Sheep and Goat Management in Alberta

Nutrition

Alberta Lamb Producers

Alberta Goat Breeders Association

This publication is available to view or order online at
http://www.ablamb.ca and
http://www.albertagoatbreeders.ca

Additional copies can be ordered from
Alberta Lamb Producers
Agriculture Centre,
97 East Lake Ramp NE
Airdrie, AB T4A 0C3

Phone: (Rite) 403-948-8533
Fax: 403-912-1455
Email: *info@ablamb.ca*

or

Alberta Goat Breeders Association
Box 330
Hay Lakes, AB T0B 1W0

Phone: 780-878-3814
Fax: 780-878-3815
Email: *info@albertagoatbreeders.ca*

The Alberta Lamb Producers and Alberta Goat Breeders Association would like to acknowledge and thank the author of this publication

Janet Kleinschmidt BSc(Agr), MSc.

Consulting Ruminant Nutritionist

Vancouver, B.C.

and the members of the Advisory Committee:

Dr. Kathy Parker on behalf of ALP,

Jackie Dunham on behalf of AGBA and

Tamara Taylor B.S.A. on behalf of AGBA.

Publishers
Alberta Lamb Producers and
Alberta Goat Breeders Association

This publication has been made possible by funding from the Diversified Livestock Fund of Alberta.

Diversified Livestock Fund of Alberta Ltd.

Contents

1. Introduction

The Nutritional Considerations of Sheep and Goats

Feed is the single largest cost associated with raising small ruminants, typically accounting for 60% or more of total production costs. With current fuel, fertilizer and commodity prices this has the potential to be much higher.

It goes without saying that nutrition exerts a huge influence on flock reproduction, milk production, and lamb and kid growth:

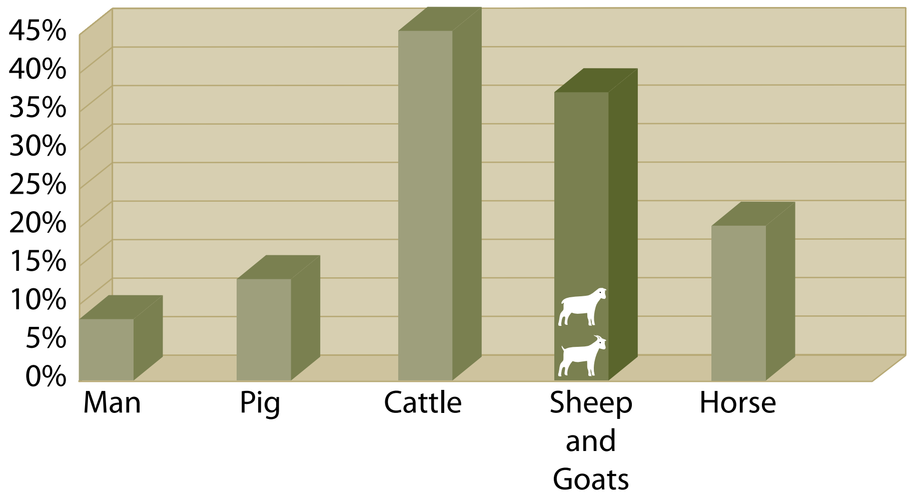
- Late-gestation and lactation are the most critical periods for ewe and doe nutrition, with lactation placing the highest nutritional demands on ewes/does.
- Nutrition level largely determines growth rate in lambs and kids. Lambs and kids with higher growth potential have higher nutritional needs, especially with regard to protein.
- Animals receiving inadequate diets are more prone to disease and will fail to reach their genetic potential.

Many factors affect the nutritional requirements of sheep and goats, including maintenance, growth, pregnancy, lactation, fibre production, activity, and environment.

As a general rule of thumb, sheep and goats will consume two to four percent of their body weight on a dry matter basis in feed. The exact percentage varies according to the size (weight) of the animal, with smaller animals needing a higher intake (percentage-wise) to maintain their weight.

Maintenance requirements increase as the animals' activity levels increase. For example, sheep or goats traveling farther distances for feed and water will have higher maintenance requirements than animals in a feed lot.

Environmental conditions also affect maintenance requirements. In cold and severe weather, sheep and goats (especially shorn ewes and short haired goats) require more feed to maintain body heat. To understand how sheep and goat GI tracts work it is helpful to compare the GI tracts of different species.



Comparative capacity of the gastrointestinal (GI) tract of different species

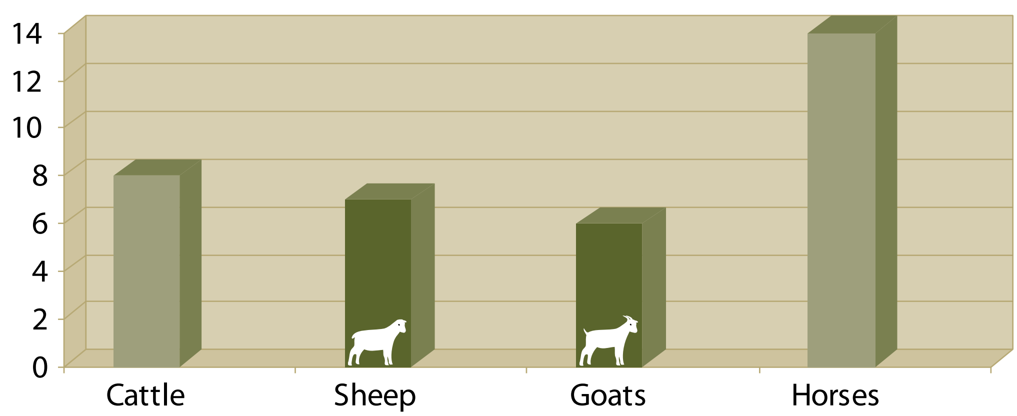
In humans, approximately eight percent of the total body weight (BW) is accounted for by the GI tract, in pigs 13 percent, in cattle 45 percent, in horses 20 percent, and for sheep and goats approximately 37 percent.

Forage Preference by Herbivores

Forage Type	Cattle	Sheep	Goats	Horses
Grasses (Pasture)	70%	60%	20%	90%
Forbs (Weeds)	20%	30%	20%	0.04%
Browse (Shrubs)	10%	10%	60%	0.06%

Although cattle, sheep and goats are all ruminants, they have some significant differences in their nutrient and feeding considerations:

- Sheep and goats use their mouths and teeth in a similar manner.
- Goats and sheep will graze grass and browse forbs (weeds and wild flowers) and brush closer than other herbivores and thus require more intense grazing management.
- Browsing is less likely to result in ingestion of internal parasites.
- Goats tend to browse vegetation of higher quality than do cattle.
- Sheep are fairly selective feeders, preferring grasses/pastures and forbs; goats, on the other hand, are mainly browsers, preferring shrubs and forbs.
- Both sheep and goats will utilize leaves, shrubs and stems that cattle avoid.
- Goats and sheep "sort" grain mixes, selectively choosing preferred ingredients, and therefore should be fed pelletized or textured feeds.
- Goats like to eat with their heads up and will select portions with higher nutrient content.
- Sheep are very sensitive to copper (Cu) toxicity, whereas goats can consume two to three times the Cu level that sheep can, with no ill effects.
- Goats, on the other hand, are very sensitive to phosphorus (P) levels (do not exceed 0.40 percent on the feed tag; 0.35 percent is ideal). Sheep have a similar P requirement to goats but are less sensitive to higher levels.



Hours spent grazing/browsing per day by various herbivores

2. The Digestive System of Sheep and Goats

In simple terms, for all animals the digestive system (a tube running from mouth to anus) is the door through which nutrients from the environment gain access to the circulatory system. Before such transfer can occur, foodstuffs first have to be reduced by a combination of mechanical and enzymatic degradation to very simple molecules. The resulting sugars, amino acids, fatty acids and the like are then transported across the epithelium lining the intestine into the bloodstream.

The digestive systems of humans, cats, mice, horses, sheep and goats are, at first glance, identical. If you look more carefully, however, it becomes apparent that each of these species has evolved certain digestive specializations that have allowed them to adapt to particular diets.

These differences become particularly apparent when you compare a carnivore (meat eater), like a cat, with an herbivore (plant eater), like a goat or a sheep. Goats and sheep have evolved from ancestors that subsisted on plants, and adapted parts of their digestive tracts into massive fermentation vats which enabled them to efficiently utilize cellulose, the major carbohydrate of plants.

In the animal world there are two distinct groups which ferment their food. The chief difference between the two groups is in the positioning of their fermentation vat relative to the stomach and small intestine:

- **Ruminants** have a large, multi-compartmented section of the digestive tract between the esophagus and the true stomach.

