg}^{0.75}$$

$$TDN = 0.027\ W_{kg}^{0.75}$$

Where W is in kg, DE and ME are in kcal per day, and TDN is in kg per day (Garrett *et al.*, 1959).

Requirements for Different Functions

Gain The values in Tables 1 and 2 are based on the formulas of Garrett *et al.* (1959):

$$DE = 138\ W_{kg}^{0.75}\ (1 + 5.3\ \text{gain})$$

$$ME = 112\ W_{kg}^{0.75}\ (1 + 5.5\ \text{gain})$$

$$TDN = 0.029\ W_{kg}^{0.75}\ (1 + 5.1\ \text{gain})$$

Gain is in kg/day, DE and ME are in kcal per day, and TDN is in kg per day. For those wishing to use NE_m and NE_g, the data given in the "Net Energy Requirements" section may be utilized.

Ewes–Nonlactating and First 15 Weeks of Gestation Requirements given in Tables 1 and 2 are intended to provide for maintenance, wool growth, and a small daily gain (Figure 1). If ewes are fat, a sub-maintenance diet is permissible to avoid overly fat ewes at lambing time. No allowance has been made for flushing the ewe to increase lamb production (see Flushing p. 23). The nutrients required for wool production depend on the genetic potential of the sheep to produce wool. The energy required for wool production represents a small fraction of the total energy consumed.

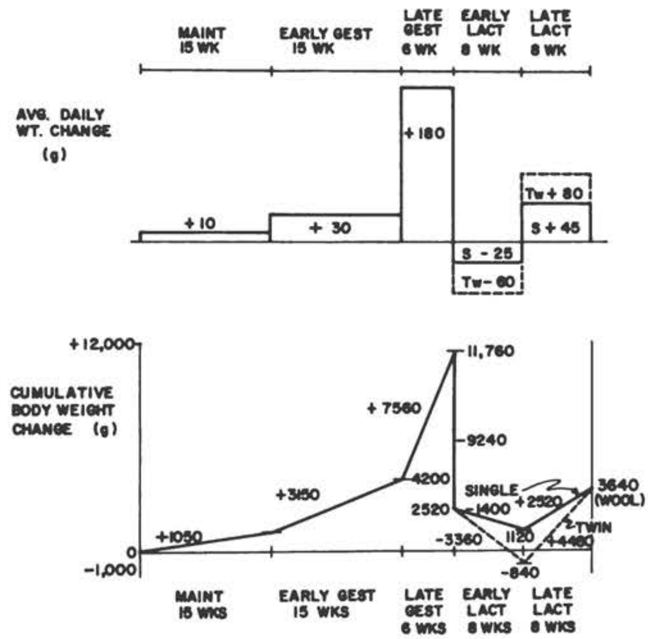


FIGURE 1 Daily and cumulative weight changes of a 60-kg ewe.

Ewes–Last 6 Weeks of Gestation During the last 6 weeks of gestation, ewes need more energy to meet increased requirements for fetal growth and the development of the potential for high milk production. The levels recommended in Tables 1 and 2 are adequate for normal fetal and mammary development in single- and twin-bearing ewes. Excessive energy intake may lead to fattening with resultant birth difficulties in single-bearing ewes. Low energy intakes can result in low birth weights with reduced viability in the lambs and perhaps pregnancy toxemia in the ewe.

Ewes–Lactation In Tables 1 and 2, energy requirements are estimated for each of four groups of lactating ewes: first 8 weeks of lactation, suckling singles; last 8 weeks of lactation, suckling singles; first 8 weeks of lactation, suckling twins; and last 8 weeks of lactation, suckling twins.

A ewe nursing twin lambs produces 20–40 percent more milk than a ewe nursing one lamb. Within the genetic capability of the ewe, milk production responds to nutrient intake of the ewe and demand for milk by the lamb(s).

Requirements for the last 8 weeks of lactation are based on the assumption that milk production during that period is approximately one-half of the production during the first 8 weeks.

In preparing these tables, it has been anticipated that the ewes will have a small weight loss early in lactation. Actually, the amount of loss varies greatly, depending on management factors (e.g., the quality and amount of feed available) and on the genetic background of the ewes. Under some range conditions, pregnant ewes lose weight in winter and gain weight during lactation in summer.

Lambs–Breeding Separate requirements are presented in the tables for replacement ewes and rams. Ram lambs have the potential to grow at a faster rate than ewe lambs, especially after they reach 50-kg body weight.

Mature size for the breed will have an influence on the energy requirements. Smaller breeds will tend to grow more slowly, whereas larger breeds grow more rapidly and have higher feed requirements.

The nutrients needed for gain by ewe and ram lambs have been compared. The performance of the ewe lambs fits the equations for maintenance and gain upon which Tables 1 and 2 are based. Ram lambs gain more rapidly than the equations suggest, have higher feed intake, and use the feed more efficiently for body weight gain. Gains in body weight of intact males are higher in water and protein and lower in fat than those of females.

Producers breeding ewe lambs to lamb as yearlings should feed for increased rates of growth and provide sufficient additional feed to meet pregnancy requirements. During lactation these ewes still require additional feed to ensure adequate milk production and continued growth.

Lambs–Finishing The recommendations in Tables 1 and 2 are based on the formulas for maintenance and gain given above (p. 3) as modified to conform to commercial feeding practices and to results of experimental feeding. Care should always be exercised in starting lambs on high-energy diets for finishing. They should be shifted gradually from roughage diets to the more-concentrated diets to avoid digestive upsets.

Early-Weaned Lambs In this section early-weaned lambs are considered to be lambs weaned at 5–8 weeks of age and fed to gain from 250 to 300 g daily. To achieve satisfactory results, palatable high-energy, adequate protein diets are necessary. These younger lambs will not have the rumen development and the capacity to utilize less-concentrated feeds considered normal for finishing lambs.

Feed Management Energy intake can be controlled by limiting the time for eating, feeding only every other day, adding fiber to the diet, or limiting the amount offered.

Net Energy Requirements

Growing–Finishing Lambs Net energy requirements for maintenance (NE_m) and gain (NE_g) were derived for lambs weaned at 1–3 days and fed milk replacers by Chiou and Jordan (1973) in Table 4 and for lambs 3–5 and 6–10 months old by Rattray *et al.* (1973a, 1973c) in Tables 5 and 6.

These data indicate that younger lambs apparently have a higher metabolic rate and require more NE_m per unit metabolic size than the older lambs, whereas the gain of the younger lambs is lower in fat and energy, thereby reducing their NE_g requirements as compared with the older lambs. For very young lambs at 10-kg body weight, the NE requirements (kcal/day) for maintenance were approximately 107 $W_{kg}{}^{0.75}$, whereas 30–40-kg lambs 3–5 months old required 79 $W_{kg}{}^{0.75}$ and 30–40-kg lambs 6–10 months old required 63 $W_{kg}{}^{0.75}$.

Although ewe lambs may deposit more fat in their gains, especially at heavier weights, their NE_m and NE_g requirements do not appear to differ significantly from wethers over most of the range of liveweight gains studied. Ewe lambs do, however, appear to have significantly lower voluntary feed intakes than wethers and would therefore take longer to reach slaughter weights. For example, on diets containing approximately 2.5 Mcal ME/kg DM, voluntary intakes of ewe lambs were only 70 percent of those of wethers on similar diets.

Pregnancy Sheep utilize ME for conceptus development with an efficiency of 12–14 percent and for pregnancy (gravid uterus plus mammary gland development) with an efficiency of 16–18 percent for diets containing 2.4–2.6 Mcal ME/kg DM (Rattray *et al.*, 1973b, 1974). The efficiency of ME utilization may be different with diets that differ markedly from those used to establish the above values. The NE_{preg} requirements (above NE_m and NE_g) of ewes bearing single, twin, and triplet fetuses that have a total fetal weight of 5.0, 9.0, and 11.5 kg, respectively, are given in Table 7 for different stages of late pregnancy (Rattray *et al.*, 1974). The NE requirements may differ from those listed, if the fetuses or other products of conception differ markedly in size or composition from those studied by these workers.

These authors also obtained data that showed that the maintenance requirement of the ewe and the efficiency of utilization of ME for maternal maintenance and gain were not changed by pregnancy. The extra heat production that occurs in pregnancy appears to be primarily of fetal origin.

The total feed requirements of a pregnant sheep can be obtained by summation of the various NE requirements, e.g., $NE_m + NE_g + NE_{preg}$ for a pregnant ewe lamb and $NE_m + NE_{preg}$ for a pregnant adult ewe. In early pregnancy, fetal growth is very small and the total feed requirement of the ewe is not significantly different from maintenance. Fetal growth and pregnancy requirements are substantial in the last 6 weeks of pregnancy and average approximately 1.5 × maintenance for single-bearing ewes and 2.0 × maintenance for twin-bearing ewes over this period.

Lactation Few estimates of the utilization of ME for lactation in sheep are available. The sheep has a relatively short lactation period, and the actual quantity and composition of the milk produced by animals suckling young is difficult to determine. Gardner and Hogue (1964) have estimated that 65–83 percent of ME is converted to milk energy during 12 weeks of lactation. The higher values were obtained from ewes suckling twins and the lower values from ewes with single lambs. The average of these values is slightly above that calculated for dairy cattle. These workers estimated that NE for lactation was 1.3–1.4 × maintenance NE in ewes with single lambs and 1.7–1.9 × maintenance NE in ewes with twin lambs.

Glucose turnover rates in lactating sheep have been shown by Bergman and Hogue (1967) to be nearly three times greater at the peak of lactation than during nonlactation (0.60 $g/h/W_{kg}^{0.75}$ vs. 0.23 $g/h/W_{kg}^{0.75}$). During maximal lactation, lactose production could account for about 60 percent of total glucose utilization.

These estimates indicate that the NE requirements of the ewe suckling twins at the peak of lactation may approximate three times the maintenance requirement, with a reduced requirement during later lactation and for ewes suckling single lambs.

NE Concentration of Feeds and NE Intakes Research by Rattray *et al.* (1973a,b) shows that the NE values (Mcal/kg DM) of feeds commonly used in the sheep industry can be quite precisely related to the ME value of the feed (Mcal/kg DM). The relationships are:

$$NE_m = 0.08\ ME - 0.41\ (r = 0.996,\ C.V. = 2.9)$$

$$NE_g = 0.67\ ME - 0.68\ (r = 0.95,\ C.V. = 15.5)$$

The relationship for prediction of NE_m was obviously more precise than the prediction of NE_g. These regressions were used to predict the NE values of diets for lambs over a range of ME concentrations and those values are shown in Table 8. Certain feeds may deviate widely from these relationships. It appears that the NE values for lambs are similar to those for beef cattle.

The influence of the ME concentration of the diet on *ad libitum* intake was reported by Rattray *et al.* (1973a). Table 9 contains voluntary dry matter intake expressed as a percentage of empty body weight and per unit of metabolic body size over a range of dietary ME concentration. Limited information indicates that sheep fed lower quality diets (i.e., lower than 1.6 Mcal ME/kg DM) may have lower intakes than listed in Table 9. The diets used by Rattray *et al.* (1973a) were fed pelleted to individually penned animals; and, therefore, in practice, intakes may vary from those listed when lambs are group-fed or fed a nonpelleted diet.

For a limited range of dietary ME concentration (2.4–2.6 Mcal ME/kg DM), the NE_{preg} value ranged from 0.38 to 0.45 Mcal NE_{preg}/kg DM.

PROTEIN

The protein requirements listed in Tables 1 and 2 are based on available research data. Satisfactory production from pregnant ewes (40–55 kg) has been realized with a daily intake of 45–60 g of digestible crude protein. These values may be minimal in the latter stages of pregnancy for those ewes carrying twins. In flocks where a large percentage of multiple births is expected, a slightly higher level of protein is suggested. These requirements may be minimal for maximal wool production, but it is uncertain whether this is a deficiency of crude protein or a shortage of the sulfur-containing amino acids at the tissue level. Requirements for lactation have been increased over those in previous editions, especially for ewes suckling twins.

Digestible energy/digestible protein ratios were considered in determining protein requirements. A ratio of about 20 g of digestible protein per Mcal of DE has been shown to be adequate for mature, nonlactating ewes. Higher levels of digestible protein are required per Mcal of DE for lactation, growth, and finishing.

The total crude protein requirements were calculated from the digestible protein requirements by using the regression

$$Y = 0.929\,X - 3.48,$$

where Y = digestible protein (percent of dry matter) and X = crude protein (percent of dry matter). Inasmuch as the formula was derived for high-roughage rations, the requirements as listed for total crude protein may be greater than needed when concentrates form appreciable portions of the diets. Apparent coefficients of digestibility of protein vary widely, ranging from 0 to 80 percent. True digestibility, however, would usually not fall below 80 percent. The higher crude fiber and lower crude protein concentrations of stemmy, mature, low-quality roughages result in lower apparent digestibility, because the metabolic nitrogen forms a greater portion of the total nitrogen in the feces. The apparent and true digestibilities of the protein in concentrates are in closer agreement.

Tables presenting protein requirements cannot be completely accurate for every situation. This is due primarily to differences in breeds, in weight of mature animals, in weight for age, and in body condition. To a lesser extent, inaccuracy results from rounding data to a form appropriate for use in tables, as when kilograms of feed intake are reported in tenths.

It is recommended that ewes beginning pregnancy in a very thin condition be fed protein levels somewhat above those recommended in the tables. Finishing lambs, gaining at a greater rate than those listed in the table and fed diets of greater energy concentrations than those listed, should also be fed somewhat greater amounts of protein.

Symptoms of Deficiency. Insufficient protein intake results in reduced appetite, lowered feed intake, and lowered efficiency in utilization of feed. Lower feed intake results in poor growth, poor muscular development, and loss of weight. The deficiency also reduces reproductive efficiency and wool production. Extreme deficiency results in severe digestive disturbances, anemia, and edema.

Quality of Protein

When the previous editions of this report were published, the quality of protein (level and balance of amino acids) was not generally considered a critical factor in the nutrition of sheep. The quantity fed and digestibility were considered more important than the source, because it had been demonstrated that sheep, through rumen fermentation, could synthesize the amino acids. Developments since that time, however, have shown that the protein produced by ruminal synthesis does not supply all the amino acids in quality or quantity needed by the host at the tissue level for maximal production. The diet fed does not appear to affect the amino acid composition of rumen bacteria and protozoa. Protozoal protein has a higher digestibility than bacterial protein. The amount of diet protein escaping microbial action and entering the abomasum can influence the quality of protein supplied to the tissues of the host animal. Less-soluble protein sources are more likely to escape the microbial action in the rumen.

Postruminal administration of protein and/or amino acids has increased voluntary consumption of feed, weight gains, and wool growth. The sulfur-containing amino acid, methionine, is the first limiting amino acid in microbial protein for both growth of wool and weight gain, followed by lysine and threonine. Cystine apparently can replace methionine for growth of wool. Treating high-quality protein sources to reduce microbial breakdown in the rumen is being actively investigated.

Heat treatment to reduce solubility and breakdown in the rumen, thereby improving retention of nitrogen, has had limited success. The use of tannic acid or one of the several aldehydes to complex proteins and reduce rumen microbial breakdown has been shown to reduce rumen ammonia levels and increase lamb performance. Much more research is necessary before such treatments become common practice in sheep production.

Nonprotein Nitrogen

Urea or other nonprotein nitrogen (NPN) sources can be used to provide all the supplemental nitrogen that may be needed in high-energy, grain-based diets, provided that the diets are properly formulated and fed continuously. The NPN can be used in either liquid or dry supplements. Maximal utilization of urea requires readily available energy, minerals, and other nutrients. Sulfur additions enhance urea-supplemented diets when sulfur is low in the feedstuffs. Wool contains a high percentage of the sulfur amino acids, and a ratio of 10 to 1 of nitrogen to sulfur in the diets is recommended for proper wool growth.

Urea is less suitable when used in high-roughage diets or when fed at infrequent intervals. However, properly prepared supplements containing urea can be used. Liquid supplements based on molasses–urea or other carriers for urea, and supplying some energy fortified with minerals and vitamins, are useful in adding nitrogen to roughage diets. Ammonium polyphosphate may form part of the nitrogen addition. "Slow release" formulations of urea and starch or other carbohydrates, ground and properly heated (partially gelatinized), may be utilized more efficiently in high-moisture diets than are urea–grain mixtures. Biuret is less soluble and releases ammonia more slowly than urea and may be used as supplemental nitrogen, especially under range conditions.

Nonprotein nitrogen sources are not used effectively until the rumen microorganisms have become adapted to the diet and dietary regime. Adaptation begins a day or two after inclusion in the diet, but may take as much as 3 to 5 weeks before maximum use of the nitrogen is obtained.

Safest and best results from urea are obtained if urea is used at not more than 1 percent of the dry matter in the diet, with grain or another readily available source of carbohydrate as the carrier. No data are available relating urea to reproduction in sheep, but in cattle the use of urea for breeding animals has been shown to have no deleterious effects.

Urea can be toxic if consumed in large amounts in a short time. Toxicity will vary, depending on the form in which urea is fed—liquid, dry, or "slow-release"—continuity of urea intakes and whether the sheep (rumen microorganisms) have or have not been adapted. Urea tends also to be more toxic if there is lack of available energy in the diet.

In a brief discussion on the use of nonprotein nitrogen in diets for sheep and lambs, it is impossible to adequately cite all research data. This review is an evaluation of data available at this time. Further research and clarification is necessary in several areas: the effectiveness of nonprotein nitrogen when it forms a large proportion of the nitrogen requirement; its effectiveness when used as the only supplemental nitrogen source under range conditions where the forage is of poor quality and energy possibly limiting; and the usefulness of certain feeds or ingredients in stimulating amino acid synthesis to supply adequate amounts and balance needed by the sheep at the tissue level.

MINERALS

Although the body contains many mineral elements, only 15 have been demonstrated to be essential for sheep. Seven are major mineral constituents: sodium, chlorine, calcium, phosphorus, magnesium, potassium, and sulfur. The other eight are trace elements: iodine, iron, copper, molybdenum, cobalt, manganese, zinc, and selenium. Additional elements under investigation with other species may eventually prove to be essential for sheep. Fluorine is discussed (p. 15) because of its toxicity to sheep.

Tables 10 and 11 present the mineral requirements of sheep, as well as the toxic levels when known. In both tables, the values are estimates based on available experimental data.

Sodium and Chlorine (Salt)

Salt serves in many functions in the body and may stimulate the appetite. The total salt requirement of growing lambs approximates 0.40 percent of diet dry matter. The sodium requirement is given in Table 10. The requirement for chlorine is unknown.

Range operators commonly provide 220–340 g of salt per ewe per month. Some drylot tests show that lambs consume about 9 g daily. Mature sheep in drylot may consume more.

When adding salt to mixed feeds, it is customary to add 0.5 percent to the complete diet or 1 percent to the concentrate portion. Salt may be safely used to limit free-choice supplement intake if adequate water is available. Such mixtures are usually 10–50 percent salt. Trace-mineralized salt should not be used for this purpose.

In many areas (commonly arid), water may contain enough salt to meet the requirements, and supplemental salt need not be offered.

Symptoms of Deficiency Animals that are deprived of adequate salt may try to satisfy their craving by chewing wood, licking dirt, or eating toxic amounts of poisonous plants. Inadequate salt intake may result in decreased feed consumption and decreased efficiency in utilization of nutrients.

Calcium and Phosphorus

Calcium and phosphorus depend on vitamin D and magnesium for proper utilization. Most pasture and range forage contains adequate amounts of calcium. Legumes are an excellent source and usually supply the animals' needs when included in the diet. Corn silage is a poor source. In some areas in the West, the soils are formed largely from calcium carbonate and dolomite, and forage in these areas may have a calcium content up to nine times higher than the level considered adequate. Areas where calcium supplementation is required when sheep are fed pasture or range forage have been reported in Florida, Louisiana, Nebraska, Virginia, and West Virginia. Finishing lamb diets based on low-quality roughage or high in concentrates may require calcium supplementation.

Phosphorus is a factor in the metabolism of almost all nutrients because of its role in enzyme activity. Mature pasture and range forage in North America are commonly deficient in phosphorus. Sheep efficiently utilize phosphorus, in part by recycling considerable amounts in the parotid and other salivary secretions. The phosphorus concentrations of parotid saliva, rumen fluid, and serum are all related to phosphorus intake. In some cases, sheep recycle more phosphorus per day in the parotid saliva than is required in the diet to maintain the body pools. This salivary phosphorus can buffer rumen phosphorus variations due to diet, particularly at lower phosphorus intakes.

Symptoms of Deficiency Diets that are decidedly lacking in calcium or phosphorus result in abnormal bone development. This condition is known as rickets in young animals and as osteomalacia in adults. In extreme cases, which may develop in lambs on high-grain diets, low levels of calcium may result in tetany.

Signs of calcium deficiency that are due to low intake of calcium develop slowly because the body draws on the supply of calcium in the bones until it is greatly reduced. Blood levels of calcium below 9 mg per 100 ml of serum indicate a calcium deficiency (hypocalcemia).

A phosphorus deficiency may be manifested by slow growth, depraved appetite, unthrifty appearance, listlessness, low level of phosphorus in the blood (less than 4 mg per 100 ml of plasma), and development of knock-knees (Figure 2).

Idaho Agricultural Experiment Station

FIGURE 2 Lamb fed a phosphorus-deficient ration and showing a typical knock-kneed condition.

Magnesium

Magnesium is necessary for many enzyme systems and for proper functioning of the nervous system. The exact requirement of magnesium for sheep is unknown, although forage containing 0.06 percent of magnesium is considered adequate for the adult range ewe. Hypocalcemia sometimes accompanies hypomagnesemic tetany and the hypocalcemia and grass tetany will respond to treatment with magnesium salts. The need for a continuous supply of magnesium is recognized. The use of intraruminal magnesium alloy pellets (bullets) weighing 30 g has effectively prevented hypomagnesemic tetany in lactating ewes.

Symptoms of Deficiency The function of magnesium is closely associated with the metabolism of calcium and phosphorus. Thus, hypocalcemia sometimes accompanies hypomagnesemic tetany, a hyperirritability of the neuromuscular system (Figure 3). Acute tetany may occur as a result of insufficient dietary magnesium or inability to mobilize skeletal magnesium. In some forms of tetany, the ratio of potassium to calcium and magnesium is altered. Blood serum normally contains about 2.5 mg of magnesium per 100 ml.

Illinois Agricultural Experiment Station

FIGURE 3 Lamb in tetany resulting from magnesium deficiency. Note stiff hind legs and head retraction.

Potassium

The potassium requirement of sheep appears to be about 0.5 percent of the diet. Research has not confirmed the theory that the high dietary ratio of potassium to sodium, often occurring in grass, depletes the body of sodium and chlorine.

Sulfur

Sulfur functions in the synthesis of sulfur-containing amino acids in the rumen and various compounds of the body. Wool is high in sulfur; thus, this element is closely related to wool production.

Much information has been obtained in recent years about sulfur metabolism in the rumen, losses that occur, requirements of the microorganisms, and the recycling of sulfur and nitrogen. This information supports the recommendation that a dietary nitrogen–sulfur ratio of 10:1 be maintained. This is narrower than the ratio formerly recommended. Requirements in percentage of diet dry matter are as follows: mature ewes, 0.14–0.18 percent; young lambs, 0.18–0.26 percent.

Practically all common feedstuffs contain more than 0.1 percent of sulfur. However, mature grass and grass hays (especially those grown on granitic soils) are sometimes low in sulfur and may not furnish enough for optimal performance. Where forages are low in sulfur, or where diets contain relatively large quantities of urea, weight gains and growth of wool can be increased by feeding a sulfur supplement, such as sulfate sulfur, elemental sulfur, or sulfur-containing proteins or amino acids. Inorganic compounds are generally more convenient and economical for supplemental feeding.

Symptoms of Deficiency The signs of sulfur deficiency are similar to the signs of protein deficiency. They also include excessive salivation, lacrimation, and shedding of wool (Figure 4).

Iodine

Iodine is necessary for the formation of thyroxine, a hormone of the thyroid gland. Iodine-deficient areas

Illinois Agricultural Experiment Station

FIGURE 4 This lamb was fed a diet containing low sulfur. Note excessive salivation, lacrimation, and shedding of wool.

are widely scattered throughout the United States. Serious losses of lambs can be prevented in these areas by feeding iodized salt to breeding ewes during gestation. Iodized salt is generally formulated by adding 0.0078 percent of stabilized iodine to salt. Stabilization is necessary to prevent losses from exposure to sunlight or moisture.

Iodized salt should not be used in a mixture with a concentrate supplement to limit feed intake, as the animals may consume an excessive amount of iodine.

Symptoms of Deficiency In newborn lambs, the most common sign of iodine deficiency is enlargement of the thyroid gland. If the condition is not advanced, the lambs may survive. Other signs are lambs born weak, dead, or without wool (Figure 5).

Signs of deficiency in mature sheep seldom take the form of a change in the animals' appearance. However, through impairment of physiological functions, deficiency may result in reduced yield of wool and reduced rate of conception.

Montana Veterinary Research Laboratory, Bozeman, Montana

FIGURE 5 *Top:* Ewe showing typical goiter due to iodine deficiency. *Bottom:* A wool-less newborn lamb, a result of iodine deficiency of the ewe.

Iron

There is no evidence that iron deficiency occurs normally in lambs or sheep. However, iron deficiency anemia sometimes occurs in lambs raised on slotted, wooden floors. This anemia can be prevented by giving intramuscular injections of iron-dextran or by offering a commercial, oral iron compound, free-choice, in the creep area. Two injections, 150 mg of iron in each, given 3 weeks apart, are required.

Copper

Copper deficiency may exist as a primary deficiency or in combination with a deficiency of cobalt or iron. Anemia is associated with copper deficiency. Animals suffering from inadequate copper intake appear unable to absorb iron at a normal rate, and a deficiency in hemoglobin synthesis results.