These fore-stomachs house a very complex ecosystem that supports fermentation. Examples of ruminants are cattle, sheep and goats.

- **Cecal digesters** are similar to dogs and humans through the stomach and small intestine, but their large intestine, where fermentation occurs, is complex and exceptionally large. Examples of cecal digesters include horses and rabbits.

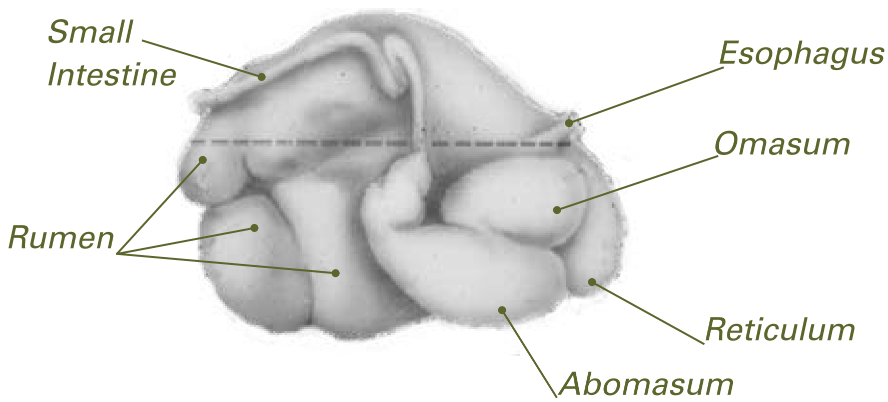
Digestive Anatomy of Sheep and Goats

Tip
-where there are "livestock," there will be "dead stock." It is recommended that you familiarize yourself with the digestive tract of your ruminants by taking the time to open up and examine the tract of an animal that has met an untimely death. Having a good understanding of the digestive tracts of your animals will help you feed and manage them to the best of your ability.

The digestive system is composed of the digestive or alimentary tube and the accessory digestive organs. If you were to describe the digestive organs' most important or predominant functions in simplistic form, the list would look like this:

- **Mouth**: Foodstuffs are broken down mechanically by chewing; saliva is added as a lubricant. In some species, saliva contains amylase, an enzyme that digests starch. Ruminant saliva does not contain amylase, but it is an important source of bicarbonate, which acts as a buffer to maintain normal pH.
- **Esophagus**: A simple, muscular tube between the mouth and stomach.
- **Stomach** (including the ruminant fore-stomachs): Where the real action begins - enzymatic digestion of proteins is initiated and foodstuffs are reduced to liquid form.
- **Liver**: The centre of metabolic activity in the body - its major role in the digestive process is to provide bile salts to the small intestine, critical for digestion and absorption of fats.
- **Pancreas**: Plays important roles as both an endocrine (secreting internally) and exocrine (secreting externally via a duct) organ - provides a potent mixture of digestive enzymes to the small intestine, critical for digestion of fats, carbohydrates and protein.
- **Small Intestine**: The most exciting place to be in the entire digestive system - this is where the final stages of chemical enzymatic digestion occur and where almost all nutrients are absorbed.
- **Large Intestine**: Differs greatly among species in extent and importance - in all animals water is absorbed, bacterial fermentation takes place and feces are formed.

The stomach of ruminants, such as sheep and goats, has four compartments: the rumen, reticulum, omasum and abomasum, as shown in the following diagram.



*The **ruminant** stomachs, as seen from the right side*

Collectively, these organs occupy almost three-quarters of the abdominal cavity, filling virtually all of the left side and extending significantly into the right. The reticulum lies against the diaphragm and is joined to the rumen by a fold of tissue. The rumen, the largest of the forestomachs, is itself divided by muscular pillars into what are called the dorsal, ventral, caudo-dorsal and caudo-ventral sacs. In many respects, the reticulum can be considered a "cranio-ventral sac" of the rumen; for example, there is a free flow of ingesta between these two organs. It is in the reticulum that metal pieces become trapped, making ruminants vulnerable to "Hardware Disease." The reticulum is connected to the spherical omasum by a short tunnel.

The abomasum is the ruminant's true or glandular stomach, and is very similar to the mono-gastric stomach of such animals as the dog or cat.

The interior of the rumen, reticulum and omasum is covered with a very distinctive mucosal structure; within each organ, some variation in wall lining is observed. The images on the next page are from a sheep.

The Rumen Wall: The interior surface of the rumen forms numerous papillae (finger like protrusions) that vary in shape and size, from short and pointed to long and foliate.

The lining of the rumen is not usually considered an absorptive type of lining. Ruminal papillae, however, are bathed in a very abundant blood flow and the volatile fatty acids (VFAs) produced by fermentation are readily absorbed across them. Venous blood from the fore-stomachs, as well as the abomasum, carries these absorbed nutrients into the portal vein and straight to the liver.

The Reticulum Wall: The lining of the reticulum appears as folds that form polygonal cells, giving it a honey-combed appearance. Numerous small papillae stud the interior floors of these cells.

The Wall of the Omasum: The inside of the omasum appears as broad longitudinal folds or leaves reminiscent of the pages in a book (the omasum is often referred to as the "book"). The omasal folds are packed with finely ground ingesta and have been estimated to represent roughly one-third of the total surface area of the fore-stomachs.

Basic Fermentation Microbiology and Ecology

Fermentation microbiology is a relatively new area in ruminant research and much is still to be learned.

The microbes of the rumen are responsible for rumen fermentation. Each millilitre of rumen content contains roughly 10 to 50 billion bacteria, one million protozoa and variable numbers of yeasts and fungi.

The environment of the rumen and large intestine is anaerobic (without oxygen) and, as expected, almost all these microbes are anaerobes. Fermentative microbes interact and support one another in a complex food web, with the waste products of some species serving as nutrients for other species.

Fermentative bacteria represent the largest part of the microbial population and many different types of bacteria exist. These organisms are often classified by the substrates (food types) they ferment or the end products they produce. Although there is some specialization, many bacteria utilize multiple substrates. Some of the major groups of bacteria are:

- Cellulolytic (digest cellulose, a fibre)
- Hemicellulolytic (digest hemicellulose, a fibre)

- Amylolytic (digest starch)
- Proteolytic (digest proteins)
- Sugar utilizing (utilize monosaccharides and disaccharides)
- Acid utilizing (utilize such substrates as lactic, succinic and malic acids)
- Ammonia producers
- Vitamin synthesizers
- Methane producers

Protozoa appear to contribute substantially to the fermentation process. Several experiments have demonstrated that lambs deprived of their ruminal protozoa show depressed growth rates and are relative "poor-doers" compared to controls with both bacteria and protozoa. In general, protozoa utilize the same set of substrates as bacteria and, as with bacteria, different populations of protozoa show distinctive substrate preferences. Many utilize simple sugars and some store ingested carbohydrate as glycogen.

__pH__ is a measure of the acidity or basicity of a solution. Pure water is said to be neutral. The pH for pure water at 25°C is close to 7.0. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline.

In addition many species of protozoa consume bacteria, a feature which is thought to play a role in limiting bacterial overgrowth.

The distribution of microbial species varies with diet. The microbial population in the rumen is quite different in animals fed a high roughage (forage) diet as compared to animals fed a high grain diet.

Environmental conditions in the fermentation vat also can have profound effects on the microbial population. Rumen fluid normally has a pH between 6 and 7, but may fall if large amounts of soluble carbohydrate in the form of grain are consumed. If pH drops to about 5.5, protozoan populations become markedly depressed due to acid intolerance. When large quantities of grain are consumed and rumen pH falls below 5.5, clinical acidosis occurs, with serious consequences to the rumen microbial population and the animal itself.

Basic Fermentation Chemistry - What Goes on in the Vat?

The fore-stomachs of sheep and goats are magnificent, continuous flow fermentation systems containing enormous numbers of microbes. What do these microbes and the process of fermentation provide to the ruminants? Obviously the microbes are responsible for fermentation, but they also provide at least three other major services:

1. **Synthesis of high quality protein in the form of microbial bodies**. In ruminants, bacteria and protozoa are constantly flowing into the abomasum and small intestine, where they are digested and absorbed. All vertebrates require certain amino acids which their cells cannot synthesize (the essential amino acids). Fermentative microbes can synthesize all the amino acids, including essential amino acids, and thereby provide them to their host.
2. **Synthesis of protein from non-protein nitrogen sources**. Fermentative microbes can, for example, utilize urea to synthesize protein. In some situations, ruminants are fed urea as an inexpensive dietary supplement. Ruminants also secrete urea formed during protein metabolism into saliva, which flows into the rumen and serves as another nitrogen source for the microbes.
3. **Synthesis of B vitamins**. Mammals can synthesize only two of the B vitamins and require dietary sources of the others. Fermentative microbes are able to synthesize all the B vitamins, and deficiency states are only occasionally encountered in animals on high carbohydrate diets where the low rumen pH adversely affects rumen microbes; and in animals preforming at extremely high levels, for example, in cows producing large quanitites of milk.

Substrates for Fermentation

All dietary carbohydrates and proteins can serve as substrates for microbial fermentation. The ruminant's real advantage is in its a bility to efficiently extract energy from cellulose, hemicellulose and other components of plant cell walls. Cellulose fibres account for 40-50% of the total dry weight of stems, leaves and roots.

The Products of Fermentation

Fermentation occurs under anaerobic conditions. As a consequence, sugars are metabolized predominantly to volatile fatty acids (VFAs); other products of fermentation include lactic acid, carbon dioxide and methane.

The principal VFAs are acetic, propionic and butyric acids, which collectively provide for the majority of a ruminant's energy needs. The ratio of these VFAs varies with diet, although the majority product is always acetate. On a diet high in fibre, the molar ratio of acetic to propionic to butyric acids is roughly 70:20:10.

As described above, proteins are also important substrates for fermentation. In ruminants, all dietary protein enters the rumen. The bulk of this protein is digested by microbial proteases and peptidases. The resulting peptides and amino acids are taken up by microbes and used in several ways, including microbial protein synthesis. However, large quantities of amino acids ingested by fermentative microbes are deaminated and enter some of the same pathways used for carbohydrate metabolism. The net result is that much of dietary protein is metabolized to VFAs.

For all ruminants, VFAs are the important product of fermentation and are used for many purposes. The paramount importance of VFAs to ruminants is that they are absorbed and serve as the animal's major fuel for energy production, to be used to lay down fat, and synthesize milk, milk fat and protein.

Rumen Physiology and Rumination

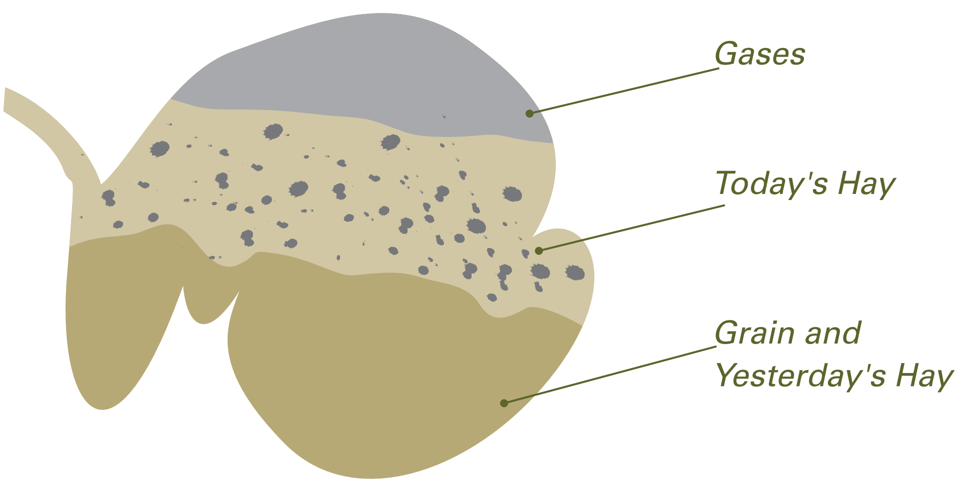
Sheep and goats evolved to consume and subsist on roughage - grasses and shrubs built predominantly of cellulose. The rumen is an excellent fermentation vat, providing an anaerobic environment, constant temperature and pH, and good mixing.

Feed, water and saliva are delivered to the reticulo-rumen of sheep and goats through the esophageal opening. Heavy objects (grain, rocks, nails) fall into the reticulum, while lighter material (grass, hay) enters the rumen proper. Added to this mixture are large quantities of gas produced during fermentation.

All ruminants produce large quantities of saliva; sheep produce approximately 7.6 litres of saliva/day. Apart from its normal lubricating qualities, saliva serves at least two very important functions in sheep and goats:

1. To provide fluid for the fermentation vat.
2. To act as a buffer - saliva is rich in bicarbonate, which buffers the large quantity of acid produced in the rumen and is probably critical for maintenance of rumen pH.

All materials entering the rumen partition into three primary zones based on their specific gravity. Gas rises to fill the top of the rumen, grain and fluid-saturated roughage ("yesterday's hay") sink to the bottom, and newly arrived roughage floats in a middle layer.



The rate of flow of solid material through the rumen is quite slow and dependent on its size and density. Water flows through the rumen rapidly and appears to be critical in flushing smaller pieces downstream.

As fermentation proceeds, feedstuffs are reduced to smaller and smaller sizes and microbes constantly proliferate. Ruminal contractions continually flush lighter solids back into the rumen. The smaller and more-dense material tends to be pushed into the reticulum and cranial sac of the rumen, from which it is pushed with microbes and liquid through the reticulo-omasal opening into the omasum.

The function of the omasum is rather poorly understood. It is thought it may function to absorb left over volatile fatty acids and bicarbonate.

The abomasum is a true, glandular stomach which secretes hydrochloric acid and acts in a similar manner to the stomach of a mono-gastric animal. One unique specialization of this organ relates to its need to process large masses of bacteria. In contrast to the stomach of non-ruminants, the abomasum secretes lysozyme, an enzyme that efficiently breaks down bacterial cell walls.

The processes described above apply to adult ruminants. For the first month up to six months of life, the ruminant is a "functional mono-gastric." The fore-stomachs are formed, but are not yet fully developed.

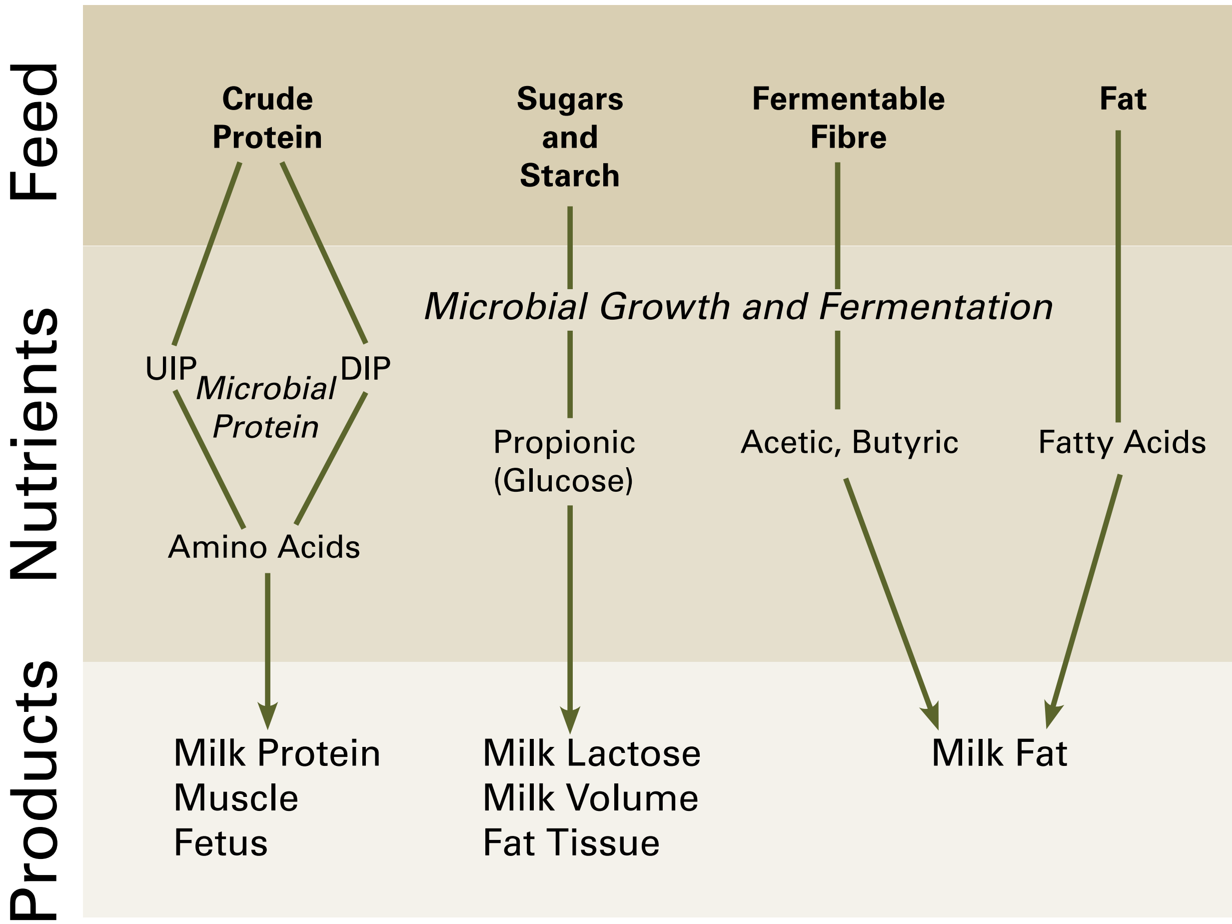
If milk is introduced into such a rumen, it basically rots rather than ferments. To avoid this problem in such young ruminants, suckling causes a reflex closure of muscular folds that form a channel from the esophageal orifice toward the omasum (the esophageal groove), shunting milk away from the rumen and straight toward the stomach, where it can be curdled by rennin and eventually digested enzymatically.