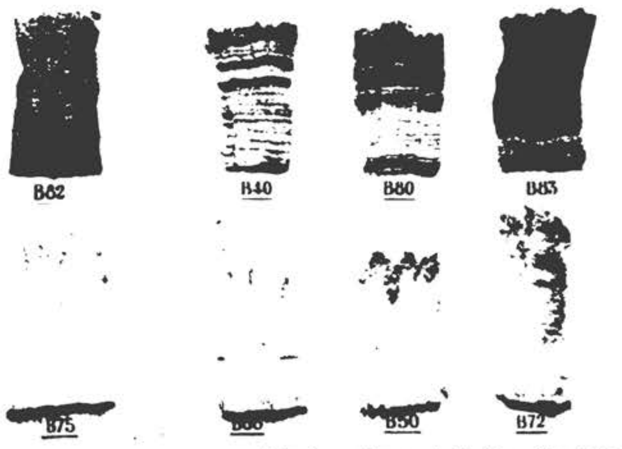
The dietary concentration of copper should be 5 ppm on a dry matter basis if molybdenum and sulfate levels are normal (discussed later). Merino sheep are less efficient in absorbing copper from feedstuffs than British breeds and therefore need an additional 1–2 ppm in their diet.

Copper as a nutritional element is found in adequate amounts over most of the United States. Deficient areas have been reported in Florida and in the coastal plains region of the Southeast. Copper can be provided conveniently in deficient areas by adding copper sulfate to the salt at a rate of about 0.5 percent. Stores of copper in the liver, kidney, heart, lungs, pancreas, and spleen serve as a reserve for as long as 4–6 months when animals are grazing copper-deficient forage.

For discussions of molybdenum and copper interrelationships and of molybdenum or copper toxicity, see "Molybdenum," below.

Symptoms of Deficiency If copper deficiency exists, signs generally seen in suckling lambs include muscular incoordination, partial paralysis of the hindquarters, and degeneration of the myelin sheath of the nerve fibers. Lambs may be born weak and may die because of their inability to nurse.

Sheep suffering from copper deficiency have been found to produce "steely" or "stringy" wool, which is lacking in crimp, tensile strength, affinity for dyes, and elasticity. Depigmentation of the wool of black sheep has been noted as a sign of severe deficiency. The condition is similar to that noted in black sheep on high levels of molybdenum (Figure 6).



Veterinary Research Station, Glenfield, New South Wales, Australia

FIGURE 6 Wool from normal and hypocuprotic sheep. The two samples on the left (B82 and B75) are from normal sheep. The other six samples are from sheep supplemented with sulfate-molybdenum to produce hypocuprosis. Note the banding of the three black wools and the loss of definition of crimp in all of the six samples.

Molybdenum

There is some question concerning the role of molybdenum in the diet of livestock. It is believed that molybdenum complexes with copper in the intestine and that the copper bound in this form is biologically inactive. Research has shown that feeds containing small amounts of molybdenum are more effectively digested and produce more rapid gains in weight than do diets not containing molybdenum.

Molybdenum and Copper Interrelationships McDonald (1968) summarized the relationships between molybdenum and copper as follows:

> Evidence from both field and laboratory work shows that dietary intakes of copper, molybdenum and sulphate form a most complex set of interactions with profound effects on the animal, but the mechanisms involved are still obscure. The main features are as follows. A high molybdenum intake can induce a copper deficiency even when the copper content of the pasture is quite high; the effect can be prevented by providing an increased copper intake. . . .
>
> When pastures provide the animals with low intakes of molybdenum, excess of copper tends to accumulate in tissues, especially the liver, even when the copper intake is moderate. The liver copper concentrations may become very high, and under certain stress conditions copper can be mobilised rapidly from the liver, increasing the copper in the blood and thus precipitating a haemolytic crisis with consequent fatal jaundice. The disease can be prevented by increasing the molybdenum intake of the animals. . . . These two contrasting situations make it very difficult to define nutrient requirements of copper and molybdenum and to predict the reactions of animals in any given pastoral situation. There are marked differences in the responses shown by sheep and cattle . . . sheep are very much more susceptible to copper poisoning than cattle; but cattle are very much more severely affected than sheep by high molybdenum intakes; . . . The physiological factors that determine these differences are by no means evident.

Although McDonald's summary is confined to animals on pasture, the increased incidence of copper toxicity in recent years seems to be associated chiefly with drylot feeding. This tendency has been noted in New Zealand, Great Britain, Canada, and the United States.

Molybdenum Toxicity and Copper Toxicity In California, Nevada, and England there are areas where an excess of molybdenum causes a scouring disease among sheep. The sheep start to scour a few days after being turned on pasture having a high molybdenum content (5–20 ppm on a dry matter basis). The feces become soft, the fleece becomes stained, and the animals lose weight rapidly. When the dietary copper level falls below normal or the sulfate level is high, molybdenum intake as low as 1 or 2 ppm may prove toxic. Molybdenum toxicity is controlled by increasing the copper level in the diet by 5 ppm.

Complete manufactured feeds for sheep in the United States may contain 25–35 ppm of copper. When vitamin–mineral preparations are added to feeds, the copper content of the diet may be equally high. These levels of copper can be extremely harmful if the molybdenum level of the diet is low. In fact, if the molybdenum level is extremely low (less than 1 ppm), forage with a "normal" copper content of 8–11 ppm can produce toxicity. The normal concentration of copper in blood is 0.7–1.3 ppm.

The concentration of copper in the liver gives a reliable indication of the copper status of sheep. The concentration in the kidney cortex is a better criterion for diagnosing copper poisoning. In most cases of copper poisoning, concentrations of copper, on a dry matter basis, are more than 500 ppm in the liver and more than 80–100 ppm in the kidney cortex. Hemolysis, jaundice (easily detected in the eyes), and hemoglobinuria are characteristic signs of toxicity and result in very dark-colored liver and kidneys (Figure 7).

In treating copper toxicity, both molybdenum and sulfate should be administered. Dietary inorganic sulfate alone has no effect on uptake or reduction of copper in the liver or on utilization of copper for synthesis of ceruloplasmin. High dietary concentrations of zinc protect against copper intoxication. A diet of 100 ppm of zinc on a dry matter basis reduces liver copper storage.

An effective pharmacological treatment for copper toxicity in lambs is to drench each lamb daily with 100 mg of ammonium molybdate and 1 g of sodium sulfate

J. R. Todd, Veterinary Research Laboratory, Stormont, Northern Ireland

FIGURE 7 Liver and kidney from a case of copper poisoning. Note characteristic black areas.

in 20 ml of water. Treatment usually requires a minimum of 3 weeks. The Food and Drug Administration does not recognize molybdenum as safe, and the law prohibits adding it to feed for sheep. Prevention can often be accomplished by reducing or eliminating extraneous sources of copper in the diet.

Cobalt

The important function of cobalt in sheep nutrition is to promote synthesis of vitamin B_{12} in the rumen. Although levels of vitamin B_{12} in the contents of the rumen and in the blood and liver are indicators of the cobalt status of sheep, the vitamin B_{12} content of the feces is an indicator that can be used with obvious advantage.

Jones and Anthony (1970) developed an equation for estimating oral intake of cobalt on the basis of the concentration of vitamin B_{12} in the feces:

$$Y = 0.0779X - 0.0757,$$

where Y represents the oral intake of cobalt expressed as ppm in dry feedstuff and X represents the concentration of vitamin B_{12} in the feces, expressed as micrograms of vitamin B_{12} per g of dry feces.

Research in sheep nutrition has shown that cobalt should be ingested frequently, even daily. Thus, an effort is made to supply it by methods that insure frequent ingestion. In the United States a highly effective method is to add cobalt to salt. Other effective methods are to add cobalt to the soil, to place cobalt pellets into the rumen that drop into the reticulum, and to administer daily doses of cobalt. All of these are superior to intermittent dosing or feeding.

Areas deficient in cobalt have been widely reported in the United States and Canada. Feed or forage containing more than 0.07 ppm of cobalt on a dry-matter basis has prevented a deficiency. Precise requirements for all sheep under all conditions are difficult to determine. The recommended amount is 0.1 ppm. An intake of 0.1 mg daily for a 54-kg sheep is considered adequate to meet this requirement.

A preventive measure suggested for deficient areas is to feed cobalt at the rate of 12 g per 100 kg of salt as cobalt chloride or cobalt sulfate. For short periods, sheep have been fed 350 mg of cobalt per 100 kg of body weight without ill effects and levels at about 450 mg per 100 kg of body weight have been suggested as toxic.

Symptoms of Deficiency Cobalt deficiency causes lack of appetite, lack of thrift, severe emaciation, weakness, anemia, decreased fertility, and decreased milk and wool production (Figure 8).

Manganese

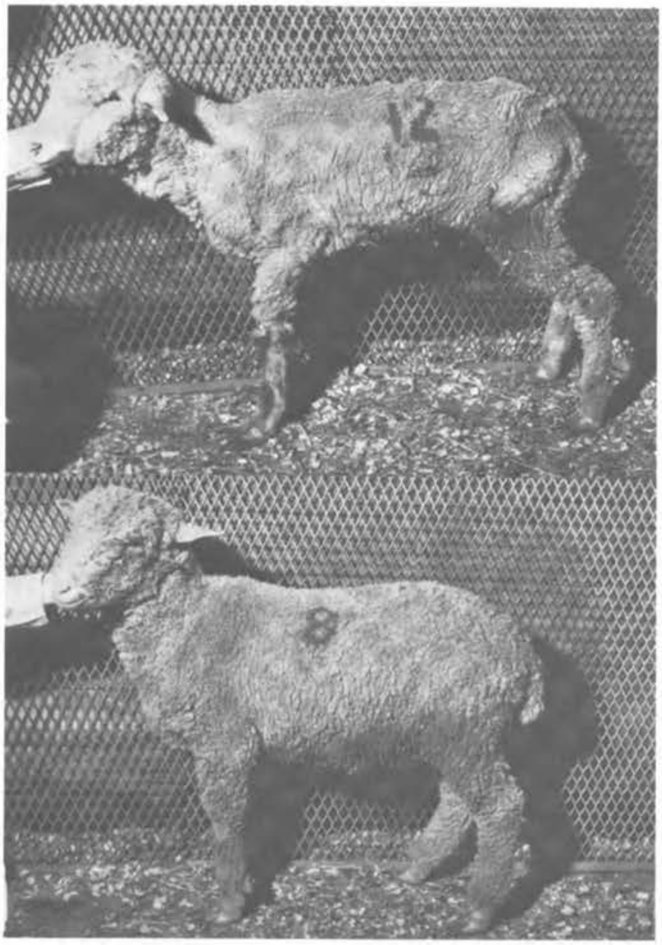
Manganese deficiency had not been produced in sheep or goats until 1968 when early-weaned lambs receiving a purified diet containing less than 1 ppm of manganese over a 5-month period exhibited bone changes similar to those seen in other manganese-deficient animals. Sheep probably need manganese for skeletal development, as various other species do. The levels of manganese in wool appear to be quite sensitive to changes in the manganese status of the lambs.

The growth of female goats fed 20 ppm of manganese for the first year of life and 6 ppm the following year was not affected, but this low manganese level did delay the onset of estrus and required more inseminations per conception. No goats aborted in the control group (100 ppm), but 23 percent of those on the low-manganese diet aborted. The low-manganese diet also resulted in a 20-percent reduction in birth weights, the birth of more male than female kids, and the death of more female than male kids. Bone structure was not affected. In mature goats the manganese content of the hair was a better indicator of manganese status than any other part of the body.

The exact requirements of sheep for manganese are not known.

Zinc

The most striking clinical signs of zinc deficiency in ram lambs are impaired growth of the testes and



Cornell Agricultural Experiment Station

FIGURE 8 *Top*: Cobalt-deficient lamb fed ration containing 0.05 ppm of cobalt—weight 22 kg at end of experimental period. *Bottom*: Positive control lamb that daily received in addition 0.1 mg of cobalt as the sulfate—weight 42 kg.

complete cessation of spermatogenesis. Atrophy of the testes can occur within 20 to 24 weeks after the lambs are put on a diet containing 2.4 ppm of zinc. When put on a diet containing 32.4 ppm of zinc, the lambs recover and testicular size and function return to normal. Adequate body growth is obtained with a diet containing 17.4 ppm of zinc. Since a diet containing 32.4 ppm is necessary to obtain normal growth of the testes, it appears that the requirement for male reproduction is greater than for growth. Evidence indicates that utilization of protein is impaired in zinc-deficient sheep. One g of zinc per kg of diet causes reduced consumption of feed and reduced gain in lambs.

Symptoms of Deficiency Two signs of deficiency, impaired growth of the testes and cessation of spermatogenesis, are referred to above. Lambs fed a zinc-deficient diet for 10 weeks showed slipping of wool, swelling and lesions around the hooves and periorbital regions of the eyes, excessive salivation, anorexia, a tendency to eat wool, general listlessness, and reduced growth. When the animals were fed a diet containing 100 ppm of zinc for 5 weeks, the daily gain was increased from 23 to 290 g and the other clinical signs were alleviated (see Figure 9).

Selenium

In the northwestern, northeastern, and southeastern parts of the United States there are extensive areas where the selenium content of crops is below 0.1 ppm (Figure 10). This is the level considered adequate for preventing deficiency in sheep, and selenium-responsive diseases are most likely to occur in these areas. In an area extending roughly from the Mississippi River to the Rocky Mountains, the selenium content of crops is predominantly in the nutritionally adequate but nontoxic range of selenium concentration (Figure 10). Parts of South Dakota, Wyoming, and Utah produce forage that causes selenium toxicity in farm animals.

Selenium deficiency has serious effects on lamb production. The major manifestations of deficiency are reduced growth and white muscle disease (WMD), which affects lambs 2–8 weeks of age.

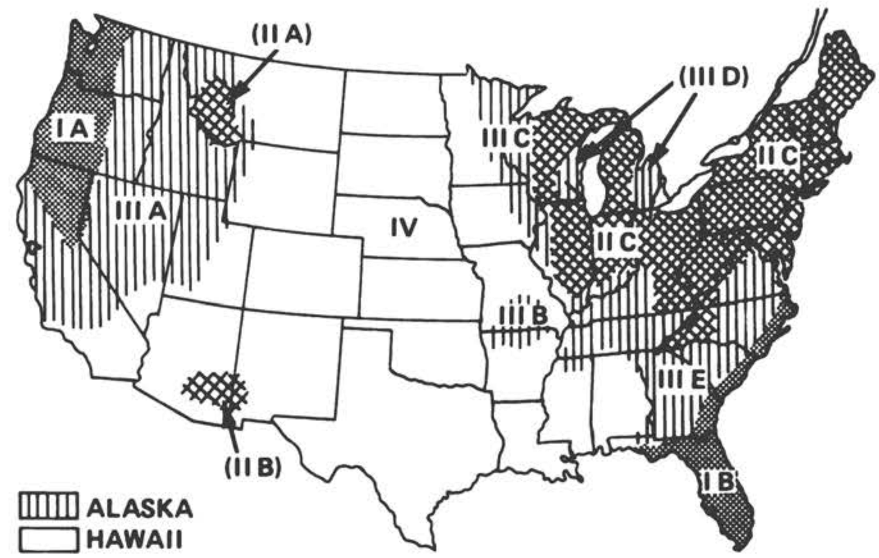
Experimentally, WMD in lambs can be prevented by adding inorganic selenium as sodium selenate to trace-mineralized salt and offering the salt, free-choice, to ewes. The addition of 26 ppm of selenium in the salt supplied about 0.15 ppm to the total diet of the ewes, and the addition of 132 ppm in the salt supplied about 0.90 ppm. While the ewes were in drylot, their diets, before supplementation, contained about 0.03 ppm of selenium. Supplementation at these levels (26 and 132 ppm) provided maximal protection against occurrence of WMD in the lambs and promoted their growth. Continuous supplementation at these levels for 4 years did not result in abnormal appearance, deaths, or excessive accumulation of selenium in the tissues of the ewes or their lambs.

Supplementation at the above levels for 1 year did not result in muscular accumulation of selenium compared with lambs without selenium supplementation, raised under practical conditions, in various parts of the United States. However, the addition of 264 ppm of selenium to the salt, which supplied about 2 ppm of selenium to the diets of the ewes, reduced the lambs' weight gains in 2 of the 4 years of experimentation.

Other experimental methods of supplying selenium to sheep include an oral drench, subcutaneous or intramuscular injection, addition of selenium to feedstuffs, and application of selenium to the soil. The

FIGURE 9 The deficient lamb on the left received a basal diet containing 3 ppm zinc. The normal lamb on the right received a diet containing 100 ppm zinc.

Purdue Agricultural Experiment Station



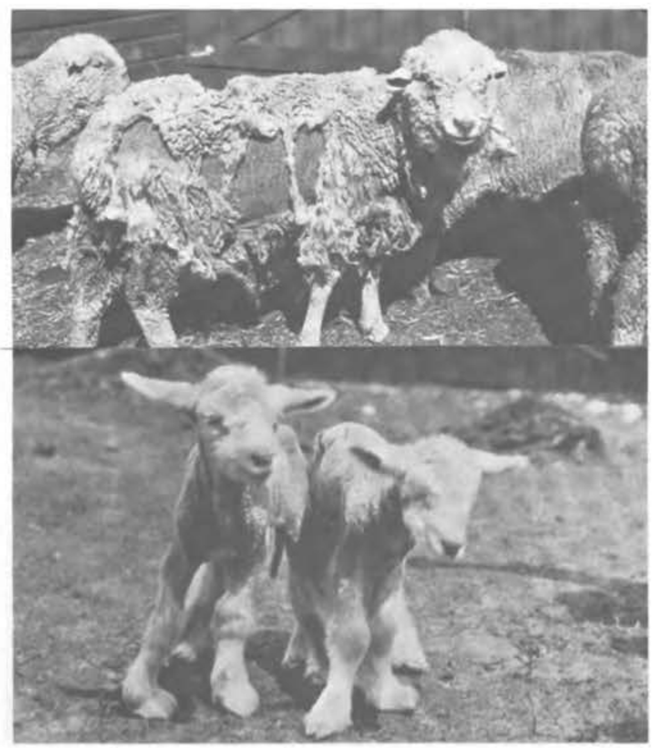
AREA	CROP	NO. OF SAMPLES	MEDIAN CONC.	FREQUENCY DISTRIBUTION (%) OF SAMPLES WITH Se CONCENTRATIONS (ppm) OF: <0.01 to 0.05	0.05 to 0.10	0.10 to 0.50	0.50 to 1.0	1.0 to 5.0	>5
I A	FORAGES	69	0.03	81	15	4	0	0	0
I B	FORAGES	26	0.02	89	11	0	0	0	0
II A	FORAGES	14	0.05	50	36	14	0	0	0
II B	FORAGES	11	0.05	36	45	19	0	0	0
II C	FORAGES	187	0.05	65	31	4	0	0	0
III A	FORAGES	261	0.09	20	31	43	4	2	0
III B	FORAGES	14	0.05	57	14	22	0	7	0
III C	FORAGES	39	0.09	20	41	26	13	0	0
III D	FORAGES	27	0.10	26	18	49	7	0	0
III E	FORAGES	79	0.06	50	23	22	5	0	0
IV	FORAGES	205	0.26	3	10	60	18	9	0
	WHEAT	856	—	— 9 —		22	30	34	5
	FEED GRAIN	262	—	— 33 —			22	38	7

FIGURE 10 Relative concentrations of selenium in crops from different areas of the United States. Data for wheat and feed grain are from U.S. Department of Agriculture Technical Bulletin 758 (1941). From Kubota *et al.* (1967). Copyright 1967 by the American Chemical Society. Reprinted by permission of the copyright owner.

most recent method reported is the incorporation of selenium in pellets, which are composed of finely divided metallic iron and elemental selenium in a proportion of 20 to 1. A single pellet in the reticulum has enhanced selenium levels in the blood and in tissues for as long as 12 months.

At present the only method of supplying selenium to lambs in deficient areas in the United States is to inject a commercial pharmacological product containing selenium and vitamin E. According to the manufacturer, lambs should receive two intramuscular injections, the first at birth and the second 2 weeks later (see "Vitamin E," p. 17). The first injection contains 0.25 mg of selenium as sodium selenite and 68 IU of vitamin E as *d*-α-tocopherol. The second injection contains 1.0 mg of selenium from the same source and 68 IU of vitamin E.

Glutathione peroxidase is the first selenoenzyme to be identified in animal tissues. The level of this enzyme in tissue can be considered a more sensitive indicator of dietary adequacy for lambs than is tissue selenium content. Using this criterion, 0.10 ppm of dietary selenium has been shown to satisfy the requirement of lambs but 0.05 ppm selenium did not.



Wyoming Agricultural Experiment Station

FIGURE 11 *Top*: Ewe suffering from selenium toxicity. Loose wool is typical of sheep afflicted with chronic selenium poisoning. *Bottom*: Congenital deformity traceable to selenium injury during fetal development.

Symptoms of Deficiency The signs of selenium deficiency in lambs are white muscle disease and reduced growth. Impaired fertility has not been found to be a deficiency sign in the areas referred to on p. 13, but it has been found to be a symptom in New Zealand.

Selenium Toxicity Chronic selenium toxicity occurs when sheep consume seleniferous plants containing more than 3 ppm of selenium over a prolonged period. Toxicity signs include loss of wool, soreness and sloughing of the hooves, and marked reduction in reproductive performance (Figure 11).

The toxicity of forage depends somewhat on its protein and sulfur content. The extent to which plants take up selenium varies greatly. Some species of plants grown on seleniferous soils contain as much as 1,000 ppm, whereas other species grown on the same soils contain only 10–25 ppm.

The most practical way to prevent livestock losses from selenium poisoning is to manage the animals' grazing so that they alternate between selenium-bearing and other areas.

Selenium is a cumulative poison, but mild chronic signs can readily be overcome. The mineral is eliminated rapidly from the body of an affected animal when it is fed selenium-low forage. Small amounts of arsanilic acids are effective in reducing the toxicity of selenium.

Fluorine

Fluorine rarely occurs free in nature, but combines chemically to form fluorides. In some parts of the world fluoride occurs in the water supply in amounts that may be high enough to have deleterious effects. Another danger lies in the use of rock phosphate that contains fluorine in amounts sufficient to be toxic—3–4 percent.

Proper defluorination procedures are necessary to make rock phosphate safe for animal supplementation. Forage growing near manufacturing units processing minerals containing fluorides may be seriously contaminated with fluoride.

Fluorine exerts a cumulative toxic effect. Symptoms may not be observed until the second or third year of animal intake of low levels of fluoride. Affected animals usually exhibit anorexia. The normal ivory color of the bones gradually changes to chalky white. The bones thicken because of periosteal hyperostosis. The teeth, especially the incisors, may become pitted and eroded to such an extent that the nerves are exposed.

Finishing lambs can tolerate up to 150 ppm of fluorine in the diet on a dry matter basis. Acute toxicity can occur at 200 ppm.

Data are not available on the tolerance level of breeding sheep over their lifetime. However, breeding sheep should not be fed a diet containing more than 60 ppm of fluorine on a dry matter basis.

VITAMINS

Vitamin A

Dietary vitamin A or its precursor, carotene, is necessary for maintaining normal epithelial tissues. The international standards for vitamin A activity as related to vitamin A and β-carotene are as follows: 1 IU of vitamin A = 1 USP unit = vitamin A activity of 0.300 μg of crystalline vitamin A alcohol, which corresponds to 0.344 μg of vitamin A acetate or 0.550 μg of vitamin A palmitate. β-Carotene is the standard for provitamin A. One IU of vitamin A activity = 0.6 μg of β-carotene. One mg of β-carotene = 1,667 IU of vitamin A based on conversion by the rat.

Since sheep do not convert carotene to vitamin A in the same ratio as rats, it is suggested that 1 mg of feed carotenes be considered as the equivalent of 400–700 IU of vitamin A. It is now recognized that relative values for carotene are lower under any of the following conditions:

Xanthophylls and other carotenes of lower biological potency are diluents of β-carotene.
Animals deficient in vitamin A.
Low diet digestibility.
Oxidants in the feed, ingesta, or tissues.
Goitrogenic agents present.
High-phosphorus diets.
Low-vitamin E diets.
Very low dietary fat levels will decrease vitamin A utilization.

It is also recognized that utilization of carotene is improved at lower levels of intake or when fed as pure β-carotene.

Guilbert *et al.* (1940) investigated the amounts of vitamin A alcohol and of carotene that are required to prevent night blindness in sheep, cattle, and swine, and the amounts required for storage and reproduction. With respect to vitamin A alcohol, they found that a daily intake of 4.3–6.3 μg (17–26 IU) per kg of body weight was required to prevent night blindness and that three times this level was required for storage and reproduction. With respect to carotene, they found that a daily intake of 25–35 μg (42–58 IU) per kg of body weight was required to prevent night blindness and that five times this level was required for storage and reproduction. The minimums (17 IU per kg of body weight for vitamin A alcohol and 25 μg per kg of body weight for carotene) were used as the bases for calculating the vitamin A and carotene requirements stated in Tables 1 and 2. The requirements for late pregnancy, lactation, and early-weaned lambs were calculated by multiplying the minimums by 5, those for replacement lambs and yearlings by multiplying by 2.5, and those for finishing lambs and for ewes during maintenance and the first 15 weeks of gestation by multiplying by 1.5.

Vitamin A is fat-soluble and is stored in the body. About 200 days are required to entirely deplete the vitamin A stores in the livers of ewe lambs previously pastured on green feed. Because of this storage, animals that graze on green forage during the normal growing season are able to do reasonably well on a low-carotene diet of dry feed for periods of 4–6 months.