Many young ruminants are not fully functional as such until they are about six months of age. When rations are designed for these young animals, special considerations must be made. For example, urea should never be fed to ruminants that do not yet have a fully functional rumen.

Reticulo-ruminal Motility

An orderly pattern of ruminal motility is initiated early in life and, except for temporary periods of disruption, persists for the lifetime of the animal. These movements serve to mix the ingesta, aid in eructation of gas, and propel fluid and fermented foodstuffs into the omasum. If motility is suppressed for a significant length of time, ruminal impaction may result.

A cycle of contractions occurs one to three times per minute. The highest frequency is seen during feeding, and the lowest when the animal is resting.



The chart illustrates, in a simplistic form, the flow of nutrients into the rumen, the products of fermentation, and, ultimately the products which producers and consumers are dependent upon.

Conditions inside the rumen can significantly affect motility. If, for example, ruminal contents become very acidic (as occurs in grain overload), motility will essentially cease. Also, the type of diet influences motility: animals on a high roughage diet have a higher frequency of contractions than those on a diet rich in concentrates.

Rumination and Eructation

Ruminants are well known for rumination or cud chewing. Rumination is regurgitation of ingesta from the reticulum, followed by remastication (further chewing) and re-swallowing. It provides for effective mechanical breakdown of roughage and increases the surface area available to microbes. Rumination mainly occurs when the animal is resting and not eating.

Fermentation in the rumen generates enormous quantities of gas, hence the controversy surrounding ruminants and green house gas production. A dairy cow produces about 1000 litres of gas in a 24 hour period; in the same period a sheep or goat will produce about 120 litres.

Eructation or belching is how ruminants continually get rid of fermentation gases. Anything that interferes with eructation is life threatening to the ruminant, because the expanding rumen rapidly interferes with breathing. Animals suffering bloat die from asphyxiation.

3. Nutrient Requirements: What are Nutrients and Where are They Digested?

What is a Requirement?

Nutrients are substances that aid in an animal's life.

Sheep and goats require nutrients for body maintenance, growth, reproduction, pregnancy, and production of products such as meat, milk and hair. The groups of nutrients that are essential for these small ruminants are water, energy, protein, minerals and vitamins.

A certain amount of each nutrient is required for maintenance of the body, to keep the animal warm and to maintain its body weight. A mature dry doe and a mature wether are examples of animals having maintenance requirements only.

Growth, pregnancy, lactation and meat, milk and hair production demand additional requirements above those needed for maintenance. As the productivity of sheep and goats is increased through selection and crossbreeding with animals having a higher production potential, nutritional requirements will also increase. Therefore, the more productive sheep and goats should be fed high quality feed, especially weaned animals being prepared for market, young replacement females and females in late gestation and early lactation. Ewes and does feeding twins or triplets have greater nutritional requirements than ewes or does feeding a single offspring.

Sheep and goats grazing very hilly pastures will have higher nutritional requirements than animals on level pastures of the same quality because they will expend more energy gathering feed on difficult terrain.

In some situations where brush control in rough areas is the primary purpose of keeping goats, less productive animals can be roughed through and forced to work on brushy areas. If their body condition deteriorates, these animals can then be grazed on better quality pastures. Once desirable body condition is achieved, the same animals can again be used to control brush.

Water: Quality and Quantity, Water Testing

The importance of high quality water cannot be stressed enough; water is the number one limiting nutrient for all animals. Limitation of water intake reduces animal performance more quickly and dramatically than any other nutrient deficiency. Water constitutes approximately 60 to 70 percent of an animal's live weight and consuming water is more important than consuming food. Domesticated animals can live about sixty days without food but only about seven days without water. **All livestock should be given all the water they can drink.**

Consumption of water may vary greatly depending on the kind and size of the animal, physical state, level of activity, dry matter intake, quality of water, temperature of water and the environmental temperature. The minimum water intake requirement is reflected in the amount needed for body growth, fetal growth or lactation and that lost in urine, manure or perspiration. Anything that influences these needs will influence the minimum requirement.

Not all water must be provided as drinking water; feeds that are high in moisture, such as green chop, silage or pasture, will provide part of the requirement, while feeds such as grain and hay offer very little moisture.

Water requirements are measured by voluntary uptake of water under a variety of conditions. Results imply that thirst is a result of need and animals drink to fill that need. An increased electrolyte salt concentration in the body fluids activates the thirst mechanism.

Typically sheep and goats can be expected to voluntarily consume eight to 12 litres of water a day.

Water in the body is involved in the performance of many functions. These include:

1. Elimination of waste products of digestion and metabolism (urine and manure).
2. Blood pressure regulation.
3. Milk and saliva production.
4. Transportation of nutrients, hormone and other chemical messages within the body in the form of blood and other blood components such as serum.
5. Temperature regulation affected by evaporation of water from the skin and respiratory tract, such as during perspiration and breathing.

Signs of dehydration or lack of water are tightening of the skin, loss of weight and drying of mucous membranes and eyes. Stress accompanying lack of water intake may need special consideration.

Newly arrived animals may often refuse water at first due to differences in palatability or may have trouble locating a water source. Allow them to become accustomed to a new water supply by mixing water from old and new sources. If this is not possible, monitor intake to ensure no signs of dehydration occur until animals show adjustment to the new water source. Water sources should be easily accessible and large or numerous enough so that "boss" animals cannot easily control them.

Water quality is as important to animals as water quantity. Water quality may affect feed consumption and animal health since poor water quality will normally result in reduced water and feed consumption.

Substances that originate on livestock farms and often contaminate water supplies include nitrates, bacteria, organic materials, and suspended solids. A high level of suspended solids and an objectionable taste, odour or colour in water can cause animals to drink less than they should.

Tip
- if you are reluctant to drink the water that you are asking your animals to drink, chances are they should not be drinking it either.

Under normal circumstances most trace (micro) elements in water do not cause problems because they do not occur at high enough levels in a soluble form. Cobalt, copper, iodine, iron, manganese, selenium and zinc may be toxic in excessive concentration but are rarely seen in water at levels high enough to cause problems.

Water quality problems affecting livestock are more commonly seen with high concentrations of macro minerals such as sodium (Na), sulphur (S) and nitrogen (N).

Bacterial contamination, heavy growths of toxic blue-green algae, or accidental spills of petroleum, pesticides, fertilizers or other industrial pollutants can affect water quality on a local scale.

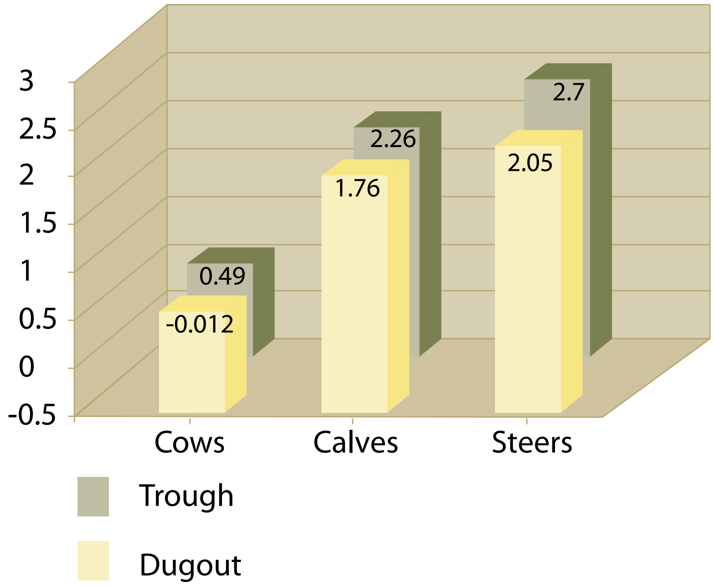
Stagnant water contaminated with manure or other nutrients may develop blue-green algae, which can poison livestock causing muscle tremors, liver damage, and death. Farm pond water needs to be observed for the presence of algae and other harmful organisms during hot, dry weather.

Decaying plant or animal protein, leaks from manure or septic tanks, nitrogen fertilizer, silage juices and other factors may contribute to high levels of nitrogen forms and potentially deadly bacteria in surface waters.

Leptospira and *Fusobacterium* ("foot rot") are two bacteria that often contaminate water and mud, respectively, and use them as modes of transportation from animal to animal.

Water access as well as quality can affect livestock performance. Pasture utilization can be greatly enhanced when animals do not have to travel far for water. A study from Missouri researched distances beef cattle traveled to water and how that affected grazing distribution and utilization of available forage. The study results on the 160 acres tested showed that pasture carrying capacity could be increased an additional 14 percent by simply keeping livestock within 800 feet of water.

An Alberta study from implies water quality greatly affects the ability of cattle to produce pounds of gain. As the table below indicates, animals in the test all averaged half a pound per day or more gain as a result of drinking trough (clean) water versus dugout/pond (muddy) water where reduced or negative gains resulted. This research continues with a focus on animal performance. While other tests have not confirmed the same amount of increase due to water quality, it is generally accepted that stale, poor tasting water can cause a reduction in water consumption and this type of water could be a host for disease organisms.



Today's concerns about water quality and long term availability for not only animal, but human, consumption lead to questions about care being given to the water resource.

In many parts of Canada, land stewardship and the protection of water are now being aggressively pursued. Using a watering system where livestock do not have to have direct access to a stream or dugout/pond not only protects the water resource, but may also increase nutrient distribution throughout the field. Through management of available water and tank placement, one can increase pasture productivity by promoting more uniform grazing. Uniform grazing results in uniform manure and urine distribution.

Water analyses typically include the following tests:

- Total coliform bacteria
- pH (acid or alkaline level)
- Total dissolved solids
- Total soluble salt
- Salinity
- Hardness
- Nitrates
- Sulphate
- Other factors such as toxicity problems with specific minerals or pesticides, or occasionally, heavy algae growth

TIP
- at least once a year, or whenever a problem is suspected, collect water samples from the end point your animals will be drinking from. The sample should be taken to a certified laboratory for analysis. Sample bottles should be obtained from the testing laboratory or local health department, because containers may be especially prepared for a specific contaminant. Sampling and handling procedures depend on the water quality concern and should be followed carefully.

What Should I Be Looking for in a Water Quality Report?

Desired and Potential Levels of Pollutants in Livestock Water Supplies		
Substance	**Desired Range**	**Problem Range**
Total bacteria per 100 millilitres	<200	>1,000,000
Fecal coliform per 100 millilitres	<1	>1 for young animals >10 for older animals
Fecal strep per 100 millilitres	<1	>3 for young animals >30 for older animals
pH	6.8 to 7.5	<5.5 or >8.5
Dissolved solids, milligrams per litre	<500	>3,000
Total alkalinity, milligrams per litre	<400	>5,000
Sulphate, milligrams per litre	<250	>2,000
Phosphate, milligrams per litre	<1	not established
Turbidity, Jackson units	<30	not established

Source—From the Agricultural Waste Management Field Handbook, pages 1 to 16. Based on research literature and field experience in the north-eastern United States.

Safe Upper Limits for Several Substances that May Be Contained in Water for Livestock and Poultry	
Substance	**Safe upper limit of concentration**
Aluminium (Al)	5 ppm
Arsenic (As)	0.2 ppm
Boron (B)	5 ppm
Cadmium (Cd)	0.05 ppm
Chromium (Cr)	1 ppm
Cobalt (Co)	1 ppm
Copper (Cu)	0.5 ppm
Fluoride (F)	2 ppm
Lead (Pb)	0.05 ppm
Mercury (Hg)	0.01 ppm
Nitrate + Nitrite	100 ppm
Nitrite	10 ppm
Selenium (Se)	0.05 to 0.10 ppm
Vanadium (V)	0.1 ppm
Zinc (Zn)	24 ppm
Total dissolved solids	10,000 ppm
Magnesium + sodium sulphates	5,000 ppm
Alkalinity (carbonate + bicarbonate)	2,000 ppm

Source—When Is Water Good Enough for Livestock? Montana State Extension

Effect of Salinity of Drinking Water on Livestock and Poultry	
Soluble salt (mg per L)	**Effect**
<1,000	Low level of salinity; presents no serious burden to any class of livestock or poultry.
1,000 to 2,999	Satisfactory for all classes of livestock and poultry; may cause temporary, mild diarrhea in livestock and watery droppings in poultry at higher levels; no effect on health or performance.
3,000 to 4,999	Satisfactory for livestock; may cause temporary diarrhea or be refused by animals no accustomed to it; poor water for poultry causing, watery feces and, at high levels, increased mortality and decreased growth (especially in turkeys).
5,000 to 6,999	Reasonably safe for dairy and beef cattle, sheep, swine, and horses; avoid use for pregnant or lactating animals; not acceptable for poultry, causes decreased growth and production or increased mortality.
7,000 to 10,000	Unfit for poultry and swine; risk in using for pregnant or lactating cows, horses, sheep, the young of these species, or animals subjected to heavy heat stress or water loss; use should be avoided, although older ruminants, horses, poultry, and swine may subsist for long periods under conditions of low stress.
>10,000	Risks are great; cannot be recommended for use under any conditions.

Source—Agricultural Waste Management Field Handbook, pages 1 to 17.

Guide to Use of Waters Containing Nitrates for Livestock	
Nitrate content* as parts per million (ppm) of nitrate nitrogen (NO3-N)**	**Comments**
Less than 100	Experimental evidence indicates this water should not harm livestock or poultry.
100 to 300	This water by itself should not harm livestock or poultry. If hays or silages contain high levels of nitrate this water may contribute significantly to a nitrate problem in cattle, sheep or horses.
More than 300	This water could cause typical nitrate poisoning in cattle, sheep, or horses, and its use for these animals is not recommended. Because this level of nitrate contributes to the salts content in a significant amount, use of this water for swine or poultry should be avoided.

Source—Water Quality for Livestock and Poultry, FO-1864-GO. University of Minnesota Extension Division, 1990.

** The values shown include nitrate and nitrite nitrogen. In no case should the waters contain more than 50 ppm nitrite nitrogen (NO2N) because of the greater toxicity of the nitrite form.*

***1 ppm of nitrate nitrogen is equivalent to 4.4 ppm of nitrate (NO3).*

Normally, hard water does not interfere with livestock performance; however, hard waters can cause difficulty in washing of milking equipment and cause water heaters to "lime up;" contaminates such as iron and sand will clog pipelines.

Well water with high iron content may pose problems with iron bacteria forming a red, slimy mass that can clog well screens and require periodic treatment with chlorine. Some wells produce considerable amounts of sand; in such cases a sand separator should be installed at the beginning of a pipeline.

Water high in sulphur, often in conjunction with high levels of iron, can be extremely corrosive on equipment and have a bad odour.

Energy: Carbohydrates, Fats and Oils

Energy is used for basal metabolic processes, body heat, physical activity, tissue maintenance and growth, fat deposition, and lactation; excess energy is stored as fat.

Energy in feedstuffs is contained primarily in the carbohydrate and fat fractions. Proteins can also supply energy when fed in excess or in times of severe malnutrition. However, this is very expensive and inefficient and not recommended.

Carbohydrates make up 65 to 75 percent of the dry weight of the plant world and supply most of the energy needed by ruminants. Carbohydrates can be subdivided according to chemical structure into five basic groups:

- Sugars
- Starch
- Cellulose
- Hemicellulose
- Lignin

The sugars and starches are found mainly in the centre of grain kernels. The cellulose, hemicellulose and lignin make up the structural or skeleton portion of plants.

The higher the fibre (cellulose, hemicellulose and lignin) level in a plant, the lower the energy content. The higher the sugars and starches, the higher the energy content of the feed stuff.