Both vitamin A and carotene are subject to loss by oxidation. Stabilized vitamin A, which is resistant to oxidation, may be added to diets of low-carotene content. Sun-cured hay is usually lower in carotene than dehydrated hay. Diets that contain little green or yellow material or that have been badly weathered, heated, or stored for long periods are low in carotene.

Sheep that are deficient in vitamin A and weigh 32 kg or more should receive 100,000 IU of vitamin A by injection, and their diets should be adjusted to provide recommended levels of vitamin A or carotene. Ewes deficient in vitamin A should be given vitamin A either orally or by injection prior to breeding.

Symptoms of Deficiency Vitamin A deficiency results in keratinization of the respiratory, alimentary, reproductive, urinary, and ocular epithelia. Keratinization causes lowered resistance to infections. A deficiency of vitamin A interferes with the normal development of bone. Also, a deficiency can result in the production of lambs that, at birth, are weak, malformed, or dead (Figure 12).

Night blindness has long been recognized as a sign of vitamin A deficiency, and its appearance or nonappearance has been the most common means of determining the vitamin A status of animals. Research with sheep and dairy calves indicates that pressure of the cerebrospinal fluid is an indicator of vitamin A status with increased pressure being a sign of deficiency.

Vitamin D

Since vitamin D is required in addition to calcium and phosphorus for preventing rickets, it has been called

California Agricultural Experiment Station

FIGURE 12 Ewe fed low-carotene ration during gestation. One lamb was born dead, and the other died 6 hours after birth.

the antirachitic factor. Additions of vitamin D to lamb rations low in this nutrient have resulted in increased growth even when the lambs did not show rickets.

Since it is fat-soluble and stored, it is less important in mature animals, except in the case of pregnancy, when demands are greater. Congenital malformations in the newborn may result from extreme deficiencies. Newborn lambs are provided with enough vitamin D from their dams to prevent rickets for 4–6 weeks, if the dams have adequate storage.

Animals exposed to sunlight obtain some of their vitamin D through irradiation, and the amount so received may be enough to meet their requirements. Animals with white skin or short wool receive more vitamin D activity through irradiation than do animals with black skin or long wool.

Sheep on pasture seldom need additional vitamin D. The question of adequacy arises if the weather is cloudy for long periods or if the sheep are fed indoors. Under these conditions, it is especially important that attention be given to the vitamin D content of the diet of fast-growing lambs. Sheep use vitamin D_2 and vitamin D_3 equally well.

In Tables 1 and 2, the requirements are given as follows: for all classifications except early-weaned lambs, 555 IU per 100 kg of body weight; for early-weaned lambs, 666 IU per 100 kg of body weight.

Sun-cured hays are fairly good sources of vitamin D. Dehydrated hays, green feeds, seeds, and by-products of seeds are poor sources. Vitamin D is subject to loss by oxidation. Although it oxidizes slower than vitamin A, its stability is poor when it is mixed with minerals (its stability is especially poor when it is mixed with calcium carbonate).

Recent research indicates that vitamin D (cholecalciferol) is converted to active forms in the liver and kidney and acts in metabolism by affecting calcium absorption, deposition, and mobilization from the bone.

Vitamin E

White muscle disease (WMD), which results from vitamin E or selenium deficiency, has been observed in lambs for many years (Figure 13). The disease is also called nutritional muscular dystrophy and stiff lamb disease. Stiffness in the muscles resulting from infection or injury is frequently mistaken for WMD.

Vitamin E is a dietary requirement for young nursing lambs, but it seems to have no further practical importance as a dietary supplement in sheep nutrition. Many

Oregon Agricultural Experiment Station

FIGURE 13 *Top*: Lamb showing "stiff" hind legs, a symptom of white muscle disease. *Bottom*: Muscle of upper hind leg showing typical "white" lesions.

experiments have been conducted to determine whether vitamin E deficiency is related to reproductive failure in sheep. No relationship has been found.

Vitamin E and selenium appear to have an additive effect on reduction of serum levels of glutamic oxaloacetic transaminase (GOT), increasing survival time and decreasing the level of urinary creatine excretion in deficient lambs less than 8 weeks of age. The need for vitamin E in the diets of young nursing lambs can therefore be related to the selenium level in the diets. Signs of WMD in lambs are prevented by providing *dl*-α-tocopherol and selenium in the diets. Both the *dl* and *d* forms of α-tocopherol are useful, with the acetate ester being more stable than the alcohol. Good responses are obtained when lambs receive 11 mg of *dl*-α-tocopherol per kg of body weight weekly in diets containing 0.1–1.0 ppm of selenium. (See "Selenium," pp. 13–15.)

Symptoms of Deficiency The signs of WMD appear in nursing lambs as a stiffness (especially in the rear quarters), tucked-up rear flanks, and arched back. On necropsy, the disease is shown as white striations in the muscles and is characterized by bilateral lesions. Serum levels of both GOT and lactic acid dehydrogenase are elevated, which is indicative of muscle damage. Blood levels of the selenium-containing enzyme glutathione peroxidase are reduced. Affected lambs often die of pneumonia and starvation.

Vitamins K_1 and K_2

Vitamins K_1 and K_2 are fat-soluble and either of the two are necessary in the blood-clotting mechanism. Green leafy materials of any kind, fresh or dry, are good sources of vitamin K_1. Vitamin K_2 is normally synthesized in large amounts in the rumen, and no need for dietary supplementation has been established.

Vitamin B Complex

The B vitamins are not required in the diet of sheep with functioning rumens, because the microorganisms synthesize these vitamins in adequate amounts. Lambs fed a niacin-deficient diet for 8 months have developed normally. Sheep fed a diet low in thiamine, riboflavin, pyridoxine, and pantothenic acid have synthesized these vitamins in their rumens. There is no evidence that supplementation with the vitamin B complex affects the performance of ewes during breeding and pregnancy.

Cobalt is necessary for the synthesis of vitamin B_{12} in the rumen. (See "Cobalt," p. 12.)

Prior to having developed rumens, young lambs (up to about 2 months of age), if early weaned, may have a dietary need for vitamin B_{12}, thiamine, pyridoxine, riboflavin, niacin, folic acid, and possibly some of the other B vitamins since they will not be receiving these in milk from their dams.

Vitamin C

Vitamin C is not an essential dietary constituent for sheep since it is synthesized rapidly enough by the tissues to meet the animals' needs.

WATER

Sheep get water from snow, dew and guttation, and metabolic water; in feed; and by drinking. The exact amount that they need is not known. However, since sheep are able to adjust water intake to balance their body water, most researchers have assumed that the voluntary intake of free water drunk is an indication of the requirement.

The amount of water that sheep voluntarily consume is determined by many factors, including ambient temperature, rainfall, snow and dew covering, age, breed, stage of production, wool covering, respiratory rate, frequency of watering, amount of feed consumed, composition of feed, and composition of pasture. Exercise or activity may become a significant factor. Observations indicate a 20-percent increase in water consumption in sheep exercised 4 miles a day at 1.5 mph.

Sheep normally drink water after consuming feed in drylot. Sheep that have been without feed for as much as 36 hours have shown no desire for water until after they have eaten. In general, voluntary consumption of water is two or three times the intake of dry matter. There appears to be no physiological water distribution change in the body until water intake is below 75 percent of *ad libitum* consumption.

Forbes (1968) has confirmed that there is a significant relationship between the total water intake (TWI) and dry matter intake (DMI) of nonpregnant ewes. The results are represented by the formula:

$$\text{TWI} = 3.86(\pm 0.75)\text{DMI} - 0.99.$$

The intake units were expressed in kilograms (per head daily) and the diet consisted of wilted grass silage. There is also a significant relationship between water intake and mean temperature higher than 1 °C:

$$\text{TWI/DMI} = 0.18(\pm 0.03)T + 1.25.$$

where TWI/DMI is the mean total water intake per unit of dry matter intake (kg/kg) and T is the mean of the daily maximum and minimum temperatures in °C for each week.

The TWI/DMI increases significantly during the third month of pregnancy and is doubled by the fifth month. Ewes carrying only one lamb need less water than those carrying twins. Failure to meet the water requirement during late pregnancy can depress dry matter intake, which could predispose ewes to pregnancy toxemia.

Forbes (1968) suggests that the estimate that lactating ewes need 50-percent more water than dry ewes (Agricultural Research Council, 1965) is too low. His data reveal that TWI/DMI in early lactation is greater than the sum of TWI/DMI of the nonpregnant ewes and the water in the milk. The same is true in late pregnancy, when the water intake is higher than can be accounted for in fetuses and fetal fluids. It is suggested that the increased water intake in late pregnancy is due to extra heat produced during pregnancy, which results in greater water loss from vaporization, and to a higher metabolic rate during lactation, which results in greater excretion. It is apparent from these data that TWI/DMI for lactating ewes during the first 4 months of lactation is double that of nonlactating ewes.

Nonbreeding Merino sheep have been maintained for two years without drinking water in a temperate climate with no reduction in wool production or body weight. In this climate the mean daily air temperatures do not exceed 25 °C, and rain usually falls each month of the year with an annual average of 854 mm. Lactation, together with low-moisture content of pasture and high ambient temperatures, resulted in a 25-percent mortality of ewes. Removal to green pasture stopped deaths, although no drinking water was offered. Ewes deprived of drinking water appeared to obtain most of their water from dew and guttation by licking the pasture and fences and by grazing more actively during the night and predawn period. There was less fecal and urinary water loss and the birth weight of lambs from ewes without drinking water was reduced. There was no reduction in numbers of lambs born.

Sheep with a restricted drinking water supply select plants of higher moisture content. Sheep with a choice of diets that are high or low in salt can reduce the effect of a restricted water supply by choosing diets that are low in salt. Sheep may consume as much as 12 times more water in summer than in winter. They will drink water as warm as 63 °C if necessary.

On the western ranges of the United States, frequent watering in summer is sometimes difficult, and snow is often the only source of water in winter. Watering sheep on alternate days may be an acceptable practice when the temperature is below 4 °C, but is not acceptable at higher temperatures because the stress can be injurious. Snow as the only source of water has not significantly reduced weight gain or feed consumption of pregnant ewes or the digestibility of dry matter and protein where ambient temperatures ranged from 0 to −21 °C. These ewes were allowed access to snow 24 hours a day. Soft, wet snow was more desirable than hard, granular snow. No data on snow as a source of water for lactating ewes are available.

The protein and mineral content of the diet markedly influences the amount of water consumed. Sheep fed 2-percent protein hay showed no decrease in feed consumption when watered every fourth day, whereas sheep fed 15-percent protein hay showed a marked decrease in feed consumption when watered at this rate. Sheep grazing on sagebrush grass desert range in Utah consumed 2.7 liters of water per head daily. When they were confined to range-growing shadscale, winter fat, or salt brush, their water consumption trebled. When sheep graze halogeton (*Halogeton glomeratus*), their water requirement increases greatly. With increased consumption of water, the sheep are able to excrete more of the toxic substance (oxalate), and the number of deaths is thereby reduced.

Breeding ewes and their lambs can tolerate "bicarbonate water" in which the total salt concentration is 0.50 percent (5,000 ppm). "Chloride water" with a total salt concentration of 1 percent can have a detrimental effect on lambs and on the fertility of ewes. Less than 1 percent does not appear harmful in most situations, but this depends on stage of production. Pen-fed sheep are less susceptible than grazed sheep apparently due to a more nutritious diet.

RANGE SHEEP: SPECIAL REQUIREMENTS

Range and pasture nutrition of sheep is closely related to management of both plants and animals. A knowledge of the nutritive value of plants in various stages of growth and of how these stages differ in productivity per unit of area is essential to optimal production of sheep.

Because it is difficult to measure the forage intake of sheep on the range, management depends to a large extent on knowledge of the nutritive value of the forage and on ability to estimate intake. Feed intake can be estimated and balance of nutrients can be evaluated by periodically weighing the animals, or by assessing body condition, or both.

Producers of range and pasture sheep also have the problem of evaluating the cost of activity. This cost is not great in some productive pastures but may be important in some of the arid and semiarid rangelands.

Seasonal functions of the animals such as breeding, gestation, and lactation need to be considered. These may be evaluated on the basis of Tables 12, 13, and 14 and Figure 1, but application of the specific values requires careful planning and management.

NUTRIENT DEFICIENCIES OF RANGE FORAGE

Research in Utah has demonstrated that range sheep respond to protein, phosphorus, and energy supplements when grazing desert winter forage. Calcium deficiency is seldom encountered.

Under range conditions, animals are rarely required to subsist on forage low in carotene for longer than 4–6 months. When animals are required to subsist on dry-grass ranges for periods longer than 6 months without intermittent periods of green feed, vitamin A supplements are recommended. The Intermountain range is deficient in iodine, but it is not known whether other trace minerals are deficient in that area.

FORMULATING SUPPLEMENTS FOR RANGE EWES

In formulating supplements for range ewes, it is first necessary to determine the composition of the grazing animals' diet, and then to compute the nutrients needed to make up any deficiencies. A useful working calculation of the diet can be obtained by weighting the percentage of each floral component of the range forage by an index of the animals' preference for each species of forage present. The preferences that have been worked out for sheep are given in Table 12. This table and Table 16 can be used to calculate the nutrient make-up of the diet. The calculations usually include only the estimated amounts of forage consumed and the protein, energy, and phosphorus content of the forage.

As an example, the energy content of a grazing diet such as that shown in Table 12 can be calculated by multiplying the "Diet" column values for each plant times their respective energy content obtained from Table 16. The last column in Table 12 gives the energy contribution of each plant and the total Mcal ME/kg of diet. Similar calculations are made for protein and phosphorus.

After these calculations have been made, the results may be compared with the sheep's requirements. The procedure is illustrated in Table 13. In this table, Line 1 states the proposed requirement for pregnant ewes under Intermountain range conditions. Line 2 indicates that the diet shown in Table 12 is only slightly deficient in phosphorus. Lines 3, 4, and 5 illustrate two basic facts concerning the diets of sheep on Intermountain ranges in winter: browse plants are the best sources of protein and phosphorus and are low in ME, and grasses are adequate in energy and seriously deficient in protein and phosphorus.

Tables 12 and 13 and the preceding discussion provide a basis for intelligent selection of supplements. Examples of physical and chemical composition of supplements are given in Table 14 and are applicable to such corrective measures as might be indicated from examination of the data in Tables 12 and 13. The data from Table 14 illustrate supplements ranging from high to low protein. The energy concentration is in an inverse order. These supplements are only examples and may be modified by availability and cost of feeds to meet indicated deficiencies. If, for example, phosphorus is the only deficiency as shown in Table 12, it may be corrected by free-choice phosphorus supplements. A 100-percent grass diet (Line 4, Table 13) should be supplemented by feeding the high-protein diet in Table 14 to correct both the protein and phosphorus deficiencies. The feeds used in Table 14 are on a 100-percent dry matter basis, and it would be necessary to adjust these values to an as-fed basis (see footnote *a* in Table 1).

If nutrients are deficient in concentration, requirements may be met by getting the animals to eat more feed or by using supplements. The normal range of supplementation for sheep is 0.1–0.2 kg per head per day, as indicated in Table 14. On a group-feeding basis, a rate of at least 0.1 kg per day is necessary if supplementation is to be compatible with the physical operation of feeding, and rates above 0.2 kg approach a level that will result in reduced intake of range forage.

RATE OF FEEDING

Supplements are fed for two main reasons: (1) to balance diets by adding small quantities of a nutrient (such as protein, a mineral, or a vitamin) or combinations of nutrients, and (2) to provide nutrients during short-term emergencies. For example, supplements may be needed to prevent sheep from eating poisonous plants, during periods when they are on the trail or when forage is covered with snow.

Except in emergencies, if it is necessary to supplement the energy content of diets at a rate that requires as much as 0.2 kg of feed per animal per day, moving the animals into a feedlot or to a better grazing area is recommended.

Exceptional skill may be required to recognize the nutritional state of the sheep, the range condition, and the need for supplement. Many managers of range-sheep operations are capable of developing grazing plans that minimize the need for supplements.

Some managers divide their sheep into flocks on the basis of age, condition, or function. Dividing them makes it possible to give the animals that require the highest levels of nutrition the best pasture or range areas on which to graze and facilitates supplementing the diets of animals that have additional requirements.

If the forage is deficient in nutrients, or if the ewes are thin, it will usually pay to feed a supplement during the winter months and continue until lambing time in the spring. Where browse and forbs contribute substantially to the diet, metabolizable energy is the most appropriate energy value to use in assessing nutrients because of the high essential oil content of the shrubs.

McDonald (1968) recognizes the complexities of grazing in the following terms:

> . . . attention has been drawn to many gaps in our present knowledge of the nutrition of grazing ruminants. It has become clear that a full understanding of the subject cannot be obtained from research on animals hand-fed in pens; it is necessary to study the many interactions between soil, plant, animal and climate so that the mechanism governing the animal's response within the ecosystem can be elucidated. Knowledge of these mechanisms is essential to permit the effective application of scientific findings to practical husbandry in the pastoral system.

OTHER ASPECTS OF SHEEP NUTRITION

QUALITY OF FORAGE

Forage intake of sheep is greatly affected by the quality of the forage. High-quality forage is more digestible than low-quality forage and passes through the digestive tract more rapidly; hence, sheep eat more.

Palatability also influences intake of forage. Greenhalgh and Reid (1967) conducted a feeding experiment in two phases. In the first, straw was placed in the rumen through a fistula and the sheep were allowed to eat grass. In the second, grass was placed in the rumen and the sheep were allowed to eat straw. Sheep in the first phase ate twice as much as those in the second.

In feeding lambs, the most favorable nutritional response is usually obtained by feeding hay produced from forages harvested before the protein content has decreased and before lignification and the fiber content have increased. In all trials having to do with the nutritive value of hay and silage in relation to date of harvesting, the nutritional response of lambs has reflected the quality of the forage. Loss of leaves, weather damage, fermentation, and leaching losses reduce the value of harvested forage.

When sheep are forced to sustain themselves on low-protein forage, intake and utilization can be increased by adding sources of natural protein or properly formulated nonprotein nitrogen supplements.

PELLETED FEEDS

Pelleted feeds are made by grinding the ingredients—which may vary from all forage, a mixture of concentrates and forage or all concentrates—and then compressing in a pellet mill. Forage pellets are much less bulky than baled or loose hay. Alfalfa pellets weigh approximately 720 kg/m^3.

The net energy derived per kg of forage is about equal, whether fed long or pelleted, with reduced loss of methane and heat loss from the pelleted material compensated by reduced fiber digestion due to the faster rate of passage through the digestive tract. The principal advantages of pelleted forage are increased intake, resulting in increased gain and increased gain per unit of feed, and reduced wastage in feeding. The response may be greater with lower quality forages. Finely grinding forage without pelleting will not achieve the same advantages because of reduced acceptability of ground feed by sheep.

Chopped forage, without grinding, can be compressed into wafers or cubes of about half of the density of pellets (285–450 kg/m^3). The main advantages of wafers are ease of handling and prevention of waste with little difference in intake and gains compared to long hay.

The effect of pelleted mixtures of grain and forage on feed intake and gain is proportional to the forage level. Thus, pelleting of diets low in forage may have an adverse effect.

Parakeratosis—a degeneration of the rumen papilla—may result from feeding pellets, particularly with a high concentrate content. Breeding animals should not be fed for extended periods on a pelleted diet without any long or chopped forage.

ANTIBIOTICS

Antibiotics may improve performance when added to creep diets and lamb-finishing diets at levels of 15–25 mg per kg of feed. Chlorotetracycline and oxytetracycline are especially effective. Responses seem to be markedly affected by differences in management and in the amount of stress to which animals are subjected. There is some evidence that antibiotics contribute to reducing the incidence of enterotoxemia.

CREEP FEEDING

The practice of providing supplemental feed to nursing lambs is called creep feeding. Lambs will usually consume some supplemental feed (creep feed) at about 2 weeks of age.

The amount of creep feed consumed is inversely proportional to the ewe's milk production. Twin lambs will usually consume more creep feed than single lambs. After the lambs are 6–8 weeks of age, milk production usually drops to the point where lambs will consume significant amounts of creep feed. However, if the lambs have access to lush pasture, they may prefer it to the creep feed.

Soybean meal is an important ingredient in creep diets because of its palatability. Acceptability of a ground creep feed can be increased by adding 5 percent molasses.

Four typical creep diets are suggested in Table 15.

FLUSHING

The practice of increasing the nutrient intake of ewes prior to mating is called flushing. Its purpose is to increase the ovulation rate and consequently the lambing rate.

Flushing is usually accomplished by providing animals with fresh pastures, supplemental harvested forage, or up to 0.25 kg of grain per day. This special feeding usually begins 2–3 weeks prior to breeding and continues into the breeding season.

In general, ewes maintained in a high state of nutrition benefit only slightly or not at all from flushing, whereas thin ewes on poor pasture tend to benefit considerably. Mature ewes apparently respond better than yearling ewes. Also, flushing may be more beneficial early and late in the breeding season than during the peak, when the ovulation rate is highest.

EARLY WEANING

Weaning lambs at about 5–8 weeks of age and placing them on a relatively high concentrate diet in drylot is a common practice. Because of a need to increase productivity, an effort is being made to wean lambs when they are 5 weeks of age or younger. No precise system for weaning at this age has been devised, but, to be successful, any system of early weaning must be in harmony with the lambs' behavior and must provide adequate nutrition.

Lambs are gregarious, and they react unfavorably to being moved from familiar surroundings. Producers who are most successful in early weaning remove the ewes from the lambs rather than vice versa. The lambs stay in the pens to which they are accustomed, and this minimizes stress. They have had access to creep feed since they were a few days old and are consuming dry feed.

A protein level of about 16 percent is required in the diets of early-weaned lambs—higher than the level required by older lambs. If lambs are in situations where they do not have access to adequate iron, as when they are raised on wooden slats, a supplement is necessary. A calcium:phosphorus ratio of at least 1:1 is required, and 2:1 may be desirable where urinary calculi have been experienced (see p. 24).

Milk replacers containing approximately 30-percent fat and 24-percent protein have been used successfully in feeding very young lambs weaned at 1 day of age after receiving colostrum. Replacers with reduced lactose content (from 42 to 27 percent on a dry matter basis) give improved performance. The milk is fed *ad libitum* at 2–4 °C to reduce overeating and bacterial contamination. During the first 3–4 weeks of age, solid feed is offered in addition to the milk. Lambs are removed from milk replacers when they are eating sufficient quantities of dry feed. Age may vary from 21 to 35 days.

OXALATE POISONING

Halogeton and greasewood are common poisonous plants that grow in the arid and semiarid saline regions of the West. They are toxic because of their high content of soluble oxalate (up to 30 percent).

There are many plants throughout the world that contain oxalate, but these two plants are the most common causes of oxalate toxicity of sheep in the United States. When the oxalate is consumed it may (1) be degraded by rumen microorganisms, (2) combine with calcium in the rumen, and (3) be absorbed into the bloodstream. Intoxication occurs when large amounts are absorbed.

Oxalate produces its effect by interference with certain steps in energy metabolism, its affinity for calcium, and its mechanical damage to rumen and kidney tissues as a result of crystal formation. The affinity of calcium for oxalate also results in hypocalcemia.

There is much less chance that a nonfasted animal will consume a lethal amount. The toxic dose, however, is much lower (approximately 60 percent) for a fasted animal than for a nonfasted animal. This is due to faster destruction of oxalate by the rumen microorganisms resulting in decreased absorption. The lethal dose is increased by nearly 50 percent after sheep have been grazing halogeton two to three days.

Prevention of halogeton and greasewood poisoning appears to lie with proper livestock management. Water is a vitally important management tool in preventing halogeton poisoning: (1) it increases excretion of toxic substances, and (2) it can also affect appetite, so sheep should have *both water and good feed* before entering halogeton areas. If sheep are abnormally thirsty and receive water in a halogeton area, expect death losses because of indiscriminate grazing resulting in abnormal intakes of halogeton. Supplementing sheep with grain, alfalfa pellets, or other pellets during stress periods of trailing or trucking is also a valuable part of the management.

The halogeton plant competes poorly with other vegetation. Therefore, it may be reduced on these ranges by careful range-management practices. Greasewood is more stabilized in plant communities, and poisoning of sheep from the oxalate in greasewood occurs but is not as commonly reported as halogeton poisoning.

PREGNANCY DISEASE

Pregnancy disease, also referred to as ketosis, acetonemia, or pregnancy toxemia, is associated with undernourishment. It occurs in ewes in late pregnancy. It is much more common in ewes carrying twins or triplets than in those carrying single lambs.

The first signs observed may be sluggishness, anorexia, staggering gait, and nervousness. In the final stages of the disease (prior to death), vision is impaired, and ewes are unable to rise or stand on account of weakness, stiffness, or partial paralysis. Ewes that give birth during the early stages of the syndrome usually recover.

Pregnancy disease is a disturbance of carbohydrate metabolism and results in reduced blood glucose and elevated blood ketones. It can be prevented by ensuring adequate feed intake in late pregnancy and by avoiding any changes in feeding or management that might reduce the plane of nutrition or result in stress. A drench of propylene glucol can be used as an energy source for ewes refusing to eat sufficient feed at the onset of symptoms.

URINARY CALCULI

Urinary calculi are mineral deposits occurring in the urinary tract. These deposits may block the flow of urine, and the blockage may rupture the urinary bladder, causing death.

Under feedlot conditions, this disease appears to have a nutritional or metabolic origin; the affected animals excrete an alkaline urine that has a high phosphorus content. In range animals, the disease is associated with the consumption of forages having a high silica content.

Sodium chloride, fed at a level equivalent to 4 percent or more of the total diet, helps in preventing urinary calculi, especially in range animals. The sodium chloride increases the consumption of water and the amount of urine. It may be fed to range animals as a part of the protein supplement provided adequate water is available.

The incidence of urinary calculi in finishing lambs can be greatly reduced by preventing an excessive intake of phosphorus and by maintaining a calcium:phosphorus ratio of 2:1 to 2.5:1. Reducing the alkalinity of urine by feeding acid-forming salts is also effective. For this purpose, ammonium chloride may be fed at a level of 7 g per head per day.

FORMULATING DIETS FOR SHEEP

This section is intended to be useful for inexperienced nutritionists as an example of a method of calculating (formulating) a diet that will meet the nutritional requirements of specific sheep using certain feeds. The sheep and feeds have been selected to demonstrate the method.

Lactating ewes (60-kg weight, first 8 weeks of lactation, suckling twin lambs) are selected as the sheep of choice and it is assumed three base feeds are available: (1) oat hay, as a home-grown inexpensive roughage source; (2) barley grain, as an energy supplement; and (3) soybean meal (soybean, seeds, solv-extd grnd, mx 7% fiber), as a protein supplement. It is assumed desirable to feed animals as much hay as possible and to include only sufficient barley and soybean meal to meet the ewe's additional requirements for energy and protein, respectively.

The ewe's nutritional requirements are first determined along with the concentration of nutrients in the feeds; then a desirable diet formula is calculated using a substitution procedure.

The requirements are found in Table 1 expressed on a per sheep basis and in Table 2 expressed as a percentage of the total diet for use in formulating complete diets in greater quantities. The values in Table 2 are used in this example as a total diet is to be formulated. The feed nutrient values are found in Table 16. Both are given on a *Dry Matter Basis*, consequently the Dry Matter Percentage will be 100.

Step 1 is to list requirement and feed values:

	Air-Dry (As-Fed) Basis	Dry Matter Basis					
	DM (%)	DM (%)	DE (Mcal/kg)	TP (%)	Ca (%)	P (%)	Carotene (mg/kg)
Requirement (60-kg lact. ewe, 0–8 wks, twins)	—	100.0	2.9	11.5	0.44	0.32	2.9
Oats, hay, s-c	88.2	100.0	2.38	9.2	0.26	0.24	101.0
Barley grain	89.0	100.0	3.79	13.0	0.09	0.47	—
Soybean meal	89.0	100.0	3.53	51.5	0.36	0.75	—

Initially the Dry Matter (DM), Digestible Energy (DE), and Total Protein (TP) values will be considered; however, the DM of the feeds on an as-fed or air-dry basis and values for Ca, P, and carotene (provitamin A) are included as they will be used in later calculations.

In Step 2 check how well oat hay alone will meet the requirements for DE and TP.

	DM (% of Diet)	DE (Mcal/kg of Diet)	TP (% of Diet)
Requirement	100.0	2.90	11.5
From oat hay	100.0	2.38	9.2
DIFFERENCE	0.0	−0.52	−2.3

Obviously, ewes fed only oat hay as 100 percent of the DM intake would be deficient in both DE and TP. Therefore, Step 3 is to substitute some of the oat hay with barley grain to balance the DE required.

The main question is how much barley grain should be substituted for oat hay. This can be calculated by noting the difference in DE between the two feeds (3.79 − 2.38 = 1.41) and the amount of DE deficient in the all-oat hay diet above (0.52). To supply the 0.52 Mcal/kg, substitute 0.52/1.41 = 0.37 or 37 percent of the ration DM as barley grain.

Therefore, the next diet of oat hay and barley grain will be as follows:

	DM (% of diet)	DE (Mcal/kg of diet)	TP (% of diet)
Requirement	100.0	2.9	11.5
From oat hay	63.0	1.5	5.8
From barley grain	37.0	1.4	4.8
TOTAL SUPPLIED	100.0	2.9	10.6
DIFFERENCE	0.0	0.0	0.9

The DE is now balanced, but the diet is still deficient in TP. Step 4 is to substitute enough soybean meal for the barley grain to supply the necessary protein. Note that because both barley and soybean meal are expressed as 100-percent DM and are not largely different in DE, substitution of one for the other will not significantly affect DM or DE.

To determine how much soybean meal to substitute for barley grain, determine the difference in TP in the two feeds (51.5 − 13.0 = 38.3) and the TP deficient in the hay–barley diet (0.9), divide as was done with the DE calculation (0.9/38.3 = 0.023 or 2.3 percent), and substitute the calculated amount (2.3 percent). The diet will therefore be as follows:

	DM (%)	DE (Mcal/kg)	TP (%)
Requirement	100.0	2.9	11.5
From oat hay	63.0	1.50	5.80
From barley grain	34.7	1.32	4.51
From soybean meal	2.3	0.08	1.18
TOTAL	100.0	2.90	11.49 (11.5)[a]
DIFFERENCE	0.0	0.0	0.0

[a] Rounded to 11.5.

The diet is now accurately balanced to provide the DE and TP necessary for the ewe within her limits of DM consumption. (The small difference in TP is within rounding error.)

However, before we mix and feed the diet we must consider the actual DM percentage of the feeds as they naturally occur and determine the amounts or ratio of the feeds to include on an air-dry matter (as-fed) basis. It is also necessary to check on the balance of other nutrients not previously considered. Step 5 is then computed:

	Air-Dry Basis			Dry Matter Basis					
	DM (%)	Parts	Percent[a] of Diet	DM (%)	DE (Mcal/kg)	TP (%)	Ca (%)	P (%)	Carotene (mg/kg)
Requirement	—	—	—	100.0	2.9	11.5	0.44	0.32	2.9
Oat hay	88.2	71.4[b]	62.5[c]	63.0	1.50	5.80	0.16	0.15	64
Barley grain	89.0	39.0	34.1	34.7	1.32	4.51	0.03	0.16	—
Soybean meal	89.0	2.6	2.3	2.3	0.08	1.18	0.01	0.02	—
TOTAL				100.0	2.90	11.5[d]	0.20	0.33	64
DIFFERENCE				0.0	0.0	0.0	−0.24	+0.1	Excess
Limestone	100.0	0.75	0.7	0.75	—	—	0.25	—	—
Salt (trace-mineralized)	100.0	0.50	0.4	0.50	—	—	—	—	—
TOTAL	—	114.25	100.0	—	—	—	—	—	—

[a] The values in this column are the final diet composition percentage, as-fed.
[b] Calculated as 63.0/88.2 = 71.4.
[c] Calculated as 71.4/114.25 = 62.5.
[d] Rounded from 11.49.

Even though the oat hay–barley–soybean meal diet is balanced for DE and TP and is high in carotene and just adequate in phosphorus, it is quite deficient in calcium. A suitable calcium supplement must be added to the diet. Limestone is usually the best and cheapest source of calcium; it contains approximately 33-percent calcium, so 0.24/0.33 = 0.73 or about 0.75-percent limestone should be added to the diet to provide the needed calcium (limestone is usually 100-percent DM). It is also customary to add about 0.5-percent salt (usually trace-mineralized) to provide I, Co, and other trace minerals to complete diets. Therefore, 0.75-percent limestone and 0.5-percent salt are added.

Finally, the calculations (as indicated in the above footnotes) are made to fill in the proper values under the "Air-Dry Basis" columns and the final diet composition is known. The diet should contain on an as-fed basis, 62.5-percent oat hay, 34.1-percent barley grain, 2.3-percent soybean meal, 0.7-percent limestone, and 0.4-percent trace-mineralized salt. Please note that, because the DM of all the feeds was not greatly different, the final diet composition is not appreciably different from that calculated on a DM basis. This would not be true if feeds such as silage were included, which are very different from grains and hays in DM. Also, the addition of limestone and salt actually decreases slightly the DE and TP of the diet but not enough to be of any consequence.

According to Tables 1 or 2, 60-kg ewes suckling twins in early lactation could consume 2.6 kg of DM from this diet or 2.6/0.89 (approximate DM percent) = 2.92 kg or 6.4 lb of this diet per day. If the feeds were hand fed separately to the ewes, 62.5 percent or 1.82 kg should be oat hay and 1.10 kg a mixture containing barley grain, soybean meal, limestone, and trace-mineralized salt. To prepare this mixture the values for these feeds in the "Parts" column above are added and total 42.85. Each feed part is divided by this value and multiplied by 100 to obtain percent. The composition of the mixture is, therefore, 91.0-percent barley grain, 6.1-percent soybean meal, 1.7-percent limestone, and 1.2-percent trace-mineralized salt.

This is only one method of formulating diets. More sophisticated methods would also include the use of simultaneous equations to algebraically arrive at a solution or to effectively use computer programs to solve even more complex sets of equations. It should be understood that the procedure discussed above does not, in its present form, include all nutrients or effects of feed palatability, economics, and other factors.

COMPOSITION OF FEEDS

Table 16 gives the composition of feeds commonly used in sheep diets. Two larger compilations are available.*

NRC NOMENCLATURE

In Table 16 and in the larger compilations, names of the feeds are based on a scheme proposed by Harris (1963) and Harris *et al.* (1968). The names, called NRC names, are designed to give a qualitative description of each product, where such information is available or pertinent. A complete NRC name consists of as many as eight components, written in linear form, with components separated by commas. The components are as follows:

- Origin (or parent material)
- Species, variety, or kind
- Part eaten
- Process(es) and treatment(s) to which the parent material or the part eaten has been subjected
- Stage of maturity (applicable only to forages)
- Cutting or crop (applicable only to forages)
- Grade, quality designations, and guarantees
- Classification

Feeds of the same origin (and of the same species, variety, or kind, if one of these is stated) are grouped into eight classes, each of which is designated by a number in parentheses. The numbers and the classes they designate are as follows:

* Publication 1684, *United States–Canadian Tables of Feed Composition*, lists about 400 feeds. Publication 1919, *Atlas of Nutritional Data on United States and Canadian Feeds*, lists about 6,150 feeds. Both are published by the National Academy of Sciences, Washington, D. C.

(1) Dry forages or dry roughages
(2) Pasture, range plants, and feeds cut and fed green
(3) Silages
(4) Energy feeds
(5) Protein supplements
(6) Minerals
(7) Vitamins
(8) Additives

Feeds that in the dry state contain on the average more than 18 percent of crude fiber are classified as forages or roughages. Feeds that contain 20 percent or more of protein are classified as protein supplements. Products that contain less than 20 percent of protein are classified as energy feeds. (These guidelines are approximate, and there is some overlapping.)

Abbreviations have been devised for some of the terms in the NRC system (Table 17). Stage-of-maturity terms are defined in Table 18.

The following listings show how three feeds are described:

Components of Name	Feed No. 1	Feed No. 2	Feed No. 3
Origin (or parent material)	Alfalfa	Soybean	Wheat
Species, variety, or kind	—	—	—
Part eaten	aerial part	seeds	flour by-product
Process(es) and treatment(s) to which product has been subjected	ensiled	solv-extd grnd	coarse sift
Stage of maturity	early bloom	—	—
Cutting or crop	—	—	—
Grade or quality designations	mn 50% dry matter	mx 7% fiber	mx 7% fiber
Classification	(3) (silages)	(5) (protein supplements)	(4) (energy feeds)

Thus, the NRC names of the three feeds are written as follows:

Feed 1: Alfalfa, aerial part, ensiled, early bloom, mn 50% dry matter, (3) Feed 2: Soybean, seeds, solv-extd grnd, mx 7% fiber, (5)

Feed 3: Wheat, flour by-product, coarse sift, mx 7% fiber, (4)

The analytical data are expressed in the metric system (with the exception of the bushel weights of the cereal grains) and are shown on a dry basis. See Table 19 for weight-unit conversion factors and Table 20 for weight equivalents.

Analytical data may differ in the various NRC reports because the data are up-dated for each report. The NRC names may also differ as feeds are more precisely characterized or as official definitions change. However, if the feed is the same, the international reference number will remain the same.

LOCATING NAMES IN THE TABLE

To locate in Table 16 the NRC name of a feed, one must know the name of the parent material (i.e., the origin of the feed) and usually the variety or kind of parent material. The first word of each NRC name is the name of the parent material. For a feed derived from a plant, the origin term is the name of the plant (e.g., alfalfa, barley, oats), not the word "plant."

A reader uncertain about the origin term that introduces an NRC name in Table 16 may find the term by referring to the common name of the feed in which he is interested. Cross references for common names appear in the table in their alphabetical place.

Names having the same origin term are arranged in an order that depends on whether the names include references to species, variety, or kind. Names lacking such references are arranged under the origin term as follows:

First: numerically, by classes

Second (within a class): alphabetically, by parts eaten, process(es), stage of maturity (in the order in which the stages occur), cutting, and grade

Names that include references to species, variety, or kind are arranged under the origin term as follows:

First, alphabetically, by species, variety, or kind

Second (within species, variety, or kind): numerically, by classes

Third (within a class): alphabetically, by parts eaten, process(es), stage of maturity (in the order in which the stages occur), cutting, and grade

Many feeds have names that were given to them by the Association of American Feed Control Officials (AAFCO), the Canada Feed Act (CFA), or the Canada Grain Act (CGA). In addition, some feeds have regional or local names. The reader will find these names under the NRC names.

A 6-digit reference number is listed after the NRC name and other names. The number may be used as the "numerical name" of a feed when performing linear programming with electronic computers.

The common name of the parent material is followed by the scientific name. (Example: Alfalfa. *Medicago sativa.*)

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TABLES

TABLE 1 Daily Nutrient Requirements of Sheep (100% Dry Matter Basis)

Body Weight		Gain or Loss		Dry Matter[a]			Nutrients per Animal										
				Per Animal		% Live Wt	Energy			Total Protein	DP[c]	Grams DP per Mcal DE	Ca	P	Carotene	Vitamin A	Vitamin D
(kg)	(lb)	(g)	(lb)	(kg)	(lb)		TDN (kg)	DE[b] (Mcal)	ME (Mcal)	(g)	(g)		(g)	(g)	(mg)	(IU)	(IU)
EWES[d]																	
Maintenance																	
50	110	10	.02	1.0	2.2	2.0	0.55	2.42	1.98	89	48	20	3.0	2.8	1.9	1275	278
60	132	10	.02	1.1	2.4	1.8	0.61	2.68	2.20	98	53	20	3.1	2.9	2.2	1530	333
70	154	10	.02	1.2	2.6	1.7	0.66	2.90	2.38	107	58	20	3.2	3.0	2.6	1785	388
80	176	10	.02	1.3	2.9	1.6	0.72	3.17	2.60	116	63	20	3.3	3.1	3.0	2040	444
Nonlactating and first 15 weeks of gestation																	
50	110	30	.07	1.1	2.4	2.2	0.60	2.64	2.16	99	54	20	3.0	2.8	1.9	1275	278
60	132	30	.07	1.3	2.9	2.1	0.72	3.17	2.60	117	64	20	3.1	2.9	2.2	1530	333
70	154	30	.07	1.4	3.1	2.0	0.77	3.39	2.78	126	69	20	3.2	3.0	2.6	1785	388
80	176	30	.07	1.5	3.3	1.9	0.82	3.61	2.96	135	74	20	3.3	3.1	3.0	2040	444
Last 6 weeks of gestation or last 8 weeks of lactation suckling singles[e]																	
50	110	175(+45)	.39	1.7	3.7	3.3	0.99	4.36	3.58	158	88	20	4.1	3.9	6.2	4250	278
60	132	180(+45)	.40	1.9	4.2	3.2	1.10	4.84	3.97	177	99	20	4.4	4.1	7.5	5100	333
70	154	185(+45)	.41	2.1	4.6	3.0	1.22	5.37	4.40	195	109	20	4.5	4.3	8.8	5950	388
80	176	190(+45)	.42	2.2	4.8	2.8	1.28	5.63	4.62	205	114	20	4.8	4.5	10.0	6800	444
First 8 weeks of lactation suckling singles or last 8 weeks of lactation suckling twins[f]																	
50	110	−25(+80)	−.06	2.1	4.6	4.2	1.36	5.98	4.90	218	130	22	10.9	7.8	6.2	4250	278
60	132	−25(+80)	−.06	2.3	5.1	3.9	1.50	6.60	5.41	239	143	22	11.5	8.2	7.5	5100	333
70	154	−25(+80)	−.06	2.5	5.5	3.6	1.63	7.17	5.88	260	155	22	12.0	8.6	8.8	5950	388
80	176	−25(+80)	−.06	2.6	5.7	3.2	1.69	7.44	6.10	270	161	22	12.6	9.0	10.0	6800	444
First 8 weeks of lactation suckling twins																	
50	110	−60	−.13	2.4	5.3	4.8	1.56	6.86	5.63	276	173	25	12.5	8.9	6.2	4250	278
60	132	−60	−.13	2.6	5.7	4.3	1.69	7.44	6.10	299	187	25	13.0	9.4	7.5	5100	333
70	154	−60	−.13	2.8	6.2	4.0	1.82	8.01	6.57	322	202	25	13.4	9.5	8.8	5950	388
80	176	−60	−.13	3.0	6.6	3.7	1.95	8.58	7.04	345	216	25	14.4	10.2	10.0	6800	444

Replacement lambs and yearlings[g]																	
30	66	180	.40	1.3	2.9	4.3	0.81	3.56	2.92	130	75	21	5.9	3.3	1.9	1275	166
40	88	120	.26	1.4	3.1	3.5	0.82	3.61	2.96	133	74	20	6.1	3.4	2.5	1700	222
50	110	80	.18	1.5	3.3	3.0	0.83	3.65	2.99	133	73	20	6.3	3.5	3.1	2125	278
60	132	40	.09	1.5	3.3	2.5	0.82	3.61	2.96	133	72	20	6.5	3.6	3.8	2550	333
RAMS																	
Replacement lambs and yearlings[g]																	
40	88	250	.55	1.8	4.0	4.5	1.17	5.15	4.22	184	108	21	6.3	3.5	2.5	1700	222
60	132	200	.44	2.3	5.1	3.8	1.38	6.07	4.98	219	122	20	7.2	4.0	3.8	2550	333
80	176	150	.33	2.8	6.2	3.5	1.54	6.78	5.56	249	134	20	7.9	4.4	5.0	3400	444
100	220	100	.22	2.8	6.2	2.8	1.54	6.78	5.56	249	134	20	8.3	4.6	6.2	4250	555
120	265	50	.11	2.6	5.7	2.2	1.43	6.29	5.16	231	125	20	8.5	4.7	7.5	5100	666
LAMBS																	
Finishing[h]																	
30	66	200	.44	1.3	2.9	4.3	0.83	3.65	2.99	143	87	24	4.8	3.0	1.1	765	166
35	77	220	.48	1.4	3.1	4.0	0.94	4.14	3.39	154	94	23	4.8	3.0	1.3	892	194
40	88	250	.55	1.6	3.5	4.0	1.12	4.93	4.04	176	107	22	5.0	3.1	1.5	1020	222
45	99	250	.55	1.7	3.7	3.8	1.19	5.24	4.30	187	114	22	5.0	3.1	1.7	1148	250
50	110	220	.48	1.8	4.0	3.6	1.26	5.54	4.54	198	121	22	5.0	3.1	1.9	1275	278
55	121	200	.44	1.9	4.2	3.5	1.33	5.85	4.80	209	127	22	5.0	3.1	2.1	1402	305
Early-weaned[i]																	
10	22	250	.55	0.6	1.3	6.0	0.44	1.94	1.59	96	69	36	2.4	1.6	1.2	850	67
20	44	275	.60	1.0	2.2	5.0	0.73	3.21	2.63	160	115	36	3.6	2.4	2.5	1700	133
30	66	300	.66	1.4	3.1	4.7	1.02	4.49	3.68	196	133	30	5.0	3.3	3.8	2550	200

[a] To convert dry matter to an as-fed basis, divide dry matter by percentage of dry matter.
[b] 1 kg TDN = 4.4 Mcal DE (digestible energy). DE may be converted to ME (metabolizable energy) by multiplying by 82%.
[c] DP = digestible protein
[d] Values are for ewes in moderate condition, not excessively fat or thin. Fat ewes should be fed at the next lower weight, thin ewes at the next higher weight. Once maintenance weight is established, such weight would follow through all production phases.
[e] Values in parentheses are for ewes suckling singles last 8 weeks of lactation.
[f] Values in parentheses are for ewes suckling twins last 8 weeks of lactation.
[g] Requirements for replacement lambs (ewe and ram) start when the lambs are weaned.
[h] Maximum gains expected. If lambs are held for later market, they should be fed as replacement ewe lambs are fed. Lambs capable of gaining faster than indicated should be fed at a higher level. Lambs finish at the maximum rate if they are self-fed.
[i] A 40-kg early-weaned lamb should be fed the same as a finishing lamb of the same weight.

TABLE 2 Nutrient Content of Diets for Sheep (Nutrient Concentration in Diet Dry Matter)

Body Weight		Daily Gain or Loss		Daily Dry Matter[a]			Energy			Total				Caro-	Vita-	Vita-
				Per Animal		% Live	TDN	DE[b]	ME	Protein	DP[c]	Ca	P	tene	min A	min D
(kg)	(lb)	(g)	(lb)	(kg)	(lb)	Wt	(%)	(Mcal/kg)	(Mcal/kg)	(%)	(%)	(%)	(%)	(mg/kg)	(IU/kg)	(IU/kg)
EWES[d]																
Maintenance																
50	110	10	.02	1.0	2.2	2.0	55	2.4	2.0	8.9	4.8	.30	.28	1.9	1275	278
60	132	10	.02	1.1	2.4	1.8	55	2.4	2.0	8.9	4.8	.28	.26	2.0	1391	303
70	154	10	.02	1.2	2.6	1.7	55	2.4	2.0	8.9	4.8	.27	.25	2.2	1488	323
80	176	10	.02	1.3	2.9	1.6	55	2.4	2.0	8.9	4.8	.25	.24	2.3	1569	342
Nonlactating and first 15 weeks of gestation																
50	110	30	.07	1.1	2.4	2.2	55	2.4	2.0	9.0	4.9	.27	.25	1.7	1159	253
60	132	30	.07	1.3	2.9	2.1	55	2.4	2.0	9.0	4.9	.24	.22	1.7	1177	256
70	154	30	.07	1.4	3.1	2.0	55	2.4	2.0	9.0	4.9	.23	.21	1.9	1275	277
80	176	30	.07	1.5	3.3	1.9	55	2.4	2.0	9.0	4.9	.22	.21	2.0	1360	296
Last 6 weeks of gestation or last 8 weeks of lactation suckling singles[e]																
50	110	175(+45)	.39	1.7	3.7	3.3	58	2.6	2.1	9.3	5.2	.24	.23	3.6	2500	164
60	132	180(+45)	.40	1.9	4.2	3.2	58	2.6	2.1	9.3	5.2	.23	.22	3.9	2684	175
70	154	185(+45)	.41	2.1	4.6	3.0	58	2.6	2.1	9.3	5.2	.21	.20	4.2	2833	185
80	176	190(+45)	.42	2.2	4.8	2.8	58	2.6	2.1	9.3	5.2	.21	.20	4.5	3091	202
First 8 weeks of lactation suckling singles or last 8 weeks of lactation suckling twins[f]																
50	110	−25(+80)	−.06	2.1	4.6	4.2	65	2.9	2.4	10.4	6.2	.52	.37	3.0	2024	132
60	132	−25(+80)	−.06	2.3	5.1	3.9	65	2.9	2.4	10.4	6.2	.50	.36	3.3	2217	145
70	154	−25(+80)	−.06	2.5	5.5	3.6	65	2.9	2.4	10.4	6.2	.48	.34	3.5	2380	155
80	176	−25(+80)	−.06	2.6	5.7	3.2	65	2.9	2.4	10.4	6.2	.48	.34	3.8	2615	171
First 8 weeks of lactation suckling twins																
50	110	−60	−.13	2.4	5.3	4.8	65	2.9	2.4	11.5	7.2	.52	.37	2.6	1771	116
60	132	−60	−.13	2.6	5.7	4.3	65	2.9	2.4	11.5	7.2	.50	.36	2.9	1962	128
70	154	−60	−.13	2.8	6.2	4.0	65	2.9	2.4	11.5	7.2	.48	.34	3.1	2125	139
80	176	−60	−.13	3.0	6.6	3.7	65	2.9	2.4	11.5	7.2	.48	.34	3.3	2267	148

Replacement lambs and yearlings[g]																
30	66	180	.40	1.3	2.9	4.3	62	2.7	2.2	10.0	5.8	.45	.25	1.5	981	128
40	88	120	.26	1.4	3.1	3.5	60	2.6	2.1	9.5	5.3	.44	.24	1.8	1214	159
50	110	80	.18	1.5	3.3	3.0	55	2.4	2.0	8.9	4.8	.42	.23	2.1	1417	185
60	132	40	.09	1.5	3.3	2.5	55	2.4	2.0	8.9	4.8	.43	.24	2.5	1700	222
RAMS																
Replacement lambs and yearlings[g]																
40	88	250	.55	1.8	4.0	4.5	65	2.9	2.4	10.2	6.0	.35	.19	1.4	944	123
60	132	200	.44	2.3	5.1	3.8	60	2.6	2.1	9.5	5.3	.31	.17	1.7	1109	145
80	176	150	.33	2.8	6.2	3.5	55	2.4	2.0	8.9	4.8	.28	.16	1.8	1214	159
100	220	100	.22	2.8	6.2	2.8	55	2.4	2.0	8.9	4.8	.30	.17	2.2	1518	198
120	265	50	.11	2.6	5.7	2.2	55	2.4	2.0	8.9	4.8	.33	.18	2.9	1962	256
LAMBS																
Finishing[h]																
30	66	200	.44	1.3	2.9	4.3	64	2.8	2.3	11.0	6.7	.37	.23	0.8	588	128
35	77	220	.48	1.4	3.1	4.0	67	3.0	2.4	11.0	6.7	.34	.21	0.9	637	139
40	88	250	.55	1.6	3.5	4.0	70	3.1	2.5	11.0	6.7	.31	.19	0.9	638	139
45	99	250	.55	1.7	3.7	3.8	70	3.1	2.5	11.0	6.7	.29	.18	1.0	675	147
50	110	220	.48	1.8	4.0	3.6	70	3.1	2.5	11.0	6.7	.28	.17	1.1	708	154
55	121	200	.44	1.9	4.2	3.5	70	3.1	2.5	11.0	6.7	.26	.16	1.1	738	161
Early-weaned[i]																
10	22	250	.55	0.6	1.3	6.0	73	3.2	2.6	16.0	11.5	.40	.27	2.0	1417	112
20	44	275	.60	1.0	2.2	5.0	73	3.2	2.6	16.0	11.5	.36	.24	2.5	1700	133
30	66	300	.66	1.4	3.1	4.7	73	3.2	2.6	14.0	9.5	.36	.24	2.7	1821	143

[a] To convert dry matter to an as-fed basis, divide dry matter by percentage of dry matter.
[b] 1 kg TDN = 4.4 Mcal DE (digestible energy). DE may be converted to ME (metabolizable energy) by multiplying by 82%. Because of rounding errors, calculations between Table 1 and Table 2 may not give the same values.
[c] DP = digestible protein.
[d] Values are for ewes in moderate condition, not excessively fat or thin. Fat ewes should be fed at the next lower weight, thin ewes at the next higher weight. Once maintenance weight is established, such weight would follow through all production phases.
[e] Values in parentheses are for ewes suckling singles last 8 weeks of lactation.
[f] Values in parentheses are for ewes suckling twins last 8 weeks of lactation.
[g] Requirements for replacement lambs (ewe and ram) start when the lambs are weaned.
[h] Maximum gains expected. If lambs are held for later market, they should be fed as replacement ewe lambs are fed. Lambs capable of gaining faster than indicated should be fed at a higher level. Lambs finish at the maximum rate if they are self-fed.
[i] A 40-kg early-weaned lamb should be fed the same as a finishing lamb of the same weight.