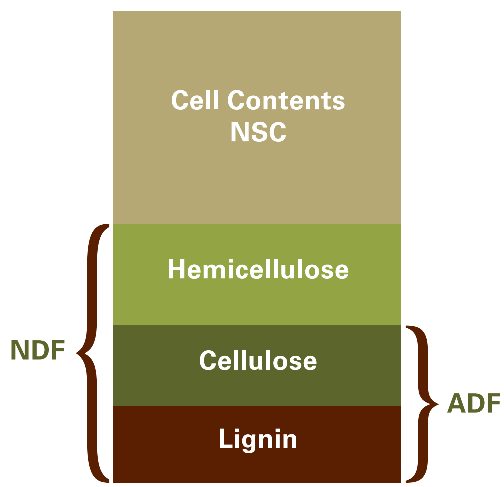
When nutritionists talk about carbohydrate nutrition they are generally referring to acid detergent fibre (ADF), neutral detergent fibre (NDF), and non structural or non fibrous carbohydrate (NSC or NFC). The names refer to the types of detergent solutions that are used to measure the forage fibre in an analysis laboratory.

The ADF contains the cellulose and lignin fractions of the forage. ADF contains a higher proportion of true indigestible or slowly digestible cellulose and lignin. ADF is a good indicator of plant or dry matter digestibility. The higher the ADF, the less digestible the forage or ration will be.

The NDF contains the total plant fibre including hemicelluloses, cellulose and lignin. NDF contains all of the fibre components that represent "bulk." NDF is a good indicator of the "dry matter intake" ability of a forage or feed. The higher the NDF, the less an animal can consume.

NSC describes the non-NDF fraction and is composed primarily of sugar, starch and pectin. Starches average between 20 and 40 percent of the diet; sugars are typically very low. Pectin, although technically structural in nature, is almost completely digested in the rumen.

NSC is usually calculated using the following equation:
NSC = 100- (%NDF + %CP + %FAT + % ASH)



Relationship between ADF and NDF

Energy requirements for sheep and goats are expressed in specific terms such as total digestible nutrients (TDN) or net energy (NE).

Total digestible nutrients (TDN), is actually calculated as the sum of digestible crude protein, crude fat, crude fibre and nitrogen-free extract (more soluble carbohydrates). TDN does not account for the energy lost in the urine or gas production or that lost as body heat.

Net energy is further divided in to Net of Lactation (NE_L), Net Energy of Maintenance (NE_M) and Net Energy of Gain (NE_G). Net energy (NE) values account for energy losses and represent the energy that is actually available for maintenance of body functions or production (growth, fattening and lactation). The Net Energy system is a more accurate method of balancing energy and is preferred over TDN, particularly for lactating animals.

Microorganisms in the rumen use the plant fibres cellulose and hemicellulose as energy. Because of this bacterial fermentation, ruminants can utilize forage as a source of energy much better than monogastrics (swine, humans) can. In fact, feeds high in cellulose can furnish most of the ruminant's maintenance energy needs.

Lignin is essentially an indigestible fibre. Young growing plants contain very little lignin; however, lignin content of plants increases with age. Old, dry, mature, weathered forage will have high lignin content and be of limited use to grazing animals. In fact, in older plants, lignin can bind the more digestible fibres and preclude them from microbial digestion.

The fermentation of fibre is a relatively slow process. Ruminal digestion of the starch contained in grain is a much more rapid and volatile process.

As previously discussed, bacteria in the rumen are job specific - some are effective fibre digesters while others handle starch more efficiently.

The normal pH in the rumen of animals being fed a high (over 60 percent) forage diet is 7.0 to 7.4. At this pH the fibre digesters are very comfortable and working at maximum productivity. Small quantities of starch (grain) are not a problem; however, large doses of grain can be serious. If large meals of grain are consumed, the starch digesters take over. A by-product of their digestion is lactic acid; as lactic acids levels in the rumen build, pH drops. A pH of 6.8 and falling means certain death for the fibre digesting bacteria in the rumen. If pH continues to fall, acidosis develops and can be fatal. Excessive starch fermentation can also result in bloat.

Tip
-ration changes should be done gradually, ideally taking two to four weeks to complete.

Maintaining normal pH levels is the main reason for making gradual shifts from one diet to another, especially when moving toward a more energy dense diet.

Fat is an excellent source of energy, but is generally low in forages and roughages. Compared to carbohydrates, fats contain two and a quarter times as much energy on a weight to weight basis.

This energy density is an asset in rations formulated for high producing dairy goats, sheep or cows.

Fat sources in a ruminant's diet can be broken down into three main categories:

1. Naturally occurring fat or basal fat, such as in the grains and forages.
2. Commodity fats, such as oils seeds and animal and vegetable fat.
3. Specialty or ruminally inert fats. Although an excellent source of energy, these products are extremely expensive and will be uneconomical for the vast majority of sheep and goat producers.

The addition of fat can elevate the energy content of the diet well above the reasonable limit for a diet limited to grains and roughage only.

How Much Fat Can We Feed?

- Basal (naturally occurring) fat level 2.5-3.0%
- Commodity fats 2.0-3.0%
- Specialty fats 2.0-3.0%

This, in theory, represents a total ration DM% of seven to eight percent as fat. However, most producers will not be using the specialty fats and therefore the typical diet should not exceed about five percent fat.

Higher fat levels, and fats introduced too quickly into a ration, will reduce dry matter intake and can result in gastrointestinal disturbance and even death.

Over feeding fat causes the rumen "mat" to become coated with fat in a manner similar to fat in a frying pan left overnight. The rumen microbes become coated and smothered by the fat, resulting in the rumen shutting down.

The rumen also needs time to adapt to added fat in the diet to avoid gastrointestinal disturbance.

Apart from its high energy properties, fat in a ration aids in the absorption of the fat-soluble vitamins (A, D, E and K) and reduces dust in premixes.

Tip
-take two to four weeks to slowly introduce fats into a ration; watch manure and cud chewing.

Protein and Amino Acid Nutrition of Sheep and Goats

For years, nutritionists struggled to define the protein content of feeds and the requirements of ruminants using the crude protein (CP) system.

The CP of feeds is determined simply by analyzing the nitrogen (N) content of the feed in question and multiplying the result by 6.25. The conversion factor of 6.25 is based on the assumption that true protein contains 16% N (100/16 = 6.25).

$$\% \text{ CP} = \%\text{N} \times 6.25$$

The very nature of the test, however, fails to differentiate between nitrogen in a true protein form and that in a non protein (NPN) form such as nitrates, ammonia, urea, single amino acids and peptides.

What are True Proteins?

Basically proteins are organic compounds which are made up chiefly of chains of amino acids. One often hears of the primary, secondary and tertiary structure of proteins. These are simply references to the amino acid sequence within a protein, the bonding of one amino acid chain to another and the final shape that the chain(s) may take, for example, alpha helix.

What are Amino Acids?

Animals do not actually have a requirement for protein. Instead, they require the specific amino acids that are the building blocks of proteins. Of the approximately twenty amino acids found in animal tissue and milk proteins, ten are generally considered to be "essential." Essential amino acids (EAA), unlike "nonessential" amino acids (NEAA), either cannot be synthesized by animal tissue or by rumen microbes, or if they are, cannot be synthesized in amounts sufficient to meet metabolic needs.

It is generally accepted that methionine and lysine are most often the first limiting amino acids for milk production, although other amino acids have also been suggested.

In sheep and goats, ruminally synthesized microbial protein supplies 50 percent or more of absorbable amino acids when rations are balanced properly. The intestinal digestibility of microbial protein sits at about 85 percent and has an EAA profile similar to that of lean body tissue and milk. The microbial protein EAA profile appears to be fairly constant and not influenced markedly by changes in diet.

The second major source of absorbed amino acids comes from undegradable intake protein (UIP), more commonly referred to as bypass protein.

What are Peptides and Other Nitrogen Containing Structures?

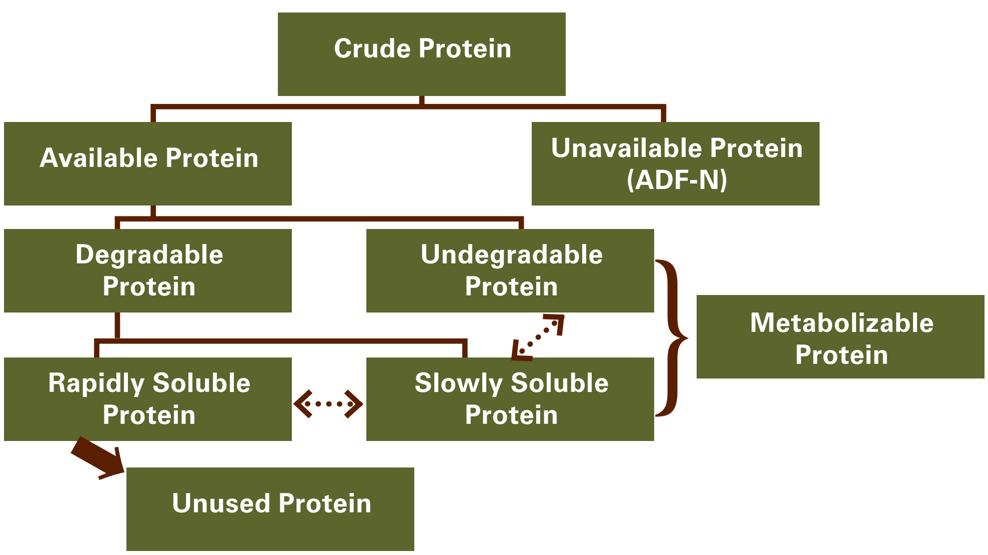
Peptides are simply short chains, the amino acid building blocks.