TABLE 3 Yearly Dry Matter, Energy, and Protein Requirements of a 60-Kg Ewe[a]

	Maintenance (15 wk)	Early Gestation (15 wk)	Late Gestation (6 wk)	Early Lactation (8 wk)[b]	Late Lactation (8 wk)[b]	Yearly Total
Dry matter						
kg/day	1.1	1.3	1.9	2.3 (S)	1.9 (S)	
				2.6 (T)	2.3 (T)	
kg/period	115.5	136.5	79.8	128.8 (S)	106.4 (S)	567.0
				145.6 (T)	128.8 (T)	606.2
Metabolizable energy						
Mcal/day	2.20	2.60	3.97	5.41 (S)	3.97 (S)	
				6.10 (T)	5.41 (T)	
Mcal/period	231.0	273.0	166.7	303.0 (S)	222.3 (S)	1196.0
				341.6 (T)	303.0 (T)	1312.3
Digestible protein						
g/day	53	64	99	143 (S)	99 (S)	
				187 (T)	143 (T)	
kg/period	5.6	6.7	4.2	8.0 (S)	5.5 (S)	30.0
				10.5 (T)	8.0 (T)	35.0

[a]See Figure 1 for daily and cumulative weight changes.
[b]S = ewes suckling singles; T = ewes suckling twins.

TABLE 4 Net Energy Requirements of Very Young Lambs (Kcal/Day)

	Body Weight (kg)				
	5.0	7.5	10.0	12.5	15.0
	NE_m Requirements				
	359	487	603	712	817
Daily Gain (g)	NE_g Requirements				
100	127	172	214	253	290
150	193	262	325	383	440
200	261	353	438	518	594
300	401	543	674	796	913
400	547	742	921	1,088	1,247

TABLE 5 Net Energy Requirements of Lambs Aged 3 to 5 Months (Kcal/Day)

	Body Weight[a] (kg)					
	25	30	35	40	45	50
	NE_m Requirements					
	890	1,020	1,145	1,265	1,380	1,495
Daily Gain (g)	NE_g Requirements[b]					
100	360	415	465	515	560	605
150	540	620	695	895	980	1,060
200	720	825	925	1,025	1,120	1,210
250	900	1,035	1,160	1,280	1,400	1,515
300	1,080	1,240	1,390	1,540	1,680	1,820

[a]Empty body basis.
[b]Wool growth included.

TABLE 6 Net Energy Requirements of Lambs Aged 6 to 10 Months (Kcal/Day)

	Body Weight[a] (kg)					
	25	30	35	40	45	50
	NE_m Requirements					
	700	810	910	1,000	1,090	1,180
Daily Gain (g)	NE_g Requirements[b]					
100	430	495	555	610	670	725
150	645	740	830	920	1,005	1,085
200	860	985	1,110	1,225	1,340	1,450
250	1,075	1,235	1,385	1,530	1,670	1,810

[a]Empty body basis.
[b]Wool growth included.

TABLE 7 NE_{preg} Requirements for Ewes Carrying Different Numbers of Fetuses (Kcal/Day)

	NE_{preg} Requirement at the Following Stages of Gestation (days)[a]		
Fetuses	100	120	140
Single	70	145	260
Twin	125	265	440
Triplets	170	345	570

[a]For gravid uterus (plus contents) and mammary gland development only.

TABLE 8 NE Concentration of Diets (Mcal NE/kg DM) as Predicted from ME Concentration (Mcal ME/kg DM)

ME Concentration	NE_m Value	NE_g Value
1.6	0.87	0.41
1.8	1.03	0.54
2.0	1.19	0.68
2.2	1.35	0.82
2.4	1.51	0.95
2.6	1.67	1.09
2.8	1.83	1.22
3.0	1.99	1.36

TABLE 9 Predicted DM Intakes for Diets of Different ME Concentration

ME Concentration (Mcal/kg DM)	DM Intake, (% Body weight)	DM Intake (g DM/$W_{kg}^{0.75}$)
1.6	4.9	115
2.0	4.6	109
2.4	4.3	103
2.8	4.0	97

TABLE 10 Macromineral Requirements of Sheep (Percentage of Diet Dry Matter)[a]

Nutrient	Requirement
Sodium	0.04–0.10
Chlorine	–
Calcium	0.21–0.52
Phosphorus	0.16–0.37
Magnesium	0.04–0.08
Potassium	0.50
Sulfur	0.14–0.26

[a] Values are estimates based on experimental data.

TABLE 11 Micromineral Requirements of Sheep and Toxic Levels (Parts per Million, Mg/Kg, of Diet Dry Matter)[a]

Nutrient	Requirement	Toxic Level
Iodine	0.10–0.80[b]	8+
Iron	30–50	–
Copper	5	8–25
Molybdenum	>0.5	5–20
Cobalt	0.1	100–200
Manganese	20–40	–
Zinc	35–50	1,000
Selenium	0.1	>2
Fluorine	–	60–200

[a] Values are estimates based on experimental data.
[b] High level for pregnancy and lactation in diets not containing goitrogens; should be increased if diets contain goitrogens.

TABLE 12 Average Degree of Utilization, or Preference Indexes, Used in Calculating a Diet for a Particular Sheep Allotment[a]

(1) Plant	(2) Plant Composition (%)	(3) Preference Index	(4) Plant Composition X Preference Index	(5) Diet[b] (%)	(6) Mcal ME/kg of Plant[c]	(7) Mcal ME[d]
Sagebrush, big (*Artemisia tridentata*)	15	40	600	19	1.27	0.241
Sagebrush, bud (*Artemisia spinescens*)	10	20	200	6	2.01	0.121
Saltbush, shadscale (*Atriplex confertifolia*)	25	20	500	15	0.88	0.132
Winterfat (*Eurotia* sp.)	24	40	960	30	1.19	0.357
BROWSE TOTAL	74	–	–	70	–	–
Wheatgrass (*Agropyron cristatum*)	14	40	560	17	2.39	0.406
Galleta (*Hilaria jamesii*)	3	25	75	2	1.31	0.026
Needle and thread (*Stipa comata*)	9	40	360	11	1.65	0.182
GRASS TOTAL	26	–	–	30	–	–
GRAND TOTAL	100	–	3,255	100	–	1.465[e]

[a] Modified from Cook *et al.* (1954).
[b] Obtained by dividing each value in column 4 by the total of that column (3,255).
[c] From Table 16, dry matter basis.
[d] Calculated as column 5 times column 6.
[e] Mcal ME/kg diet.

TABLE 13 Typical Requirement, Probable Intake, and Deficiencies for 60-kg Ewes in Early and Mid-Pregnancy Grazing Intermountain Winter Range (100% Dry Matter Basis) [a]

Line No.		Daily Intake kg	Daily Intake lb	Digestible Protein (%)	Metabolizable Energy (Mcal/kg)	Phosphorus (%)
1	Requirement	1.63	3.59	4.4	1.466	0.18
2	If 70% browse and 30% grass as given in Table 12	–	–	5.0	1.47	0.14[b]
3	If 100% browse	–	–	6.5	1.22[c]	0.15[b]
4	If 100% grass	–	–	1.6[c]	2.05	0.12[c]
5	If 70% grass and 30% browse	–	–	3.1[c]	1.80	0.13[c]

[a] Adapted from Cook *et al.* (1954) and Harris *et al.* (1956). Requirements for range ewes appear to differ slightly from those reported in Tables 1 and 2 for farm sheep.
[b] Slightly deficient.
[c] Deficient.

TABLE 14 Formulas for Range Supplements for Sheep (100% Dry Matter Basis) [a]

Feed[b]		Recommended Level of Protein (%) High (%)	Medium (%)	Low (%)
Barley, grain		–	33.0	67.0
Corn, dent yellow, grain, gr 2 US mn 54 lb per bushel		5.0	10.0	15.0
Beet, sugar, molasses, mn 48% invert sugar mn 79.5 degrees brix, or Sugarcane, molasses, mn 48% invert sugar mn 79.5 degrees brix		5.0	5.0	10.0
Cotton, seeds w some hulls, solv-extd grnd, mn 41% protein mx 14% fiber mn 0.5% fat (cottonseed meal)		62.5	32.0	–
Soybean, seeds, solv-extd grnd, mx 7% fiber (soybean meal)		10.0	10.0	–
Alfalfa, aerial part, dehy grnd, mn 17% protein, or Alfalfa, hay, s-c, early bloom		12.5	6.0	5.0
Calcium phosphate, dibasic, commercial		4.0	3.0	2.0
Salt or trace mineralized salt		1.0	1.0	1.0
TOTAL		100.0	100.0	100.0
Composition[c]				
Protein (N X 6.25)	%	36.5	26.4	12.0
Digestible protein	%	29.6	21.4	9.1
Metabolizable energy	Mcal/kg	2.4	2.7	3.0
Phosphorus	%	1.7	1.3	0.8
Carotene	mg/kg	22	11	9
Rate of feeding (kg/day)[d]		0.1-0.2	0.1-0.2	0.1-0.2[e]

[a] Feeds to be mixed and fed in meal or pellet form.
[b] See Table 16.
[c] Sugarcane, molasses and alfalfa hay, s-c, early bloom not included.
[d] Listed as dry matter basis, calculate to as-fed basis for mixing and feeding.
[e] In emergency situations, up to 0.45 kg may be fed.

TABLE 15 Creep Diets in Use under Varied Conditions[a]

Ingredient	Amount (as-fed basis)
Diet 1 (grind at first; feed whole later)[a]	
Corn, dent yellow, grain, gr 2 US mn 54 lb per bushel	58.5%
Oats, grain or barley, grain	20.0
Wheat, bran, dry milled	10.0
Flax, seeds, solv-extd grnd, mx 0.5% acid insoluble ash (linseed meal) or	
Soybean, seeds, solv-extd grnd, mx 7% fiber (soybean meal)	10.0
Limestone, grnd, mn 33% calcium	1.0
Trace mineralized salt	0.5
	100.0%
Alfalfa, hay, s-c, early bloom	free-choice
Diet 2 (hand- or self-fed, ground, or pelleted)	
Alfalfa, hay, s-c, early bloom	65.0%
Soybean, seeds, solv-extd grnd, mx 7% fiber (soybean meal)	10.0
Corn, dent yellow, grain, gr 2 US mn 54 lb per bushel	12.0
Oats, grain	9.0
Sugarcane, molasses, mn 48% invert sugar mn 79.5 degrees brix	3.0
Sodium phosphate, monobasic, $NaH_2PO_4 \cdot H_2O$, technical	1.0
	100.0%
Chlortetracycline or oxytetracycline	15–25 mg/kg
Vitamin A supplement	555 IU/kg
Vitamin D supplement	55 IU/kg
Diet 3 (hand- or self-fed, ground, or pelleted)	
Corn, ears, grnd	55.0%
Alfalfa, hay, s-c, early bloom	30.0
Soybean, seeds, solv-extd grnd, mx 7% fiber (soybean meal)	10.0
Sugarcane, molasses, mn 48% invert sugar mn 79.5 degrees brix	5.0
	100.0%
Chlortetracycline or oxytetracycline	15–25 mg/kg
Diet 4 (ground diet may be hand- or self-fed)	
Corn, dent yellow, grain, gr 2 US mn 54 lb per bushel	84.0%
Soybean, seeds, solv-extd grnd, mx 7% fiber (soybean meal)	15.0
Limestone, grnd, mn 33% calcium	1.0
	100.0%

[a] Feed the highest quality alfalfa hay in a separate rack. Feed hay and grain twice daily to keep them fresh. Offer trace mineralized salt free-choice for all diets.

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellu-lose (%)	Crude fiber (%)	Lignin (%)
1	ALFALFA. *Medicago sativa*										
2	–aerial part, dehy grnd, mn 15% protein, (1)	1-00-022	92.3	2.41	1.97	54.	16.9	11.7	–	27.7	–
3	–aerial part, dehy grnd, mn 17% protein, (1)	1-00-023	92.7	2.45	2.01	56.	19.3	13.9	28.2	26.2	–
4	–hay, s-c, early vegetative, (1)	1-00-050	89.1	2.61	2.14	59.	24.8	18.8	–	20.4	–
5	–hay, s-c, late vegetative, (1)	1-00-054	87.5	2.52	2.06	57.	20.0	14.5	–	27.3	–
6	–hay, s-c, early bloom, (1)	1-00-059	90.1	2.45	2.01	56.	19.7	14.2	–	28.5	–
7	–hay, s-c, mid-bloom, (1)	1-00-063	89.5	2.37	1.94	54.	17.5	12.3	26.6	30.6	8.7
8	–hay, s-c, full bloom, (1)	1-00-068	87.6	2.29	1.88	52.	16.6	11.5	–	32.2	9.3
9	–hay, s-c, mature, (1)	1-00-071	91.2	2.20	1.80	50.	13.9	9.0	–	37.5	–
10	–aerial part, fresh, (2)	2-00-196	25.9	2.53	2.07	57.	21.9	16.2	–	21.1	5.2
11	–aerial part, ensiled, (3)	3-00-212	28.3	2.38	1.95	54.	17.9	12.6	–	–	11.7
12	–aerial part, ensiled, early bloom, mn 50%										
13	dry matter, (3)	3-08-151	55.0	2.47	2.02	56.	17.9	12.6	–	28.2	–
14	–aerial part, ensiled, early bloom, mn 30%										
15	mx 50% dry matter, (3)	3-08-150	38.5	2.42	1.98	55.	17.6	12.4	–	28.6	–
16	–aerial part, ensiled, early bloom, mx 30%										
17	dry matter, (3)	3-08-149	28.3	2.38	1.95	54.	18.6	13.3	–	28.9	–
18	–aerial part, wilted ensiled, (3)	3-00-221	38.1	2.38	1.95	54.	17.8	12.5	–	30.2	–
19	–aerial part w molasses added, ensiled, (3)	3-00-238	29.9	2.38	1.95	54.	17.3	12.1	–	28.8	–
20	ALFALFA-BROME, SMOOTH. *Medicago sativa.*										
21	*Bromus inermis*										
22	–aerial part, fresh, (2)	2-00-262	21.6	2.78	2.28	63.	19.6	15.2	–	25.3	–
23	–aerial part, fresh, early bloom, (2)	2-00-261	21.6	2.78	2.28	63.	19.6	14.1	–	25.3	–
24	–aerial part, ensiled, mn 50% dry matter, (3)	3-08-148	55.0	2.47	2.02	56.	14.4	7.5	–	33.7	–
25	–aerial part, ensiled, mn 30% mx 50% dry										
26	matter, (3)	3-08-147	46.5	2.42	1.99	55.	15.5	8.1	–	33.0	–
27	–aerial part, ensiled, mx 30% dry matter, (3)	3-08-146	25.0	2.51	2.06	57.	15.2	7.9	–	30.8	–
28	ALFALFA-ORCHARDGRASS. *Medicago sativa,*										
29	*Dactylis glumerata*										
30	–aerial part, ensiled, mn 50% dry matter, (3)	3-08-143	61.0	2.47	2.02	56.	16.2	8.4	–	30.5	–
31	–aerial part, ensiled, mn 30% mx 50% dry										
32	matter, (3)	3-08-144	40.0	2.47	2.02	56.	17.2	8.9	–	31.6	–
33	–aerial part, ensiled, mx 30% dry matter, (3)	3-08-145	28.0	2.47	2.02	56.	17.1	8.9	–	31.4	–
34	ALKALI SACATON. *Sporobolus airoides*										
35	–aerial part, fresh, stem cured, (2)	2-05-599	86.0	1.96	1.65	35.	3.4	.0	33.0	–	10.0
36	ANIMAL.										
37	–carcass residue, dry rendered dehy grnd, mn 9%										
38	indigestible material mx 4.4% phosphorus, (5)	5-00-385	93.5	3.09	2.53	70.	57.1	46.8	–	2.5	–
39	Meat meal (AAFCO)										
40	Meat scrap										
41	–carcass residue w bone, dry rendered dehy grnd,										
42	mn 9% indigestible material mn 4.4%										
43	phosphorus, (5)	5-00-388	94.0	2.91	2.39	66.	53.8	44.1	–	2.3	–
44	Meat and bone meal (AAFCO)										
45	–bone, cooked dehy grnd, mn 10% phosphorus, (6)	6-00-397	94.5	–	–	–	18.8	–	–	–	–
46	Feeding bone meal (CFA)										
47	–bone, steamed dehy grnd, (6)	6-00-400	95.0	.70	.58	16.	12.7	8.6	–	2.1	–
48	Bone meal, steamed (AAFCO)										
49	–bone charcoal, retort-charred grnd, (3)	6-00-403	90.0	–	–	–	9.4	–	–	–	–
50	Bone black (CFA)										
51	Bone char (CFA)										
52	ANIMAL-POULTRY.										
53	–fat, heat rendered, mn 90% fatty acids mx 2.5%										
54	unsaponifiable matter mx 1% insoluble										
55	matter, (4)	4-00-409	99.5	5.68	4.66	129.	–	–	–	–	–
56	Animal fat (AAFCO)										
57	BARLEY. *Hordeum vulgare*										
58	–hay, s-c, (1)	1-00-495	87.3	2.51	2.06	57.	8.9	5.0	–	26.4	–
59	–straw, (1)	1-00-498	88.2	1.81	1.48	41.	4.1	.7	–	42.4	–
60	–grain, (4)	4-00-549	89.0	3.79	3.11	86.	13.0	10.3	–	5.6	–
61	–grain, Pacific coast, (4)	4-07-939	89.0	3.48	2.86	79.	10.9	7.8	–	7.0	–
62	–grain screenings, (4)	4-00-542	89.0	3.70	3.04	84.	13.5	10.8	–	9.0	–
63	BEAN. *Phaseolus* sp										
64	–navy, seeds, (5)	5-00-623	90.0	3.84	3.15	87.	25.4	22.4	–	4.7	–
65	BEEF–see Cattle										

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

On a dry basis (moisture free)

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
1																			
2	1.32	–	.190	11.2	–	.129	.033	.31	31.1	–	.24	2.50	.540	.08	–	21.5	109.5	–	–
3	1.43	–	.390	10.6	–	.161	.049	.31	31.2	–	.26	2.68	.645	.10	–	17.2	173.3	–	473.0
4	2.12	.34	–	–	–	–	.020	.26	38.6	–	.30	2.26	–	.22	.63	–	501.2	–	–
5	1.25	–	–	–	8.0	–	–	–	–	–	.23	–	–	–	–	–	–	–	–
6	1.25	.38	.090	13.4	10.0	–	.020	.30	31.5	–	.23	2.08	–	.15	.30	–	127.2	26.0	1991.0
7	1.35	–	–	15.4	10.0	–	.010	.35	16.5	–	.22	1.46	–	–	–	–	33.3	–	–
8	1.28	–	–	13.4	–	–	.020	.35	33.7	–	.20	.55	–	–	–	–	37.0	–	–
9	–	–	–	–	–	–	–	–	–	–	.	–	–	–	–	–	–	–	–
10	1.72	.47	.090	9.9	–	–	.030	.27	50.5	–	.31	2.03	–	.20	.39	17.6	198.9	152.1	.2
11	1.61	.50	.150	9.7	–	–	.030	.34	50.3	–	.38	2.40	–	.16	.36	–	89.7	–	288.8
12																			
13	1.61	–	–	–	–	–	–	–	–	–	.38	–	–	–	–	.	–	–	–
14																			
15	1.52	–	–	–	–	–	–	–	–	–	.30	–	–	–	–	–	–	–	–
16																			
17	1.40	–	–	–	–	–	–	.36	–	–	.32	2.36	–	–	–	–	–	–	–
18	1.40	–	–	9.3	–	–	.030	.33	52.0	–	.32	2.36	–	–	–	–	51.6	–	.6
19	1.74	–	–	12.6	–	–	.030	.34	42.6	–	.31	2.56	–	–	–	–	97.2	–	–
20																			
21																			
22	1.52	–	–	–	–	–	–	.35	–	–	.37	3.87	–	–	–	–	–	–	–
23	1.52	–	–	–	–	–	–	.35	–	–	.37	3.87	–	–	–	–	–	–	–
24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25																			
26	–	–	–	–	.	–	–	–	–	–	.	–	–	–	–	–	–	–	–
27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28																			
29																			
30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31																			
32	–	–	–	–	–	.	–	–	–	–	–	–	–	–	–	–	–	–	–
33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34																			
35	.67	–	–	–	–	–	–	–	–	–	.08	–	–	–	–	–	.4	–	–
36																			
37																			
38	8.49	1.40	.137	10.4	–	–	.047	.29	10.2	–	4.31	.59	–	1.80	.53	–	–	–	–
39																			
40																			
41																			
42																			
43	11.25	.37	.195	1.6	–	–	.053	1.20	13.1	–	5.39	1.55	–	.78	–	–	–	–	–
44																			
45	27.32	–	–	–	–	–	–	–	–	–	13.07	–	–	–	–	–	–	–	–
46																			
47	30.51	–	.100	17.2	–	–	.088	.67	32.0	–	14.31	–	–	.48	–	447.1	–	–	–
48																			
49	30.11	–	–	–	–	–	–	.59	–	–	14.14	.16	–	–	–	–	–	–	–
50																			
51																			
52																			
53																			
54																			
55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
56																			
57																			
58	.21	–	–	–	–	–	–	–	39.2	–	.30	–	–	–	–	.	–	–	–
59	.34	–	–	–	–	–	.030	.19	17.2	–	.09	2.28	–	.14	–	–	–	–	–
60	.09	–	.100	8.6	–	–	.006	.14	18.3	–	.47	.63	–	.02	–	17.2	–	11.0	–
61	.07	–	–	–	–	–	–	–	–	–	.45	–	–	–	–	–	–	–	–
62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
63																			
64	.17	–	–	–	–	–	–	–	–	–	.63	1.89	–	–	–	–	–	–	–
65																			

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations—Continued

				On a dry basis (moisture free)							
Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellu-lose (%)	Crude fiber (%)	Lignin (%)
66	BEET, MANGELS. *Beta* sp										
67	—roots, (4)	4-00-637	10.6	3.79	3.11	86.	13.2	5.1	–	8.3	–
68	BEET, SUGAR. *Beta saccharifera*										
69	—aerial part w crowns, ensiled, (3)	3-00-660	20.7	2.38	1.95	54.	12.7	10.0	–	13.3	–
70	—molasses, mn 48% invert sugar mn 79.5 degrees										
71	brix, (4)	4-00-668	77.0	3.31	2.71	75.	8.7	3.0	–	–	–
72	Beet molasses (AAFCO)										
73	Molasses (CFA)										
74	—pulp, dehy, (4)	4-00-669	91.0	3.18	2.60	72.	10.0	5.0	–	20.9	8.8
75	Dried beet pulp (AAFCO) (CFA)										
76	—pulp, wet, (4)	4-00-671	10.0	3.31	2.71	75.	9.0	5.0	–	20.0	–
77	—pulp w molasses, dehy, (4)	4-00-672	92.0	3.48	2.86	79.	9.9	6.5	–	17.4	–
78	BERMUDAGRASS. *Cynodon dactylon*										
79	—hay, s-c, (1)	1-00-703	91.1	2.16	1.77	49.	8.9	4.5	–	29.6	–
80	BERMUDAGRASS, COASTAL. *Cynodon dactylon*										
81	—hay, s-c, (1)	1-00-716	91.5	2.20	1.81	50.	9.5	4.8	–	30.5	–
82	BIRDSFOOT Trefoil—see Trefoil, birdsfoot										
83	BLOOD MEAL—see Animal, blood, dehy grnd										
84	BLUEGRASS, CANADA. *Poa compressa*										
85	—hay, s-c, early vegetative, (1)	1-00-760	96.7	2.71	2.22	61.	17.3	12.1	–	25.8	–
86	—hay, s-c, (1)	1-00-762	93.4	2.42	1.99	55.	11.6	7.0	–	28.9	–
87	—aerial part, fresh, early vegetative, (2)	2-00-763	25.9	2.76	2.26	62.	18.7	13.8	–	25.5	–
88	—aerial part, fresh, (2)	2-00-764	30.6	2.56	2.10	58.	17.0	12.3	–	26.4	–
89	BLUEGRASS, KENTUCKY. *Poa pratensis*										
90	—aerial part, fresh, early vegetative, (2)	2-00-778	30.5	2.78	2.28	63.	17.3	13.1	20.0	25.1	3.8
91	—aerial part, fresh, early bloom, (2)	2-00-779	35.7	2.64	2.17	60.	14.8	10.8	28.3	27.8	4.6
92	BLUESTEM. *Andropogon* sp										
93	—aerial part, fresh, early vegetative, (2)	2-00-821	31.6	2.54	2.08	57.	11.0	7.2	–	28.9	–
94	—aerial part, fresh, mature, (2)	2-00-825	71.3	2.04	1.67	46.	4.5	1.2	–	34.0	–
95	BONE MEAL—see Animal										
96	BONE BLACK—see Animal, bone charcoal										
97	BONE CHAR—see Animal, bone charcoal										
98	BRAN—see Wheat										
99	BREWERS DRIED GRAINS—see Grains										
100	BREWERS DRIED YEAST—see Yeast, brewers										
101	BROME. *Bromus* sp										
102	—hay, s-c, (1)	1-00-890	89.7	2.28	1.90	52.	11.8	7.2	–	32.0	–
103	—aerial part, fresh; early vegetative, (2)	2-00-892	32.5	2.78	2.28	63.	20.3	16.6	–	23.9	–
104	—aerial part, fresh, mature, (2)	2-00-898	56.1	2.25	1.84	51.	6.4	3.0	–	33.0	–
105	BUFFALOGRASS. *Buchloe dactyloides*										
106	—aerial part, fresh, (2)	2-01-010	47.7	2.46	2.02	56.	9.2	5.6	–	27.7	–
107	CACTUS, PRICKLYPEAR. *Opuntia* sp										
108	—aerial part, fresh, (2)	2-01-061	17.1	2.34	1.92	53.	5.0	2.5	–	13.3	
109	CALCIUM PHOSHPATE										
110	—dibasic, commercial, (6)	6-01-080	96.0	–	–	–	–	–	–	–	–
111	Dicalcium phosphate (AAFCO)										
112	CANARYGRASS, REED. *Phalaris arundinacea*										
113	—hay, s-c, (1)	1-01-104	91.3	2.25	1.84	51.	10.5	6.0	–	34.3	–
114	—aerial part, fresh, (2)	2-01-113	25.8	2.60	2.13	59.	13.2	9.3	29.0	26.8	4.7
115	CANE MOLASSES—see Sugarcane										
116	CARROT. *Daucus* sp										
117	—roots, fresh, (4)	4-01-145	11.9	3.84	3.15	87.	10.1	7.7	–	9.2	–
118	CATTLE. *Bos* sp										
119	—milk, dehy, feed gr mx 8% moisture mn										
120	26% fat, (5)	5-01-167	93.7	5.73	4.70	130.	26.9	–	–	.2	–
121	Dried whole milk, feed grade (AAFCO)										
122	—milk, fresh, (5)	5-01-168	12.0	5.73	4.70	130.	25.8	24.8	–	–	–
123	—milk, skimmed centrifugal, (5)	5-01-170	9.6	4.19	3.44	95.	28.5	26.8	–	.0	–
124	—milk, skimmed dehy, mx 8% moisture, (5)	5-01-175	94.0	3.79	3.11	86.	35.6	32.0	–	.2	–
125	Dried skimmed milk, feed grade (AAFCO)										
126	CITRUS. *Citrus* sp										
127	—pulp, ensiled, (3)	3-01-234	19.5	3.88	3.18	88.	7.1	1.8	–	15.9	–
128	—pulp wo fines, shredded dehy, (4)	4-01-237	90.0	3.40	2.78	77.	7.3	3.9	–	14.4	–
129	Dried citrus pulp (AAFCO)										
130	—syrup, mn 45% invert sugar mn 71										
131	degrees brix, (4)	4-01-241	65.0	3.40	2.78	77.	10.9	5.6	–	–	–

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

On a dry basis (moisture free)

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D₂ (IU/g)
66																			
67	.19	1.23	–	–	–	–	.019	.19	–	–	.19	1.98	–	.66	.19	–	–	–	–
68																			
69	2.32	–	–	–	–	–	–	–	–	–	.20	–	–	–	–	–	–	–	–
70																			
71	.21	–	.500	22.9	–	–	.010	.30	6.0	–	.04	6.20	–	1.52	–	–	–	–	–
72																			
73																			
74	.75	–	.100	13.7	–	–	.033	.30	38.5	–	.11	.23	–	–	–	.8	–	–	606.2
75																			
76	.90	–	–	–	–	–	–	–	–	–	.10	.20	–	–	–	–	–	–	–
77	.61	–	–	–	–	–	–	.14	–	–	.11	1.78	–	–	–	–	–	–	–
78																			
79	.46	–	–	–	–	.115	.029	.17	–	–	.20	1.47	–	–	–	–	128.7	–	–
80																			
81	.46	–	–	–	–	–	–	.17	–	–	.18	–	–	–	–	–	–	–	–
82																			
83																			
84																			
85	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
86	.30	–	–	–	–	–	–	.33	92.6	–	.29	1.59	–	–	–	–	–	–	–
87	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
88																			
89	.39	–	–	–	–	–	–	.16	79.2	–	.39	2.04	–	–	–	–	–	–	–
90	.56	–	–	14.1	–	–	.030	.18	80.3	–	.47	2.28	–	–	–	–	383.0	–	–
91	.46	–	–	–	–	–	–	.11	–	–	.39	2.01	–	–	–	–	–	156.1	–
92																			
93	.63	–	–	36.8	–	–	.070	–	83.3	–	.17	1.35	–	–	–	–	219.2	–	–
94	.40	–	–	16.1	–	–	.060	.06	36.8	–	.11	.51	–	–	–	–	–	–	–
95																			
96																			
97																			
98																			
99																			
100																			
101																			
102	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
103	.59	–	–	–	–	–	–	.18	–	–	.37	4.30	–	–	–	–	459.5	–	–
104	.30	–	–	–	–	–	–	–	–	–	.26	1.25	–	–	–	–	–	–	–
105																			
106	.52	–	–	–	–	–	–	.14	–	–	.16	.71	–	–	–	–	93.7	–	–
107																			
108	6.29	.21	–	–	–	–	.090	1.65	–	–	.08	1.21	–	.30	.23	–	–	–	–
109																			
110	23.13	–	–	–	–	–	–	–	–	–	18.65	–	–	–	–	–	–	–	–
111																			
112																			
113	.34	–	–	11.9	–	–	.020	.26	92.4	–	.25	2.35	–	–	–	–	90.4	–	–
114	.40	–	–	–	–	–	–	–	–	–	.30	3.64	–	–	–	–	–	–	–
115																			
116																			
117	.42	.50	–	10.9	–	–	.017	.17	31.1	–	.34	2.10	–	1.60	.17	–	890.8	–	–
118																			
119																			
120	.95	–	–	–	–	–	.018	–	.4	–	.72	1.08	–	.38	–	–	7.5	–	.3
121																			
122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	24.2
123	1.26	–	.110	.9	–	–	.017	–	–	.4	1.03	1.01	–	–	.32	–	–	–	–
124	1.34	–	.117	12.2	–	–	.005	.12	2.3	–	1.10	1.78	–	–	–	–	–	–	.4
125																			
126																			
127	2.04	–	–	–	–	–	.016	.16	–	–	.15	.62	–	–	–	–	–	–	–
128	2.18	–	–	6.3	–	–	.018	.18	7.6	–	.13	.69	–	–	–	16.1	–	–	–
129																			
130																			
131	2.01	–	–	112.0	–	–	.050	.22	40.0	–	.25	.14	–	–	–	136.7	–	–	–

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations—Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellu-lose (%)	Crude fiber (%)	Lignin (%)
132	Citrus molasses (AAFCO)										
133	CLOVER, ALSIKE. *Trifolium hybridum*										
134	—hay, s-c, (1)	1-01-313	87.9	2.47	2.02	56.	14.7	9.8	–	29.4	–
135	CLOVER, CRIMSON. *Trifolium incarnatum*										
136	—hay, s-c, (1)	1-01-328	87.4	2.29	1.88	52.	16.9	11.3	–	32.2	–
137	CLOVER, LADINO. *Trifolium repens*										
138	—hay, s-c, (1)	1-01-378	91.2	2.51	2.06	57.	23.0	14.3	–	19.2	11.7
139	CLOVER, RED. *Trifolium pratense*										
140	—hay, s-c, (1)	1-01-415	87.7	2.56	2.10	58.	14.9	9.1	26.1	30.1	14.6
141	—aerial part, fresh, early bloom, (2)	2-01-428	19.6	2.78	2.28	63.	21.1	14.1	–	19.0	–
142	—aerial part, fresh, full bloom, (2)	2-01-429	27.7	2.60	2.13	59.	14.9	10.0	–	29.6	–
143	—aerial part, fresh, cut 2, (2)	2-01-432	27.1	2.82	2.31	64.	17.3	11.2	–	25.1	–
144	CLOVER, SWEET—see Sweetclover										
145	COCONUT. *Cocos nucifera*										
146	—meats, mech-extd grnd, (5)	5-01-572	93.0	3.66	3.00	83.	21.9	18.4	–	12.9	–
147	Coconut meal, mechanical extracted (AAFCO)										
148	Copra meal, mechanical extracted (AAFCO)										
149	—meats, solv-ext grnd, (5)	5-01-573	92.0	3.31	2.71	75.	23.1	19.4	–	16.3	1.1
150	Coconut meal, solvent extracted (AAFCO)										
151	Copra meal, solvent extracted (AAFCO)										
152	CORN. *Zea mays*										
153	—aerial part, s-c, (1)	1-02-775	82.4	2.82	2.31	64.	8.9	5.1	–	25.9	–
154	Corn fodder, sun-cured										
155	—aerial part wo ears wo husks, s-c, mature, (1)	1-02-776	87.2	2.73	2.24	62.	5.9	3.1	–	37.1	–
156	Corn stover, sun cured, mature										
157	—cobs, grnd, (1)	1-02-782	90.4	2.16	1.77	49.	2.8	.7	–	35.8	–
158	Ground corn cob (AAFCO)										
159	—aerial part, ensiled, mature, well-eared mn 50%										
160	dry matter, (3)	3-08-152	55.0	3.09	2.53	70.	7.8	4.3	–	23.0	–
161	—aerial part, ensiled, mature, well-eared mx 50%										
162	mn 30% dry matter, (3)	3-08-153	40.0	3.04	2.49	69.	8.1	4.4	–	24.4	–
163	—aerial part, ensiled, mature, well-eared mx 30%										
164	dry matter, (3)	3-08-154	27.9	3.00	2.46	68.	8.4	4.6	–	26.3	–
165	—aerial part wo ears wo husks, ensiled, (3)	3-02-836	27.2	2.38	1.95	54.	7.2	2.7	–	32.1	–
166	Corn stover silage										
167	—ears w husks, ensiled, (3)	3-02-839	43.4	3.18	2.60	72.	8.8	4.8	–	11.8	–
168	—ears, grnd, (4)	4-02-849	87.0	3.44	2.82	78.	9.3	5.1	–	9.2	–
169	Corn and cob meal (AAFCO)										
170	Ear corn chop (AAFCO)										
171	Ground ear corn (AAFCO)										
172	CORN GRAIN—see Corn, dent yellow										
173	—grits by-product, mn 5% fat, (4)	4-02-887	90.6	3.92	3.22	89.	11.8	7.6	–	5.5	–
174	Hominy feed (AAFCO) (CFA)										
175	—distillers grains, dehy, (5)	5-02-842	92.0	3.62	2.96	82.	29.5	21.2	–	13.0	–
176	Corn distillers dried grains (AAFCO) (CFA)										
177	—distillers grains w solubles, dehy, mn 75%										
178	original solids, (5)	5-02-843	92.0	3.31	2.71	75.	29.8	14.6	–	9.8	6.5
179	Corn distillers dried grains with solubles (AAFCO)										
180	—distillers solubles, dehy, (5)	5-02-844	93.0	3.97	3.25	90.	28.9	23.7	–	4.3	2.2
181	Corn distillers dried solubles (AAFCO)										
182	—gluten, wet milled dehy, (5)	5-02-900	91.0	3.79	3.11	86.	47.1	40.5	–	4.4	–
183	Corn gluten meal (AAFCO) (CFA)										
184	—gluten w bran, wet milled dehy, (5)	5-02-903	90.0	3.70	3.04	84.	28.1	24.2	–	8.9	–
185	Corn gluten feed (AAFCO) (CFA)										
186	CORN, DENT YELLOW. *Zea mays indentata*										
187	—grain, gr 2 US mn 54 lb per bushel, (4)	4-02-931	89.0	4.14	3.31	94.	10.0	7.8	–	2.2	–
188	—grain, gr 3 US mn wt 52 lb per bushel, (4)	4-02-932	86.0	4.05	3.24	92.	10.1	7.6	–	2.3	–
189	CORN, SWEET. *Zea mays saccharata*										
190	—cannery residue, fresh, (2)	2-02-975	77.0	3.18	2.60	72.	8.8	5.3	–	22.1	–
191	Corn, sweet, cannery refuse										
192	—cannery residue, ensiled, (3)	3-07-955	29.4	3.18	2.60	72.	8.8	4.8	–	26.8	–
193	CORN, WHITE. *Zea mays*										
194	—grits by-product, mn 5% fat, (4)	4-02-990	89.9	–	–	–	12.0	–	–	5.2	–
195	White hominy feed (AAFCO) (CFA)										
196	CORN-SOYBEAN. *Zea mays, Glycine max*										
197	—aerial part, ensiled, (3)	3-03-015	26.1	3.18	2.60	72.	10.0	6.8	–	26.9	–

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
	On a dry basis (moisture free)																		
132																			
133																			
134	1.31	.78	–	6.0	–	–	.030	.45	69.0	–	.25	1.70	–	.46	.21	–	187.0	–	–
135																			
136	1.42	.63	–	–	–	–	.070	.27	171.3	–	.18	1.54	–	.39	.28	–	–	–	–
137																			
138	1.38	.28	.150	8.8	–	–	.060	.50	132.5	–	.40	2.17	–	.13	.22	17.0	161.2	–	–
139																			
140	1.61	.26	.150	11.2	–	–	.010	.45	65.7	–	.22	1.76	–	.15	.17	17.2	36.8	–	1912.5
141	2.26	–	–	–	–	–	–	–	–	–	.38	2.49	–	–	–	–	–	–	–
142	1.01	–	–	–	–	–	–	.51	–	–	.27	1.96	–	–	–	–	–	–	–
143	1.88	–	–	–		–	–	–	–	–	.46	2.59	–	–	–	–	–	–	–
144																			
145																			
146	.23	–	–	20.1	–	–	.211	.28	59.6	–	.66	1.20	–	.04	–	–	–	–	–
147																			
148																			
149	.18	.03	–	–	–	–	–	–	–	–	.66	–	–	–	–	–	–	–	–
150																			
151																			
152																			
153	.50	.19	–	4.8	–	–	.010	.29	68.1	–	.25	.93	–	.03	.14	–	4.4	–	–
154																			
155	.49	–	–	–	–	–	–	–	–	–	.09	–	–	–	–	–	–	–	–
156																			
157	.12	–	.130	7.3	–	–	.023	.07	6.2	–	.04	.84	–	–	.47	–	.7	–	–
158																			
159																			
160	.27	–	–	–	–	–	–	–	–	–	.19	–	–	–	–	–	–	–	–
161																			
162	.27	–	–	–	–	–	–	–	–	–	.20	1.05	–	–	–	–	–	–	–
163																			
164	.28	–	–	–	–	–	–	.18	–	–	.21	.95	–	–	–	–	–	–	119.0
165	.38	–	–	–	–	–	–	.31	–	–	.19	1.43	–	–	–	–	–	–	–
166																			
167	.06	–	–	–	–	–	–	–	–	–	.27	–	–	–	–	–	–	–	–
168	.05	–	.300	8.8	–	–	.008	.17	15.0	–	.31	.61	–	–	–	–	–	–	–
169																			
170																			
171																			
172																			
173	.06	–	.066	16.1	–	–	.007	.26	16.1	–	.58	.74	–	–	.03	–	10.1	–	–
174																			
175	.10	–	.100	48.6	–	–	.020	.07	20.5	–	.40	.10	–	.98	–	–	–	–	–
176																			
177																			
178	.10	–	.100	48.6	–	–	.020	.07	20.5	–	.40	.10	–	.98	–	–	4.0	–	551.1
179																			
180	.38	–	–	88.9	–	–	.059	.69	79.0	–	1.47	1.87	–	–	–	–	.8	–	–
181																			
182	.18	–	.100	31.0	–	–	.040	.05	8.0	–	.44	.03	–	.10	–	–	–	–	–
183																			
184	.51	–	.100	53.0	–	–	.060	.32	26.4	–	.86	.67	–	1.06	–	–	–	–	–
185																			
186																			
187	.02	–	–	–	–	–	–	–	–	–	.35	–	–	–	–	–	2.0	24.7	–
188	.02	–	–	–	–	–	.002	–	6.4	–	.29	–	–	–	–	–	–	–	–
189																			
190	–	–	–	–	–	–	–	–	–	–	.90	–	–	–	–	–	–	–	–
191																			
192	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
193																			
194	.06	–	–	–	–	–	–	–	–	–	1.10	–	–	–	–	–	–	–	–
195																			
196																			
197	1.09	–	–	–	–	–	–	–	–	–	.46	–	–	–	–	–	–	–	–

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations–Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellulose (%)	Crude fiber (%)	Lignin (%)
198	COTTON. *Gossypium* sp										
199	–bolls, s-c, (1)	1-01-596	91.0	2.07	1.70	47.	10.0	2.6	–	33.6	–
200	–seed hulls, (1)	1-01-599	90.3	2.51	2.06	57.	4.3	.5	60.3	47.5	26.6
201	Cottonseed hulls (AAFCO)										
202	–seeds, grnd, (5)	5-01-608	92.7	4.19	3.44	95.	24.9	19.7	–	18.2	–
203	Cottonseed, whole, ground										
204	–seeds, mech-extd grnd, (5)	5-01-609	92.4	2.91	2.39	66.	30.3	21.8	–	23.2	–
205	Whole pressed cottonseed, mechanical										
206	extracted (AAFCO)										
207	–seeds w some hulls, mech-extd grnd, mn 36%										
208	protein mx 17% fiber mn 2% fat, (5)	5-01-615	93.5	3.84	3.15	87.	42.4	36.0	–	16.8	–
209	Cottonseed meal, 36% protein										
210	–seeds w some hulls, mech-extd grnd, mn 41%										
211	protein mx 14% fiber mn 2% fat, (5)	5-01-617	94.0	3.22	2.68	73.	43.6	35.3	–	12.8	–
212	Cottonseed meal, 41% protein										
213	–seeds w some hulls, solv-extd grnd, mn 41%										
214	protein mx 14% fiber mn 0.5% fat, (5)	5-01-621	91.5	3.00	2.46	68.	44.8	36.3	–	13.1	–
215	Cottonseed meal, solvent extracted,										
216	41% protein										
217	–seeds wo hulls, pre-press solv-extd grnd,										
218	mn 50% protein, (5)	5-07-874	92.5	3.40	2.78	77.	54.0	45.4	–	9.2	–
219	Cottonseed meal, pre press solvent										
220	extracted, 50% protein										
221	COWPEA. *Vigna* sp										
222	–hay, s-c, (1)	1-01-645	90.5	2.51	2.06	57.	18.4	12.7	–	27.3	–
223	DEFLUORINATED PHOSPHATE–see										
224	Phosphate defluorinated										
225	DESERT MOLLY. *Kochia vestita*										
226	–browse, fresh, stem cured, (2)	2-07-988	80.0	2.16	1.90	50.	9.0	5.5	13.0	–	8.0
227	DICALCIUM PHOSPHATE–see Calcium										
228	phosphate, dibasic, comm										
229	DISTILLERS GRAINS–see Corn, see										
230	Sorghum, grain variety, see Rye										
231	DROPSEED, SAND. *Sporobolus cryptandrus*										
232	–aerial part, fresh, stem cured, (2)	2-05-596	86.0	2.41	2.07	59.	5.0	1.9	46.0	–	8.0
233	Sand dropseed										
234	EAR CORN CHOP–see Corn, ears, grnd										
235	FEEDING BONE MEAL–see Bone,										
236	cooked dehy grnd										
237	FEEDING OAT MEAL–see Oats, cereal										
238	by-product, mx 4% fiber										
239	FAT–see Animal-poultry										
240	FESCUE, MEADOW. *Festuca elatior*										
241	–hay, s-c, (1)	1-01-912	88.5	2.47	2.02	56.	9.5	5.1	27.8	31.2	6.9
242	Fescue hay, tall										
243	FISH, MENHADEN. *Brevoortia tyrannus*										
244	–whole or cuttings, cooked mech-extd										
245	dehy grnd, (5)	5-02-009	92.0	3.26	2.68	74.	66.6	53.9	–	1.1	–
246	FLAX. *Linum usitatissimum*										
247	–seed screenings, (4)	4-02-056	91.6	2.82	2.31	64.	17.4	9.7	–	14.5	–
248	–seeds, mech-extd grnd, mx 0.5% acid										
249	insoluble ash, (5)	5-02-045	91.0	3.53	2.89	80.	38.8	32.6	–	9.9	–
250	Linseed meal, mechanical extracted (AAFCO)										
251	Linseed meal (CFA)										
252	–seeds, solv-extd grnd, mx 0.5% acid										
253	insoluble ash, (5)	5-02-048	91.0	3.44	2.82	78.	38.6	33.6	–	9.9	–
254	Linseed meal, solvent extracted (AAFCO)										
255	Solvent extracted linseed meal (CFA)										
256	–seed screenings, extn unspecified grnd, (5)	5-02-053	91.3	2.60	2.13	59.	26.4	14.9	–	12.5	–
257	Flax seed screenings oil feed (CFA)										
258	–seed screenings, mech-extd grnd, (5)	5-02-054	91.0	3.31	2.71	75.	17.4	13.2	–	13.2	–
259	Flaxseed screenings meal, mechanical extracted (AAFCO)										
260	GALLETA. *Hilaria jamesii*										
261	–aerial part, fresh, stem cured, (2)	2-05-594	86.0	1.67	1.31	39.	5.5	1.4	28.0	–	8.0
262	GLUTEN FEED–see Corn, gluten w bran										
263	GRAIN SORGHUM–see Sorghum, grain variety										

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

	On a dry basis (moisture free)																		
Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
198																			
199	1.13	–	–	–	–	–	–	.28	–	–	.12	3.08	–	–	–	–	–	–	–
200	.16	.02	.020	15.7	–	–	.010	.14	117.7	–	.10	.84	–	.02	–	22.0	–	–	–
201																			
202	.15	–	–	–	–	–	–	–	–	–	.73	1.20	–	–	–	–	–	–	–
203																			
204	–	–	–	–	–	–	–	–	–	–	–	1.35	–	–	–	–	–	–	–
205																			
206																			
207																			
208	.20	–	–	–	–	–	–	–	–	–	1.09	–	–	–	–	–	–	–	–
209																			
210																			
211	.17	–	.160	20.7	–	–	.032	.60	22.9	–	1.28	1.49	–	.04	–	–	–	–	–
212																			
213																			
214	.17	–	.164	21.3	–	–	.033	.61	23.5	–	1.31	1.53	–	.04	–	–	–	–	–
215																			
216																			
217																			
218	.17	–	.100	19.4	–	–	.012	.50	24.6	–	1.09	1.36	–	.05	–	79.2	–	–	–
219																			
220																			
221																			
222	1.34	.17	.070	–	–	–	.090	.47	485.1	–	.32	1.99	–	.27	.35	–	–	–	–
223																			
224																			
225																			
226	2.37	–	–	–	–	–	–	–	–	–	.12	–	–	–	–	–	18.1	–	–
227																			
228																			
229																			
230																			
231																			
232	.57	–	–	–	–	–	–	–	–	–	.06	–	–	–	–	–	.4	–	–
233																			
234																			
235																			
236																			
237																			
238																			
239																			
240																			
241	.50	–	–	–	–	–	–	.50	24.5	–	.36	1.87	–	–	–	–	–	–	–
242																			
243																			
244																			
245	5.97	–	–	9.1	–	–	.061	–	27.9	–	3.05	–	–	–	–	–	–	–	–
246																			
247	.40	–	–	–	–	–	–	–	–	–	.47	–	–	–	–	–	–	–	–
248																			
249	.48	–	.500	29.0	–	–	.019	.64	43.3	–	.98	1.36	–	.12	–	–	.2	–	–
250																			
251																			
252																			
253	.44	–	.200	28.2	–	–	.036	.66	41.3	–	.91	1.52	–	.15	–	–	–	–	–
254																			
255																			
256	.48	–	–	–	–	–	–	–	–	–	.69	–	–	–	–	–	–	–	–
257																			
258	.41	–	–	–	–	–	–	–	–	–	.47	–	–	–	–	–	–	–	–
259																			
260																			
261	1.05	–	–	–	–	–	–	–	–	–	.07	–	–	–	–	–	.4	–	–
262																			
263																			