Ammonia, nitrates and urea are nitrogen containing compounds of various complexities, which are important contributors to the N pool of the ruminant animal.

The lack of specificity of the old crude protein test, coupled with its inability to distinguish available nitrogen forms from non-available ones prompted the development of a new protein system adopted by NRC in 1989 and based on the Cornell System.

In the development of the system, several new terms were introduced and several different ways of describing the protein components were developed. The schematic diagram shown in below is an attempt to be both accurate yet simplify the categories described.

The 1989 NRC system differentiated between the various nitrogen forms by breaking the protein content of feed down into fractions. Although at first glance the terminology appeared confusing, all of the descriptions were based on three factors: availability, site of digestion and degree of rumen solubility.



Protein Categories (based on the Cornell System)

To fully understand the 1989 NRC system all of the associated terms (and their many equivalents) must be defined:

Unavailable Protein, ADF-N, and Bound Protein: Is the portion of the protein that is simply not available to the animal and passes through in the feces. It is measured as acid detergent fibre bound nitrogen.

Available Protein: The remaining portion of the protein that is used by the rumen microbes or directly by the ruminant.

Undegradable Protein (Bypass Protein, Escape Protein. UIP, RUP, Etc.): Portion of the available protein that eludes rumen degradation and is digested lower in the tract in a similar fashion to monogastric digestion.

Degradable Protein (DIP): Portion of the available protein that can be degraded in the rumen.

Rapidly Soluble Protein (SIP): That portion of the degradable protein that is rapidly available to the rumen microbes.

Slowly Soluble Protein: That portion of the degradable protein that degrades slowly in the rumen.

Metabolizable Protein: The combined undegradable and microbial protein digested by the ruminant to meet her protein requirements.

The use of the "DIP/SIP" system was a big step forward in better describing protein requirements and utilization in ruminants, but it is a static model. The interchanges represented by the dotted lines (illustration on previous page) indicate that there may be change or shifts in the amounts of the various protein fractions depending primarily on the rate of passage of the digesta.

Protein and amino acid nutrition is a very active area of research, along with its inseparable Siamese twin, carbohydrate nutrition.

The goal of protein nutrition is to provide the appropriate quantities and balance of amino acids to the intestine for absorption and utilization. The approach utilized should be both of a biological and economic nature. For example, it is possible to provide similar quantities of amino acids in the small intestine by supplying high levels of UIP sources **or** by increasing the quantity of microbial protein synthesized. (See earlier comments about microbial protein quality and digestibility.) Which would be most cost effective?

Minerals and Vitamins for Sheep and Goats

The nutrient requirements of goats are not well defined, certainly not as well defined as those for beef and dairy cattle, sheep, swine or poultry. Much of the research with goats has involved dairy goats in confinement-fed conditions. Very little work has been done with free grazing goats.

To determine nutrient requirements, research scientists create an artificial environment wherein animals are deficient in the particular nutrient of interest. Then, under very controlled conditions, the nutrient of interest is added to the diet in increments, until growth, lactation or the physiological response per additional increment of nutrient is negligible.

To add further complication, mineral requirements are dependent upon age, sex, stage and level of production and can vary across breeds within a species of livestock. Research projects of this type are very expensive and time consuming. Consequently, many of the mineral specifications used in the development of goats' feeds are extrapolated from other species, particularly sheep, or are the result of practical experience.

There are many minerals that are required in the diet of sheep and goats. These are usually divided into macro-minerals and micro or trace minerals.

Macro-minerals are required in larger amounts than trace minerals, with that requirement expressed as a percent of the diet, or as grams per head per day.

Some of these are already in sufficient quantity in forages, so supplementation is not needed. Others may not be present in adequate amounts, so must be supplemented. You will only know how much of each macro element you have in your forages by performing forage analysis at a certified forage analysis laboratory.

Plant content of mineral elements is dependent upon the interaction of a number of factors, including soil, plant species, stage of maturity, yield, pasture management and climate. Most naturally occurring mineral deficiencies in herbivores are associated with specific regions and are directly related to soil characteristics.

Young and alkaline soils tend to be more abundant in most trace elements than the older, more acid, coarse, sandy soils.

It is generally accepted that forbs (weeds) and legumes are richer in a number of minerals than are grasses. For example, legumes contain over twice as much calcium as grasses and are more than adequate to meet animal requirements.

As plants mature, mineral content declines due to the natural dilution processes and translocation of nutrients to the root system.

The seven major essential minerals (in addition to carbon, hydrogen, oxygen and nitrogen) are listed below. Macro-mineral requirements are usually expressed as a percent of the diet while micro-mineral requirements are typically quoted in parts per million (ppm) of the diet. Other minerals which are possibly essential at very low levels include chromium, nickel, vanadium, silicon, tin and arsenic.

Macro and Micro Minerals	
Macro	**Micro**
Calcium	Iron
Phosphorus	Iodine
Sodium	Copper
Chlorine	Zinc
Magnesium	Molybdenum
Potassium	Manganese
Sulphur	Cobalt
	Selenium

Bioavailability is a concern when considering mineral nutrition, because for most minerals, it is less than 100%. For example, if a doe is fed four grams of mineral X, the amount of mineral X that is digested, absorbed and available for use will be less than four grams. Depending upon the chemical structure, bioavailability can range from zero to over ninety percent.

In general, availability is highest for sulphates, intermediate for carbonates and lowest for the oxide forms of a mineral. Using supplemental iron sources as an example:

ferrous sulphate > ferrous carbonate > ferric oxide.

Bioavailability of one mineral is also influenced by the concentration of other minerals in the diet. For example, high levels of sulphur or molybdenum interfere with copper absorption. While analysis of the copper concentration in the diet may reflect a sufficient amount, because of this antagonism, an animal may actually be copper deficient.

Practical determination of animal's mineral status is often very difficult. Blood analysis is a poor indication of mineral status for many of the minerals. The body has a significant storage capability for many of the minerals (for example, the calcium in bone, and iron in the blood). Therefore, until body reserves are depleted, symptoms of deficiency may not be apparent. More involved processes like liver biopsy may be required to determine the mineral status of an animal.

Following is a very brief list of some of the functions of macro- and micro-minerals in the body.

Calcium (Ca): Most abundant mineral in the body; 98 percent is found in the bones and teeth. Functions in blood clotting, membrane permeability, muscle contraction, nerve function, cardiac regulation and enzyme activation. Vitamin D is required for active absorption. As dietary calcium intake increases, absorption is reduced. Cereal grains (corn, oats, wheat, barley) are low in calcium.

Phosphorus (P): The most deficient mineral throughout the world and must be supplemented throughout the world. Eighty percent of the phosphorus in the body is found in the bones and teeth. In addition it functions with calcium in bone formation, is essential for cell growth, energy utilization, maintaining acid-base balance, is a component of DNA and is required by rumen microbes for optimal growth and activity. The greatest bang for the buck in mineral supplementation is generally associated with providing phosphorus. However, palatability of phosphorus is low and recent land stewardship regulations have forced livestock producers and scientists alike to amend phosphorus requirements for all livestock categories.

Potassium (K): Is the third most abundant mineral in the body and is essential for the maintenance of osmotic and fluid balance in the body. Cereal grains and mature, weathered forages have low potassium content. Oilseed meals and green, growing forages are excellent sources.

Magnesium (Mg): Sixty-five to 70 percent of magnesium is found in the skeleton. It functions in carbohydrate and fat metabolism and is a catalyst in over 300 enzyme systems. Like phosphorus, magnesium is bitter and is sometimes used to limit consumption of mineral supplements.

Sodium (Na): Sodium is usually considered with chlorine (Cl); sodium chloride (NaCl) is salt. Both are critical electrolytes in body fluids. Sodium functions in amino acid and glucose transport and muscle contractions. Chlorine is a component in hydrochloric acid formation and activation of amylase, a starch digesting enzyme.