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations–Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellulose (%)	Crude fiber (%)	Lignin (%)
264	GRAINS.										
265	GRAINS SCREENINGS–see also Barley,										
266	grain screenings; Wheat, grain screenings										
267	–screenings, refuse mx 100% small weed seeds										
268	chaff hulls dust scourings noxious seeds, (4)	4-02-151	90.3	2.38	1.95	54.	16.0	11.5	–	31.3	–
269	Refuse screenings (CFA)										
270	–screenings, uncleaned, mn 12% grain mx 3%										
271	wild oats mx 17% buckwheat and large										
272	seeds mx 68% small weed seeds chaff										
273	hulls dust scourings noxious seeds, (4)	4-02-153	91.5	2.91	2.39	66.	15.6	11.2	–	18.3	–
274	Uncleaned screenings (CFA)										
275	–brewers grains, dehy, mn 3% dried spent hops, (5)	5-02-141	92.0	3.04	2.49	69.	28.1	20.8	–	16.3	–
276	Brewers dried grains (AAFCO) (CFA)										
277	GRAMA. *Bouteloua* sp										
278	–aerial part, fresh, early vegetative, (2)	2-02-163	41.0	2.69	2.20	61.	13.1	9.2	–	27.2	–
279	–aerial part, fresh, mature, (2)	2-02-166	63.4	2.20	1.80	50.	6.5	3.0	–	32.7	–
280	GRASS-LEGUME.										
281	–aerial part, ensiled, (3)	3-02-303	29.3	2.47	2.02	56.	11.8	6.0	–	31.4	–
282	–aerial part w molasses added, ensiled, (3)	3-02-309	30.0	2.51	2.06	57.	11.2	5.7	–	31.1	–
283	GROUNDNUT–see Peanut										
284	HOMINY FEED–see Corn, grits by-product										
285	JOHNSONGRASS–see Sorghum, Johnsongrass										
286	KAFIR–see Sorghum, kafir										
287	KENTUCKY BLUEGRASS–see Bluegrass,										
288	Kentucky										
289	LESPEDEZA. *Lespedeza* sp										
290	–hay, s-c, late vegetative, (1)	1-07-954	92.1	2.69	2.21	61.	17.8	12.5	–	23.7	–
291	–hay, s-c, early bloom, (1)	1-02-510	93.4	2.60	2.13	59.	15.5	10.5	–	29.6	–
292	–hay, s-c, mid-bloom, (1)	1-02-511	93.0	2.51	2.06	57.	15.7	10.6	–	30.7	–
293	–hay, s-c, full bloom, (1)	1-02-512	93.2	2.38	1.95	54.	13.4	8.6	–	31.0	–
294	–aerial part, fresh, early bloom, (2)	2-02-540	25.0	2.64	2.16	60.	16.4	12.3	–	32.0	–
295	–aerial part, fresh, mature, (2)	2-02-542	35.5	2.29	1.88	52.	12.8	8.9	–	44.9	–
296	LIMESTONE.										
297	–grnd, mn 33% calcium, (6)	6-02-632	100.0	–	–	–	–	–	–	–	–
298	Limestone, ground (AAFCO)										
299	LINSEED MEAL–see Flax										
300	MANGEL–see Beet, mangels										
301	MEADOW HAY–see Native plants, Intermountain										
302	MEAT AND BONE MEAL–see Animal,										
303	carcass residue										
304	MEAL MEAL–see Animal, carcass residue										
305	MEAT SCRAP–see Animal, carcass residue										
306	MILK–see Cattle, milk										
307	MILO–see Sorghum, milo										
308	MOLASSES–see Beet, sugar, molasses; see										
309	Citrus, syrup; see Sugarcane, molasses										
310	MONOSODIUM PHOSPHATE–see Sodium										
311	phosphate, monobasic										
312	NAPIERGRASS. *Pennisetum purpureum*										
313	–aerial part, fresh, late vegetation, (2)	2-03-158	14.9	2.34	1.92	53.	11.0	6.4	–	31.5	–
314	–aerial part, fresh, late bloom, (2)	2-03-162	23.0	2.16	1.77	49.	7.8	3.6	–	39.0	–
315	NATIVE PLANTS, INTERMOUNTAIN.										
316	–hay, s-c, (1)	1-03-181	92.9	2.34	1.92	53.	9.1	2.9	–	30.1	–
317	Meadow hay										
318	NATIVE PLANTS, MIDWEST.										
319	–hay, s-c, early vegetative, (1)	1-03-183	89.5	2.69	2.20	61.	8.7	4.4	–	36.5	–
320	Prairie hay, early vegetative										
321	–hay, s-c, mid-bloom, (1)	1-07-956	91.0	2.47	2.02	56.	8.1	4.1	–	30.5	–
322	Prairie hay, mid-bloom										
323	–hay, s-c, full bloom, (1)	1-03-184	83.3	2.42	1.99	55.	7.6	3.4	–	33.0	–
324	Prairie hay, full bloom										
325	–hay, s-c, late bloom, (1)	1-07-957	91.3	2.34	1.91	53.	6.6	2.2	–	32.5	–
326	Prairie hay, late bloom										
327	–hay, s-c, milk stage, (1)	1-03-185	91.9	2.25	1.84	51.	4.8	1.0	–	33.6	–
328	Prairie hay, milk stage										
329	–hay, s-c, mature, (1)	1-03-187	92.3	2.16	1.77	49.	4.6	.7	–	33.8	–

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

Line No	On a dry basis (moisture free) Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
264																			
265																			
266																			
267																			
268	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
269																			
270																			
271																			
272																			
273	.40	–	–	–	–	–	–	–	–	–	.45	–	–	–	–	–	–	–	–
274																			
275	.29	–	.100	22.2	–	–	.027	.15	40.9	–	.54	.09	–	.28	–	–	–	–	–
276																			
277																			
278	.53	–	–	5.5	–	–	–	–	37.9	–	.19	–	–	–	–	–	–	–	–
279	.34	–	.180	12.8	–	–	–	.13	47.4	–	.12	.35	–	–	–	–	30.4	–	–
280																			
281	.78	–	–	–	–	–	–	–	–	–	.28	–	–	–	–	–	–	–	–
282	1.04	–	–	–	–	–	–	–	–	–	.28	–	–	–	–	–	–	–	–
283																			
284																			
285																			
286																			
287																			
288																			
289																			
290	1.14	–	–	–	–	–	–	–	–	–	.26	–	–	–	–	–	–	–	–
291	1.23	–	–	–	–	–	.040	.28	205.1	–	.25	1.00	–	–	–	–	–	–	–
292	1.19	–	–	–	–	–	.032	.27	–	–	.26	1.05	–	–	–	–	–	–	–
293	1.04	–	–	–	–	–	.030	.24	151.5	–	.23	1.03	–	–	–	–	–	–	–
294	1.35	–	–	–	–	–	.025	.27	–	–	.21	1.12	–	–	–	–	–	–	–
295	1.02	–	–	–	–	–	.020	.16	85.1	–	.31	.77	–	–	–	–	–	–	–
296	33.84	–	–	–	–	–	.330	–	279.6	–	.02	–	–	.06	–	–	–	–	–
297																			
298																			
299																			
300																			
301																			
302																			
303																			
304																			
305																			
306																			
307																			
308																			
309																			
310																			
311																			
312																			
313	.60	–	–	–	–	–	–	–	–	–	.41	–	–	–	–	–	–	–	–
314	.35	–	–	–	–	–	–	–	–	–	.30	–	–	–	–	–	–	–	–
315																			
316	.57	–	–	–	–	–	–	–	–	–	.17	–	–	–	–	–	–	–	–
317																			
318																			
319	.57	–	–	–	–	–	.010	.24	–	–	.19	1.08	–	–	–	–	–	–	–
320																			
321	.34	–	–	–	–	–	–	–	–	–	.21	–	–	–	–	–	20.1	–	–
322																			
323	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
324																			
325	.36	–	–	–	–	–	–	–	–	–	.13	–	–	–	–	–	7.9	–	–
326																			
327	.39	–	–	–	–	–	–	–	–	–	.13	–	–	–	–	–	–	–	–
328																			
329	.38	.13	.130	–	–	–	.010	.24	–	–	.09	.68	–	.01	–	–	10.4	–	–

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations—Continued

				On a dry basis (moisture free)							
Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellu-lose (%)	Crude fiber (%)	Lignin (%)
330	Prairie hay, mature										
331	—hay, s-c, post ripe (1)	1-03-188	91.5	2.07	1.70	47.	4.0	.2	–	34.4	–
332	Prairie hay, post ripe										
333	NEEDLEANDTHREAD. *Stipa comata*										
334	—aerial part, fresh, dormant, (2)	2-07-989	86.0	1.97	1.65	47.	4.0	1.2	33.0	–	8.0
335	OATS. *Avena sativa*										
336	—hay, s-c, (1)	1-03-280	88.2	2.38	1.95	54.	9.2	5.1	–	31.0	–
337	—straw, (1)	1-03-283	90.1	1.90	1.56	43.	4.4	.4	40.1	41.0	14.6
338	—aerial part, ensiled, (3)	3-03-298	31.7	2.78	2.28	63.	9.7	5.0	–	31.6	–
339	—cereal by-product, mx 4% fiber, (4)	4-03-303	91.0	4.19	3.44	95.	17.4	13.9	–	4.4	–
340	Feeding oat meal (AAFCO)										
341	Oat middlings (CFA)										
342	—grain, (4)	4-03-309	89.0	3.31	2.71	75.	13.2	10.3	18.0	12.4	10.0
343	—grain, Pacific coast, (4)	4-07-999	91.2	3.53	2.89	80.	9.9	7.7	–	12.1	–
344	—groats, (4)	4-03-331	91.0	4.45	3.65	101.	18.4	16.6	–	3.3	–
345	Oat groats (AAFCO) (CFA)										
346	Hulled oats (CFA)										
347	OATS, WHITE. *Avena sativa*										
348	—grain, gr 1 heavy US mn wt 36 lb per										
349	bushel mx 2% foreign material, (4)	4-03-384	90.0	3.44	2.82	78.	13.3	10.0	–	12.2	–
350	—grain, gr 2 US mn wt 32 lb per bushel										
351	mx 3% foreign material, (4)	4-03-388	90.0	3.31	2.71	75.	12.4	9.3	–	12.2	–
352	—grain, gr 3 US mn wt 30 lb per bushel										
353	mx 4% foreign material, (4)	4-03-389	91.0	3.17	2.60	72.	11.4	9.0	–	13.2	–
354	—grain, gr 4 US mn wt 27 lb per bushel										
355	mn 5% foreign material, (4)	4-03-390	92.0	2.95	2.42	67.	9.5	7.0	–	13.0	–
356	ORCHARDGRASS. *Dactylis glomerata*										
357	—hay, s-c, (1)	1-03-438	88.3	2.38	1.95	54.	9.7	4.9	25.0	34.0	7.6
358	—aerial part, fresh, early vegetative, (2)	2-03-440	23.8	2.95	2.42	67.	18.4	14.1	–	23.6	–
359	—aerial part, fresh, early bloom, (2)	2-03-442	27.5	2.73	2.24	62.	13.1	9.2	–	28.8	–
360	OYSTERS. *Crassostrea* sp, *Ostrea* sp										
361	—shells, fine grnd, mn 33% calcium, (6)	6-03-481	100.0	–	–	–	1.0	–	–	–	–
362	Oyster shell flour (AAFCO)										
363	PEA. *Pisum* sp										
364	—aerial part wo seeds, ensiled, (3)	3-03-596	24.5	2.51	2.06	57.	13.1	7.7	–	29.8	–
365	Pea vine silage										
366	PEANUT. *Arachis hypogaea*										
367	—kernels, mech-extd grnd, mx 7% fiber, (5)	5-03-649	92.0	3.88	3.18	88.	49.8	45.3	–	12.0	–
368	Peanut meal (AAFCO) (CFA)										
369	—kernels, solv-extd grnd, 45% protein, (5)	5-03-650	92.0	3.66	3.00	83.	51.5	46.9	–	14.1	–
370	Solvent extracted peanut meal (AAFCO)										
371	Groundnut meal, solvent extracted										
372	PHOSPHATE ROCK.										
373	—defluorinated grnd, mx 1 part fluorine per										
374	100 parts phosphorus, (6)	6-01-780	99.8	–	–	–	–	–	–	–	–
375	Phosphate, defluorinated (AAFCO)										
376	Defluorinated phosphate (CFA)										
377	POTATO. *Solanum tuberosum*										
378	—tubers, ensiled, (3)	3-03-768	25.1	3.48	2.86	79.	10.0	6.0	–	8.5	–
379	—tubers, fresh, (4)	4-03-787	24.6	3.70	3.04	84.	9.0	5.7	–	2.1	–
380	PRAIRIE HAY—see Native plants, Midwest										
381	RAPE. *Brassica* sp										
382	—seeds, mech-extd grnd, (5)	5-03-870	93.6	3.40	2.78	77.	39.6	32.5	–	14.6	–
383	Rapeseed meal, expeller extracted										
384	—seeds, solv-extd grnd, (5)	5-03-871	90.3	3.18	2.60	72.	43.6	35.8	–	15.3	–
385	Rapeseed meal, solvent extracted										
386	REDTOP. *Agrostis alba*										
387	—aerial part, fresh, full bloom, (2)	2-03-891	26.3	2.60	2.13	59.	8.1	4.5	–	25.1	–
388	REFUSE SCREENINGS—see Grains screenings										
389	RICE. *Oryza sativa*										
390	—bran w germ, dry milled, mx 13% fiber										
391	calcium carbonate declared above 3% mn, (4)	4-03-928	91.0	3.53	2.89	80.	14.8	10.1	–	12.1	–
392	Rice bran (AAFCO)										
393	—groats, polished, (4)	4-03-942	89.0	3.92	3.22	89.	8.2	6.2	–	.4	–
394	Rice, white, polished										

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

Line No	On a dry basis (moisture free) Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D$_2$ (IU/g)
330																			
331	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
332																			
333																			
334	.88	–	–	–	–	–	–	–	–	–	.07	–	–	–	–	–	.4	–	–
335																			
336	.26	.52	.070	4.4	–	–	.050	.29	74.7	–	.24	.97	–	.17	–	–	101.0	–	–
337	.33	.78	–	10.1	–	–	.020	.18	39.2	–	.10	2.44	–	.37	.24	–	–	–	–
338	.37	–	–	5.5	–	–	.010	.02	40.4	–	.30	3.41	–	–	–	–	119.5	–	–
339	.09	–	–	–	–	–	.042	–	48.4	–	.54	–	–	–	–	–	–	–	–
340																			
341																			
342	.11	–	.070	6.6	–	–	.008	.19	42.9	–	.39	.42	–	.07	–	–	–	36.6	–
343	.10	–	–	–	–	–	–	–	–	–	.36	–	–	–	–	–	–	–	–
344	.08	–	–	7.0	–	–	–	.10	31.4	–	.47	.37	–	–	–	–	–	–	–
345																			
346																			
347																			
348																			
349	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
350																			
351	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
352																			
353	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
354																			
355	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
356																			
357	.45	.41	.020	13.7	–	–	.010	.32	249.6	–	.37	2.10	–	–	.26	18.1	33.5	–	–
358	.58	–	–	–	–	–	.020	.31	134.3	–	.55	3.38	–	–	–	–	337.4	–	–
359	.25	–	–	33.1	–	–	.080	–	104.1	–	.39	–	–	–	–	–	–	108.9	–
360																			
361	38.05	–	–	–	–	–	.290	.30	133.3	–	.07	.10	–	.21	–	–	–	–	–
362																			
363																			
364	1.31	–	–	–	–	–	–	–	–	–	.24	–	–	–	–	–	–	–	–
365																			
366																			
367	.18	–	–	–	–	–	–	.36	27.7	–	.62	1.25	–	–	–	–	–	–	–
368																			
369	.22	–	–	–	–	–	–	.04	31.5	–	.71	–	–	–	–	–	–	–	–
370																			
371																			
372																			
373																			
374	33.07	–	–	–	–	–	.922	–	–	–	18.04	.09	–	3.96	–	–	–	–	–
375																			
376																			
377																			
378	.04	–	–	–	–	–	–	–	–	–	.23	–	–	–	–	–	–	–	–
379	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
380																			
381																			
382	.64	–	–	–	–	–	–	–	–	–	1.04	–	–	–	–	–	–	–	–
383																			
384	.44	–	–	–	–	–	–	–	–	–	1.00	–	–	–	–	–	–	–	–
385																			
386																			
387	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	152.6	–	–
388																			
389																			
390																			
391	.07	–	–	14.3	–	–	.021	1.04	459.2	–	2.00	1.91	–	–	–	32.9	–	–	–
392																			
393	.03	–	–	3.3	–	–	.002	.02	12.3	–	.14	.15	–	–	–	2.0	–	–	–
394																			

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations–Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellulose (%)	Crude fiber (%)	Lignin (%)
395	RUSSIAN THISTLE, TUMBLING. *Salsola*										
396	*kali tenuifolia*										
397	–hay, s-c, (1)	1-03-988	88.4	1.90	1.56	43.	11.9	7.8	–	28.3	–
398	–aerial part, fresh, stem cured, (2)	2-08-000	80.0	2.14	1.78	50.	14.7	9.7	18.0	–	7.0
399	RYE. *Secale cereale*										
400	–straw, (1)	1-04-007	88.9	1.72	1.41	39.	3.0	1.6	–	47.6	–
401	–flour by-product, coarse sift, mx 8.5% fiber, (4)	4-04-031	90.0	3.48	2.86	79.	19.0	14.2	–	6.7	–
402	Rye middlings (AAFCO)										
403	–flour by-product mill run, mx 9.5% fiber, (4)	4-04-034	90.0	3.31	2.71	75.	19.1	14.1	–	5.6	–
404	Rye mill run (AAFCO)										
405	–grain, (4)	4-04-047	89.0	3.75	3.07	85.	13.4	10.6	–	2.2	–
406	–distillers grains, dehy, (5)	5-04-023	93.0	2.87	2.35	65.	24.1	14.5	–	15.1	–
407	Rye distillers dried grains (AAFCO) (CFA)										
408	RYEGRASS, ITALIAN. *Lolium multiflorum*										
409	–aerial part, fresh, (2)	2-04-073	24.3	2.25	1.84	51.	16.3	7.0	–	21.8	–
410	SAFFLOWER. *Carthamus tinctorius*										
411	–seeds, (4)	4-07-958	93.1	3.88	3.18	88.	17.5	13.9	–	28.6	–
412	–seeds, mech-extd grnd, (5)	5-04-109	91.0	2.07	1.70	47.	21.7	18.7	–	34.1	–
413	Safflower seed, mechanical extracted (AAFCO)										
414	Safflower meal, expeller extracted										
415	–seeds, solv-extd grnd, (5)	5-04-110	91.8	2.38	1.95	54.	23.3	18.7	–	35.2	–
416	Safflower seed, solvent extracted (AAFCO)										
417	Safflower meal, solvent extracted										
418	–seeds wo hulls, solv-extd grnd, (5)	5-07-959	90.5	3.40	2.78	77.	49.1	41.3	–	9.4	–
419	Safflower meal without hulls, solvent extracted										
420	SAGE, BLACK. *Salvia mellifera*										
421	–browse, fresh, stem cured, (2)	2-05-564	76.0	2.08	1.12	47.	8.5	4.4	22.0	–	16.0
422	SAGEBRUSH, BIG. *Artemisia tridentata*										
423	–browse, fresh, stem cured, (2)	2-07-992	76.0	2.30	1.27	51.	9.4	5.4	21.0	–	16.0
424	SAGEBRUSH, BUD. *Artemisia spinescens*										
425	–browse, fresh, early vegetative, (2)	2-07-991	25.0	2.42	1.99	55.	17.3	13.7	18.0	–	8.0
426	–browse, fresh, late vegetative, (2)	2-04-124	28.9	2.29	1.88	52.	14.4	10.4	–	23.4	–
427	SAGEBRUSH, FRINGED. *Artemisia frigida*										
428	–browse, fresh, mid-bloom, (2)	2-04-129	43.2	2.51	2.06	57.	8.5	4.9	–	26.5	–
429	–browse, fresh, mature, (2)	2-04-130	50.0	2.20	1.81	50.	6.0	2.6	–	31.7	–
430	SALTBUSH, NUTTAL. *Atriplex nuttallii*										
431	–browse, fresh, stem cured, (2)	2-07-993	75.0	1.49	1.32	36.	7.2	3.4	19.0	–	10.0
432	SALTBUSH, SHADSCALE. *Atriplex confertifolia*										
433	–browse, fresh, stem cured, (2)	2-05-565	80.0	1.26	.88	31.	7.7	4.3	18.0	–	13.0
434	SALTGRASS. *Distichlis* sp										
435	–hay, s-c, (1)	1-04-168	88.4	2.20	1.81	50.	8.8	4.5	–	31.2	–
436	–aerial part, fresh, post ripe, (2)	2-04-169	74.4	1.94	1.59	44.	4.2	.9	–	34.9	–
437	–aerial part, fresh, (2)	2-04-170	74.4	2.29	1.88	52.	6.5	3.0	–	30.3	–
438	SALTGRASS, DESERT. *Distichlis stricta*										
439	–aerial part, fresh, (2)	2-04-171	75.0	2.16	1.77	49.	5.9	2.5	–	29.7	–
440	SAND DROPSEED–see Dropseed, sand										
441	SCREENINGS–see Barley, grain screenings;										
442	see Grains, screenings; see Wheat,										
443	grain screenings										
444	SEDGE. *Carex* sp										
445	–hay, s-c, (1)	1-04-193	90.2	2.20	1.81	50.	10.3	5.2	–	30.9	–
446	SESAME. *Sesamum indicum*										
447	–seeds, mech-extd grnd, (5)	5-04-220	93.0	3.55	2.71	81.	51.5	41.2	–	5.4	–
448	Sesame meal, expeller extracted										
449	SHORTS–see Wheat, flour by-product,										
450	coarse sift, mx 7% fiber										
451	SKIMMED MILK–see Cattle, milk, skim										
452	SODIUM PHOSPHATE.										
453	–monobasic, $NaH_2PO_4 \cdot H_2O$, technical, (6)	6-04-288	96.7	–	–	–	–	–	–	–	–
454	Monosodium phosphate (AAFCO)										
455	SODIUM TRIPOLYPHOSPHATE.										
456	–commercial, (6)	6-08-076	96.0	–	–	–	–	–	–	–	–
457	Sodium tripolyphosphate (AAFCO)										
458	SORGHUM GRAIN–see Sorghum, grain										
459	variety; Sorghum, kafir; Sorghum, milo										

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

On a dry basis (moisture free)

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
395																			
396																			
397	1.84	–	–	–	–	–	–	1.19	–	–	.29	–	–	–	–	–	–	–	–
398	3.30	–	–	–	–	–	–	–	–	–	.16	–	–	–	–	–	9.0	–	–
399																			
400	.28	.24	–	4.0	–	–	–	.08	6.6	–	.10	.97	–	.13	.11	–	–	–	–
401	.07	–	–	–	–	–	–	–	48.9	–	.70	.70	–	–	–	–	–	–	–
402																			
403	.08	–	–	–	–	–	–	.26	–	–	.66	.92	–	–	–	–	–	–	–
404																			
405	.07	–	–	8.8	–	–	.009	.13	75.2	–	.38	.52	–	.02	–	34.3	–	–	–
406	.14	–	–	–	–	–	–	.18	19.9	–	.44	.12	–	.18	–	–	–	–	–
407																			
408																			
409	.64	–	–	–	–	–	–	.35	–	–	.41	2.00	–	–	–	–	–	–	–
410																			
411	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
412	.25	–	–	10.7	–	–	.050	.36	19.6	–	.78	.79	–	.05	–	43.7	–	–	–
413																			
414																			
415	.37	–	–	–	–	–	–	–	–	–	.92	–	–	–	–	–	–	–	–
416																			
417																			
418	.26	–	–	–	–	–	–	–	–	–	1.83	–	–	–	–	–	–	–	–
419																			
420																			
421	.60	–	–	–	–	–	–	–	–	–	.16	–	–	–	–	–	17.6	–	–
422																			
423	.67	–	–	–	–	–	–	–	–	–	.18	–	–	–	–	–	16.1	–	–
424																			
425	.97	–	–	–	–	–	–	–	–	–	.33	–	–	–	–	–	23.8	–	–
426	1.06	–	–	–	–	–	–	.49	–	–	.29	–	–	–	–	–	–	–	–
427																			
428	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
429	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
430																			
431	2.21	–	–	–	–	–	–	–	–	–	.21	–	–	–	–	–	19.0	–	–
432																			
433	2.53	–	–	–	–	–	–	–	–	–	.09	–	–	–	–	–	19.6	–	–
434																			
435	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
436	.23	–	–	–	–	–	–	.30	–	–	.07	–	–	–	–	–	–	–	–
437	.21	–	–	–	–	–	.020	.28	154.8	–	.09	.24	–	–	–	–	–	–	–
438																			
439	.16	–	–	–	–	–	–	–	–	–	.09	–	–	–	–	–	–	–	–
440																			
441																			
442																			
443																			
444																			
445	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
446																			
447	2.18	–	–	–	–	–	–	–	51.6	–	1.39	–	–	–	–	–	–	–	–
448																			
449																			
450																			
451																			
452																			
453	–	–	–	–	–	–	–	–	–	–	22.46	–	–	33.40	–	–	–	–	–
454																			
455																			
456	–	–	–	–	–	–	–	–	–	–	25.98	–	–	–	–	–	–	–	–
457																			
458																			
459																			

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations–Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellu-lose (%)	Crude fiber (%)	Lignin (%)
460	SORGHUM, GRAIN VARIETY. *Sorghum vulgare*										
461	–aerial part, s-c, (1)	1-04-372	90.3	2.42	1.99	55.	6.9	2.6	–	27.5	–
462	Grain sorghum fodder, suncured										
463	–aerial part wo heads, s-c, (1)	1-07-961	85.1	2.12	1.74	48.	5.3	1.0	–	32.6	–
464	Grain sorghum stover, suncured										
465	–aerial part, ensiled, (3)	3-07-962	29.4	2.56	2.10	58.	7.3	1.7	–	26.3	–
466	Grain sorghum fodder silage										
467	–grain, (4)	4-04-383	89.0	3.66	3.00	83.	12.5	7.1	–	2.2	–
468	–grain, mn 6% mx 9% protein, (4)	4-08-138	88.0	3.97	3.25	90.	7.9	6.4	–	2.2	–
469	–grain, mn 9% mx 12% protein, (4)	4-08-139	88.0	3.97	3.25	90.	11.7	9.5	–	2.4	1.3
470	–grain, mn 12% mx 15% protein, (4)	4-08-140	88.0	3.92	3.22	89.	13.0	10.5	–	2.0	–
471	–distillers grains, dehy, (5)	5-04-374	94.0	3.70	3.04	84.	33.2	27.6	–	12.8	–
472	Grain sorghum distillers dried grains (AAFCO)										
473	SORGHUM, JOHNSONGRASS. *Sorghum halepense*										
474	–hay, s-c, (1)	1-04-407	90.7	2.47	2.02	56.	7.7	3.4	–	33.3	–
475	SORGHUM, KAFIR. *Sorghum vulgare*										
476	–grain, (4)	4-04-428	90.0	4.01	3.29	91.	13.1	10.6	–	2.2	–
477	SORGHUM, MILO. *Sorghum vulgare*										
478	–grain, (4)	4-04-444	89.0	4.14	3.40	94.	12.4	9.7	–	2.2	–
479	–heads, chopped, (4)	4-04-446	90.0	3.75	3.07	85.	11.1	8.4	–	7.8	–
480	SORGHUM, SORGO. *Sorghum vulgare*										
481	*saccharatum*										
482	–aerial part, ensiled, (3)	3-04-468	26.0	2.60	2.13	59.	6.3	1.4	–	26.8	–
483	Sorghum, sorgo, fodder, silage										
484	SORGHUM, SUDANGRASS. *Sorghum vulgare*										
485	*sudanense*										
486	–hay, s-c, (1)	1-04-480	88.9	2.29	1.88	52.	12.7	6.5	31.9	28.9	13.6
487	–aerial part, fresh, early vegetative, (2)	2-04-484	17.6	2.60	2.13	59.	16.8	11.6	–	30.9	–
488	–aerial part, fresh, mid-bloom, (2)	2-04-485	22.7	2.42	1.99	55.	8.7	6.0	–	36.1	–
489	–aerial part, ensiled, (3)	3-04-499	23.3	2.47	2.02	56.	10.2	7.0	–	34.4	–
490	SORGO–see Sorghum, sorgo										
491	SOYBEAN. *Glycine max*										
492	–hay, s-c, (1)	1-04-558	89.2	2.38	1.95	54.	16.3	11.2	31.1	32.1	11.4
493	–hulls, (1)	1-04-560	91.3	1.90	1.56	43.	13.7	8.8	52.1	38.9	6.5
494	Soybean hulls (AAFCO)										
495	Soybran flakes										
496	–straw, (1)	1-04-567	87.6	1.90	1.56	43.	5.5	1.6	–	44.1	–
497	–aerial part, ensiled, (3)	3-04-581	28.0	2.42	1.99	55.	14.7	11.6	–	31.1	–
498	–seeds, (5)	5-04-610	90.0	4.10	3.36	93.	42.1	37.9	–	5.6	–
499	–seeds, mech-extd grnd, mx 7% fiber, (5)	5-04-600	90.0	3.66	3.00	83.	48.7	43.8	–	6.7	–
500	Soybean meal, mechanical extracted (AAFCO)										
501	–seeds, solv-extd grnd, mx 7% fiber, (5)	5-04-604	89.0	3.53	2.89	80.	51.5	46.4	–	6.7	–
502	Soybean meal, solvent extracted (AAFCO)										
503	SOYBRAN FLAKES–see Soybean, hulls										
504	SPENT BONE BLACK–see Animal, bone										
505	charcoal										
506	SQUIRRELTAIL. *Sitanion* sp										
507	–aerial part, fresh, stem cured, (2)	2-05-566	86.0	1.91	1.61	46.	4.5	1.1	38.0	–	9.0
508	SUDANGRASS–see Sorghum, sudangrass										
509	SUGARCANE. *Saccharum officinarum*										
510	–molasses, dehy, (4)	4-04-695	96.0	3.44	2.81	80.	10.7	–	–	5.2	–
511	Cane molasses, dried, Molasses, cane, dried										
512	–molasses, mn 48% invert sugar mn 79.5										
513	degrees brix, (4)	4-04-696	75.0	3.18	2.60	72.	4.3	1.2	–	–	–
514	Cane molasses (AAFCO)										
515	Molasses, cane										
516	SUNFLOWER. *Helianthus* sp										
517	–seeds wo hulls, mech-extd grnd, (5)	5-04-738	93.0	3.09	2.53	70.	44.1	39.2	–	14.0	–
518	Sunflower meal without hulls mechanical										
519	extracted (AAFCO)										
520	–seeds wo hulls, solv-extd grnd, (5)	5-04-739	93.0	2.87	2.35	65.	50.3	44.8	–	11.8	–
521	Sunflower meal without hulls, solvent										
522	extracted (AAFCO)										
523	SWEETCLOVER. *Melilotus* sp										
524	–hay, s-c, (1)	1-04-754	87.2	2.34	1.92	53.	16.3	11.6	–	32.2	–

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
	On a dry basis (moisture free)																		
460																			
461	.62	–	–	–	–	–	–	–	–	–	.19	–	–	–	–	–	–	–	–
462																			
463	.40	–	–	–	–	–	–	–	–	–	.11	–	–	–	–	–	–	–	–
464																			
465	.25	–	–	–	–	–	–	–	–	–	.18	–	–	–	–	–	–	–	–
466																			
467	.05	–	.138	10.8	–	–	–	.19	16.3	–	.35	.38	–	.05	–	15.4	–	–	–
468	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
469	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
470	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
471	.15	–	–	–	–	–	–	–	–	–	.63	–	–	–	–	–	–	–	–
472																			
473																			
474	.81	–	–	–	–	–	.060	.35	–	–	.31	1.35	–	–	–	–	37.0	–	–
475																			
476	.04	–	–	7.0	–	–	.010	–	17.6	–	.37	–	–	–	–	–	–	–	–
477																			
478	.04	–	.100	15.8	–	–	–	.22	14.5	–	.33	.39	–	.01	–	–	–	–	–
479	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
480																			
481																			
482	.35	–	–	31.3	–	–	.020	.27	–	–	.20	1.22	–	–	–	–	–	–	–
483																			
484																			
485																			
486	.56	–	.130	36.8	–	–	.020	.40	93.3	–	.31	1.54	–	.02	.06	–	–	–	–
487	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
488	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
489	.64	–	–	36.6	–	–	.010	.49	98.8	–	.23	3.07	–	–	–	–	–	–	–
490																			
491																			
492	1.29	.15	.090	9.0	–	–	.030	.79	92.6	–	.23	.97	–	.12	.26	24.0	35.7	26.7	709.8
493	.59	–	–	–	–	–	–	–	13.9	–	.17	–	–	–	–	–	–	–	–
494																			
495																			
496	1.59	–	–	–	–	–	–	.92	51.2	–	.06	.53	–	–	–	–	–	–	–
497	1.25	–	–	9.3	–	–	.040	.38	113.5	–	.49	.93	–	–	–	–	77.6	–	–
498	.28	–	–	–	–	–	–	–	–	–	.66	–	–	–	–	–	–	36.6	–
499	.30	–	.200	20.0	–	–	.018	.28	35.9	–	.70	1.90	–	.27	–	–	–	–	–
500																			
501	.36	–	.100	40.8	–	–	.013	.30	30.9	–	.75	2.21	–	.38	–	–	–	–	–
502																			
503																			
504																			
505																			
506																			
507	.67	–	–	–	–	–	–	–	–	–	.07	–	–	–	–	–	1.1	–	–
508																			
509																			
510	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
511																			
512																			
513	1.19	–	–	79.4	–	–	.025	.47	56.3	–	.11	3.17	–	–	–	–	–	–	–
514																			
515																			
516																			
517	.46	–	–	–	–	–	–	–	24.6	–	1.12	1.16	–	–	–	–	–	–	–
518																			
519																			
520	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
521																			
522																			
523																			
524	1.77	–	–	10.1	–	–	.020	.62	103.0	–	.26	1.34	–	–	–	–	124.4	–	–

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations—Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellulose (%)	Crude fiber (%)	Lignin (%)
525	TIMOTHY. *Phleum pratense*										
526	—hay, s-c, late vegetative, (1)	1-04-881	88.6	2.60	2.13	59.	12.3	7.8	–	32.9	–
527	—hay, s-c, early bloom, (1)	1-04-882	87.7	2.47	2.02	56.	8.7	4.7	29.6	33.2	7.6
528	—hay, s-c, mid-bloom, (1)	1-04-883	88.4	2.38	1.95	54.	8.5	5.2	–	33.5	–
529	—hay, s-c, late bloom, (1)	1-04-885	88.0	2.34	1.91	53.	8.3	3.6	–	32.4	–
530	—aerial part, fresh, late vegetative, (2)	2-04-903	28.3	2.56	2.10	58.	9.3	5.0	–	33.5	–
531	—aerial part, fresh, mid-bloom, (2)	2-04-905	28.1	2.42	1.99	55.	9.6	3.7	31.0	33.7	6.3
532	—aerial part, ensiled, (3)	3-04-922	37.5	2.56	2.10	58.	10.2	5.5	–	33.9	–
533	TORULA DRIED YEAST—see Yeast,										
534	torulopsis										
535	TREFOIL, BIRDSFOOT. *Lotus corniculatus*										
536	—hay, s-c, (1)	1-05-044	91.2	2.47	2.02	56.	15.6	10.7	–	29.6	–
537	—aerial part, fresh, (2)	2-07-998	20.0	2.73	2.24	62.	28.0	23.0	–	20.7	–
538	TURNIP. *Brassica rapa*										
539	—roots, fresh, (4)	4-05-067	9.3	3.57	2.93	81.	14.0	9.0	–	11.8	–
540	VETCH. *Vicia* sp										
541	—hay, s-c, (1)	1-05-106	88.2	2.69	2.21	61.	20.0	15.6	–	28.5	–
542	WHEAT. *Triticum* sp										
543	—hay, s-c, (1)	1-05-172	85.9	2.29	1.88	52.	7.5	4.0	–	27.8	–
544	—straw, (1)	1-05-175	90.1	1.68	1.37	38.	3.6	1.5	50.1	41.5	13.7
545	—aerial part, fresh, early vegetative, (2)	2-05-176	21.5	3.13	2.57	71.	28.6	23.6	–	17.4	–
546	—bran, dry milled, (4)	4-05-190	89.0	2.91	2.39	66.	18.0	13.5	–	11.2	–
547	Wheat bran (AAFCO)										
548	Bran (CFA)										
549	—flour by-product, coarse sift, mx 7% fiber, (4)	4-05-201	90.0	3.75	3.07	85.	20.4	17.3	–	5.6	–
550	Wheat shorts, mx 7 fiber (AAFCO)										
551	Shorts, mx 8 fiber (CFA)										
552	—flour by-product, mx 9.5% fiber, (4)	4-05-205	90.0	3.31	2.71	75.	19.1	14.9	–	8.9	–
553	Wheat middlings (AAFCO)										
554	Wheat standard middlings										
555	—flour by-product mill run, mx 9.5% fiber, (4)	4-05-206	90.0	3.57	2.93	81.	17.0	11.6	–	8.9	–
556	Wheat mill run (AAFCO)										
557	—grain, (4)	4-05-211	89.0	3.88	3.18	88.	14.3	11.2	–	3.4	–
558	—grain, Pacific coast, (4)	4-08-142	89.2	3.88	3.18	88.	11.1	8.6	–	3.0	–
559	—grain, thresher-run, wt mn 55 mx 60 lb per										
560	bushel mx 5% foreign material, (4)	4-08-165	88.0	3.84	3.15	87.	18.0	14.0	–	2.9	–
561	—grain, thresher-run, mn wt 60 lb per bushel										
562	mx 5% foreign material, (4)	4-08-164	88.0	3.88	3.18	88.	15.4	12.0	–	2.5	–
563	WHEAT GRAIN—see also Wheat, hard										
564	red spring; see Wheat, soft red winter										
565	—grain screenings, (4)	4-05-216	89.0	3.40	2.78	77.	16.9	12.2	5.6	7.9	7.9
566	—germ, grnd, mn 25% protein mn 7% fat, (5)	5-05-218	90.0	4.28	3.51	97.	29.1	27.4	–	3.3	–
567	Wheat germ meal (AAFCO)										
568	WHEAT, HARD RED SPRING. *Triticum aestivum*										
569	—grain, (4)	4-05-258	86.5	3.88	3.18	88.	16.1	12.6	–	3.4	–
570	WHEAT, HARD RED WINTER. *Triticum aestivum*										
571	—grain, (4)	4-05-268	89.1	3.88	3.18	88.	14.6	11.4	–	3.0	–
572	WHEAT, SOFT RED WINTER. *Triticum aestivum*										
573	—grain, (4)	4-05-294	89.1	3.88	3.18	88.	12.3	9.2	–	2.5	–
574	WHEATGRASS. *Agropyron* sp										
575	—aerial part, fresh, mature, (2)	2-05-363	60.5	2.29	1.88	52.	5.3	1.9	–	36.6	–
576	WHEATGRASS, CRESTED. *Agropyron cristatum*										
577	—hay, s-c, (1)	1-05-418	92.0	2.29	1.88	52.	10.8	3.9	–	32.6	–
578	—aerial part, fresh, early vegetative, (2)	2-05-420	30.8	2.87	2.35	65.	23.6	19.0	34.1	22.2	5.9
579	—aerial part, fresh, early bloom, (2)	2-05-442	42.5	2.56	2.10	58.	11.0	7.2	–	29.5	–
580	—aerial part, fresh, full bloom, (2)	2-05-424	50.0	2.38	1.95	54.	9.8	6.1	34.8	30.3	6.2
581	—aerial part, fresh, mature, (2)	2-05-427	60.0	2.20	1.81	50.	5.7	2.3	39.1	35.6	6.9
582	—aerial part, fresh, post ripe, (2)	2-05-428	80.0	2.03	1.66	46.	3.1	.0	–	40.3	–
583	WHITE HOMINY FEED—see Corn, white,										
584	grits by-product										
585	WHOLE PLANT CORN SILAGE—see Corn,										
586	aerial part, ensiled										
587	WINTERFAT. *Eurotia* sp										
588	—aerial part, fresh, stem cured, (2)	2-07-996	76.0	1.46	1.19	33.	11.0	6.9	25.0	–	9.0

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D, (IU/g)
	On a dry basis (moisture free)																		
525																			
526	.66	–	–	–	–	–	–	–	–	–	.34	–	–	–	–	–	–	–	–
527	.60	–	–	–	–	–	–	–	–	–	.26	.92	–	–	–	–	–	13.0	1580.6
528	.41	–	–	–	–	–	–	.16	–	–	.19	–	–	–	–	–	53.4	–	–
529	.38	–	–		–	–	–	–	–	–	.18	–	–	–	–	–	9.7	–	–
530	.50	–	–	–	–	–	–	.15	–	–	.35	2.40	–	–	–	–	–	–	–
531	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
532	.55	–	–	5.5	–	–	.010	.15	90.2	–	.29	1.69	–	–	–	–	78.9	–	–
533																			
534																			
535																			
536	1.75	–	–	–	–	–	–	–	–	–	.22	–	–	–	–	–	–	–	–
537	2.20	–	–	–	–	–	–	–	–	–	.25	2.30	–	–	–	–	–	–	–
538																			
539	.64	–	–	–	–	–	–	–	–	–	.22	–	–	–	–	–	–	–	–
540																			
541	1.36	–	.350	9.9	–	–	.050	.27	60.9	–	.34	2.12	–	.52	.15	–	–	–	–
542																			
543	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	111.6	–	–
544	.17	.30	.040	3.3	–	–	.020	.12	40.4	–	.08	1.11	–	.14	.19	–	2.2	–	–
545	.42	–	–	–	–	–	–	.21	–	–	.40	3.50	–	–	–	–	520.2	–	–
546	.16	–	.044	13.8	–	–	.019	.62	130.0	–	1.32	1.39	–	.07	–	–	–	3.1	–
547																			
548																			
549	.12	–	.100	10.3	–	–	.011	.29	116.1	–	.84	.94	–	.08	–	–	–	31.7	–
550																			
551																			
552	.16	–	.100	24.4	–	–	.010	.41	131.5	–	1.01	1.08	–	.24	–	–	–	–	–
553																			
554																			
555	.10	–	.200	20.8	–	–	.010	.57	114.1	–	1.13	1.42	–	.24	–	–	–	–	–
556																			
557	.06	–	.090	8.1	–	–	.006	.18	54.6	–	.41	.58	–	.10	–	15.4	–	34.2	–
558	.14	–	–	–	–	–	–	–	–	–	.34	–	–	–	–	–	–	–	–
559																			
560	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
561																			
562	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
563																			
564																			
565	.09	–	–	–	–	–	–	–	–	32.1	.40	–	–	–	–	–	–	–	–
566	.08	–	–	9.8	–	–	.012	–	149.9	–	1.16	–	–	–	–	–	–	158.7	–
567																			
568																			
569	.06	–	–	12.3	–	–	.006	–	71.9	–	.47	–	–	–	–	–	–	–	–
570																			
571	.06	–	.100	5.1	–	–	–	.11	43.6	–	.45	.57	–	–	–	–	–	–	–
572																			
573	.10	–	–	11.0	–	–	–	.11	42.9	–	.33	.44	–	–	–	–	–	–	–
574																			
575	.36	–	–	–	–	–	–	.09	–	–	.15	–	–	–	–	–	68.4	–	–
576																			
577	.33	–	.240	–	–	–	–	–	–	–	.21	–	–	–	–	–	–	–	–
578	.46	–	–	–	–	–	–	.28	–	–	.35	–	–	–	–	–	433.7	–	–
579	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
580	.39	–	–	–	–	–	–	–	–	–	.28	–	–	–	–	–	153.5	–	–
581	.29	–	–	–	–	–	–	–	–	–	.17	–	–	–	–	–	75.4	–	–
582	.27	–	.240	8.4	–	–	–	–	52.9	–	.07	–	–	–	–	–	.2	–	–
583																			
584																			
585																			
586																			
587																			
588	2.14	–	–	–	–	–	–	–	–	–	.12	–	–	–	–	–	16.8	–	–

TABLE 16 Composition of Feeds Commonly Used in Sheep Rations–Continued

Line No	SCIENTIFIC NAME National Research Council Name (NRC) American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Name	Reference No.	Dry matter (%)	On a dry basis (moisture free) DE sheep (Mcal/kg)	ME sheep (Mcal/kg)	TDN sheep (%)	Protein (%)	Dig. protein (%)	Cellulose (%)	Crude fiber (%)	Lignin (%)
589	YEAST. *Saccharomyces cerevisiae*										
590	–brewers Saccharomyces, dehy grnd, mn										
591	40% protein, (7)	7-05-527	93.0	3.22	2.64	73.	47.9	40.7	–	3.2	–
592	Brewers dried yeast (AAFCO)										
593	YEAST, TORULOPSIS. *Torulopsis utilis*										
594	–dehy, mn 40% protein, (7)	7-05-534	93.0	2.95	2.42	67.	51.9	44.6	–	2.2	–
595	Torula dried yeast (AAFCO)										
596	YELLOWBRUSH. *Chrysothannus stenophyllus*										
597	–browse, fresh, stem cured, (2)	2-07-997	70.0	2.26	1.68	50.	6.6	3.1	22.0	–	13.0

(1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

Line No	Calcium (%)	Chlorine (%)	Cobalt (mg/kg)	Copper (mg/kg)	Fluorine (mg/kg)	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Molybdenum (mg/kg)	Phosphorus (%)	Potassium (%)	Selenium (mg/kg)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Provitamin A (carotene) (mg/kg)	Vitamin E (mg/kg)	Vitamin D_2 (IU/g)
	On a dry basis (moisture free)																		
589																			
590																			
591	.14	–	.200	35.5	–	–	.010	.25	6.1	–	1.54	1.85	–	.08	–	41.6	–	–	–
592																			
593																			
594	.61	–	–	14.4	–	–	.010	.14	13.7	–	1.81	2.02	–	.01	–	106.7	–	–	–
595																			
596																			
597	1.90	–	–	–	–	–	–	–	–	–	.10	–	–	–	–	–	4.6	–	–

TABLE 17 Abbreviations for Terms Used in Table 16

AAFCO	Association of American Feed Control Officials	lb	pound(s)
		mech	mechanical
Can	Canadian	mech-extd	mechanically extracted, expeller-extracted, hydraulic-extracted, or old process
CE	Canadian Eastern		
CGA	Canada Grain Act	μg	microgram
CFA	Canada Feeds Act	mg	milligram
cp	chemically pure	mm	millimeter
CW	Canadian Western	mn	minimum
dehy	dehydrated	mx	maximum
extd	extracted	NRC	National Research Council
extn	extraction	ppm	parts per million
extn unspec	extraction unspecified	s-c	suncured
g	gram(s)	solv-extd	solvent-extracted
gr	grade	sp	species
grnd	ground	US	United States
ICU	International Chick Unit	USP	United States Pharmacopoeia
IU	International Units	w	with
kcal	kilocalories	wo	without
kg	kilogram(s)	wt	weight

TABLE 18 Stage-of-Maturity Terms Used in Table 16

Preferred Term	Definition	Comparable Terms
For Plants That Bloom		
Germinated	Stage in which the embryo in a seed resumes growth after a dormant period	Sprouted
Early vegetative	Stage at which the plant is vegetative and before the stems elongate	Fresh new growth, before heading out, before inflorescence emergence, immature prebud stage, very immature, young
Late vegetative	Stage at which stems are beginning to elongate to just before blooming; first bud to first flowers	Before bloom, bud stage, budding plants, heading to in bloom, heads just showing, jointing and boot (grasses), prebloom, preflowering, stems elongated
Early bloom	Stage between initiation of bloom and stage in which 1/10 of the plants are in bloom; some grass heads are in anthesis	Early anthesis, first flower, headed out, in head, up to 1/10 bloom
Mid-bloom	Stage in which 1/10 to 2/3 of the plants are in bloom; most grass heads are in anthesis	Bloom, flowering, flowering plants, half bloom, in bloom, mid anthesis
Full bloom	Stage in which 2/3 or more of the plants are in bloom	3/4 to full bloom, late anthesis
Late bloom	Stage in which blossoms begin to dry and fall and seeds begin to form	15 days after silking, before milk, in bloom to early pod, late to past anthesis
Milk stage	Stage in which seeds are well formed but soft and immature	After anthesis, early seed, fruiting, in tassel, late bloom to early seed, past bloom, pod stage, post anthesis, post bloom, seed developing, seed forming, soft, soft immature
Dough stage	Stage in which the seeds are of dough-like consistency	Dough stage, nearly mature, seeds dough, seeds well developed, soft dent
Mature	Stage in which plants are normally harvested for seed	Dent, dough to glazing, fruiting, fruiting plants, in seed, kernels ripe, ripe seed
Post ripe	Stage that follows maturity; seeds are ripe and plants have been cast and weathering has taken place (applies mostly to range plants)	Late, seed, over ripe, very mature
Stem cured	Stage in which plants are cured on the stem; seeds have been cast and weathering has taken place (applies mostly to range plants)	Dormant, mature and weathered, seeds cast
Regrowth early vegetative	Stage in which regrowth occurs without flowering activity; vegetative crop aftermath; regrowth in stubble (applies primarily to fall regrowth in temperate climates); early dry season regrowth	Vegetative recovery growth
Regrowth late vegetative	Stage in which stems begin to elongate to just before blooming; first bud to first flowers; regrowth in stubble with stem elongation (applies primarily to fall regrowth in temperate climates)	Recovery growth, stems elongating, jointing and boot (grasses)
For Plants That Do Not Bloom[a]		
1 to 14 days' growth	A specified length of time after plants have started to grow	2 weeks' growth
15 to 28 days' growth	A specified length of time after plants have started to grow	4 weeks' growth
29 to 42 days' growth	A specified length of time after plants have started to grow	6 weeks' growth
43 to 56 days' growth	A specified length of time after plants have started to grow	8 weeks' growth
57 to 70 days' growth	A specified length of time after plants have started to grow	10 weeks' growth

[a]These classes are for species that remain vegetative for long periods and apply primarily to the tropics. When the name of a feed is developed, the age classes form part of the name (e.g., Pangolagrass, 15 to 28 days' growth). Do not use terms which apply to plants that bloom and those which do not bloom in same name. For plants growing longer than 70 days, the interval is increased by increments of 14 days.

TABLE 19 Weight-Unit Conversion Factors

Units Given	Units Wanted	For Conversion Multiply by	Units Given	Units Wanted	For Conversion Multiply by
lb	g	453.6	μg/kg	μg/lb	0.4536
lb	kg	0.4536	Mcal	kcal	1,000.
oz	g	28.35	kcal/kg	kcal/lb	0.4536
kg	lb	2.2046	kcal/lb	kcal/kg	2.2046
kg	mg	1,000,000.	ppm	μg/g	1.
kg	g	1,000.	ppm	mg/kg	1.
g	mg	1,000.	ppm	mg/lb	0.4536
g	μg	1,000,000.	mg/kg	%	0.0001
mg	μg	1,000.	ppm	%	0.0001
mg/g	mg/lb	453.6	mg/g	%	0.1
mg/kg	mg/lb	0.4536	g/kg	%	0.1

TABLE 20 Weight Equivalents

1 lb = 453.6 g = .4536 kg = 16 oz
1 oz = 28.35 g
1 kg = 1,000 g = 2.2046 lb
1 g = 1,000 mg
1 mg = 1,000 μg = .001 g
1 μg = .001 mg = .000001 g
1 μg per g or 1 mg per kg is the same as ppm