Sulphur (S): Two amino acids (methionine, cysteine) and two B-vitamins (biotin, thiamine) contain sulphur. Sulphur also functions in maintaining bone, cartilage, tendon and blood vessel integrity (contained in chondroitin). **Note**: Rumen microbes are capable of synthesizing all of the sulphur containing compounds from inorganic sulphur. High sulphur levels in the diet partially inhibit the use of copper and molybdenum. See page 141 for further details.

Copper (Cu): Copper is second only to phosphorus in severity of deficiency throughout the world. Copper is involved in haemoglobin formation, enzyme systems, nervous and immune system function. Copper interacts with iron, zinc, sulphur and molybdenum in antagonistic relationships. Sheep are very susceptible to copper poisoning as dietary copper levels approach or exceed 20 ppm.

Iodine (I): Primarily involved in the thyroid hormones that regulate rate of metabolism. Deficiency usually is not a problem except with goitrogenic forages or feedstuffs like turnips, kale, rape, white clovers. Cottonseed and soybean meal also have some goitrogenic properties. Use of iodized salt has eliminated iodine deficiency problems.

Iron (Fe): Involved in cellular respiration and oxygen transport via haemoglobin. Fifty percent of the body's iron is involved in haemoglobin. Iron can inhibit copper and zinc availability.

Zinc (Zn): Important in stress management, immune response, enzyme systems and protein synthesis. Zinc is second only to copper on the list of likely micro-mineral deficiencies.

Selenium (Se): Involved in the prevention of white muscle disease. The requirement for selenium is very close to its toxicity level.

Manganese (Mn): Cofactor in several enzyme systems.

Cobalt (Co): Cobalt is a component of vitamin B12.

Mineral requirements are not well defined in the scientific literature and are influenced by many factors. Requirement tables are only for reference purposes, not as standards against which to hold those who develop mineral supplements.

It is generally recommended that the dietary calcium-phosphorus ratio be at least 2:1, especially if males are being fed. In addition, phosphorus levels above 0.38-0.40 ppm do not enhance performance and appear to aggravate potential urinary calculi problems.

Direct methods of supplementation include adding deficient minerals to the drinking water, oral drenching, injection, ruminal boluses, force-feeding in protein/energy feeds and free-choice supplementation.

Of these, free-choice supplementation is the most widely used method for grazing ruminants. Development of a balanced, palatable, free-choice mineral with predictable consumption by sheep and goats is difficult and requires significant practical experience.

Mineral consumption varies daily, across animals within the herd and across seasons of the year. Forage quality, dry matter content, degree of hunger and level of boredom seem to influence the amount of mineral consumed. Commercially prepared free-choice minerals are generally developed for specific geographical areas to meet 100-125 percent of the average herd's requirement reared in the average environment for that region. Unfortunately, there is no average herd or environment.

Most commercially prepared goat feeds are balanced for the entire mineral profile and do not require mineral supplementation.

Mineral supplements are most often warranted when goats are grazing, especially when forage is dormant, mature and/or weathered. The ability to include mineral/vitamin fortification and present a complete balanced package affords commercially prepared feeds a significant advantage over feeds mixed on the farm.

Salt (White, Blue and Red): None of these qualify as a mineral supplement. They are mainly salt with cobalt added to the blue block and small amounts of trace mineral in the case of the red block. Salt is sometimes used to limit the consumption of free-choice oilseed meal and/or ground cereal grain supplements.

On a dollar per bag basis, mineral supplements are expensive when compared to other feeds or supplements. However, daily consumption should be relatively low. A rule of thumb for daily mineral consumption by mature sheep and goats on pasture is 25 to 30 grams per day. Consumption may be excessive immediately after introduction to mineral, but will generally level off after 10 to 14 days. Mineral must be consumed if it is to be of benefit.

Remember sheep are very susceptible to excess dietary copper. Most sheep diets are formulated to contain less than 20 ppm copper. Goats are much more tolerant of copper than sheep. Consequently, many commercially prepared goat feeds are formulated to contain 25 to 30+ ppm copper. Do not offer goat feeds to sheep unless the copper content is well understood.

The B complex vitamins are eight water soluble vitamins involved in the metabolic pathways of the body. They include: ***Vitamin B1*** *Thiamine,* ***Vitamin B2*** *Riboflavin,* ***Vitamin B3*** *Niacin,* ***Vitamin B5*** *Pantothenic acid,* ***Vitamin B6*** *Pyridoxamine,* ***Vitamin B7,*** *Vitamin H,* ***Vitamin B9*** *Folic Acid, and* ***Vitamin B12*** *Cobalamin.*

Sheep and goats, as small ruminants, can manufacture the **B-complex vitamins** in their rumens. However, animals who are under a health stress, producing milk at extremely high levels or whose rumen is not functioning may not be able to accommodate their body's need for the B-complex vitamins and supplementation may be required.

Vitamins A and E are made from compounds found in green forage. Vitamin A can be stored in the liver for two or three months after sheep and goats have been eating green forage for several months. Consequently, when animals are eating fresh pasture, or fresh or well-made hay, no supplemental vitamins are needed. Similarly, vitamin E can be stored in fatty tissue for short periods of time.

However, when sheep and goats are eating forage that is old, weathered, mature, or otherwise low in vitamin A precursor, then this vitamin should be added to the mineral mixture. Other feeds that will result in inadequate vitamin A levels are corn silage, corn stalks, and straw.

Vitamin D is made from exposure to sunshine. For animals housed indoors for more than two to four weeks, such as lambs being finished in confinement, vitamin D should be included in the diet.

Most commercial minerals for sheep designed for free-choice feeding will contain added vitamins A, D, and E. When making a total mixed ration, add vitamin premixes to the formulation, if a free-choice mineral is not going to be fed.

Vitamin A: Essential for normal growth and for the formation of strong bones, teeth, for normal vision and cell structure, for protecting the linings of the respiratory, digestive, and urinary tracts and for healthy skin. Reserves can be stored in the liver for a few months. Young animals with coccidiosis have an increased vitamin A requirement because of impaired absorption.

Vitamin B1 (thiamine): This vitamin plays a vital role in the activities of various enzymes involved in the breakdown and utilization of carbohydrates and in the functioning of the nerves, muscles and the heart. Young animals that do not yet have a fully developed rumen need a dietary source of B-complex vitamins. B-vitamins also should be added to the diet or administered by injection to sick animals and those with poor rumen function or marked change in diet.

Vitamin B12: Also known as cyanocobalamin, a vitamin that plays a vital role in the activities of several enzymes. It is important in the production of the genetic material of cells (and thus in the growth and development), in the production of red blood cells in bone marrow, in the utilization of folic acid and carbohydrates in the diet, and in the functioning of the nervous system.

Vitamin D: There are two main forms of vitamin D, D2 (ergocalciferol) and D3 (cholecalciferol). They play several vital roles in the body. The vitamin helps regulate the balance of calcium and phosphate, aids in the absorption of calcium and is essential for strong bones and teeth. Excess of vitamin D can cause problems.

Vitamin E: It is essential for normal cell structure, for maintaining the activities of certain enzymes and for the formation of red blood cells. It also protects the lungs and other tissues from damage by pollutants and help prevent red blood cells from being destroyed by poisons in the blood. Its main action is as an antioxidant; it stabilizes polyunsaturated fatty acids, vitamin A, and various hormones and enzymes. Vitamin E and selenium are closely interrelated.

4. Feedstuffs for Sheep and Goats

Forages: Types, Quality, Matching Forages to the Nutrient Needs

Feed costs represent the single largest expense in most livestock operations. Producing and properly preserving high-quality forages can help reduce the costs associated with feeding concentrates and supplements. Astute producers recognize the economic significance of producing high-quality forage crops and, consequently, place a great deal of emphasis on the production of quality forages.

The primary methods of harvesting and preserving forage crops include hay making, silage making, green chopping and pasturing. Each of these methods of forage harvest and/or preservation has benefits and limitations that make it more desirable than the others for a specific livestock operation. However, any given operation may use each of the methods at varying times, depending on the availability of resources. Producers must review each management practice and evaluate their own production situation to determine which method to use to gain the maximum economic return.

Hay

Hay is one of the most versatile of stored forages in that:

1. It can be kept for long periods of time with little loss of nutrients if protected from weather.
2. A large number of crops can be successfully used for hay production.
3. It can be produced and fed in small or large amounts.
4. It can be harvested, stored and fed by hand or the production and feeding can be completely mechanized.
5. Hay can supply most nutrients needed by sheep and goats.

The ultimate test of hay quality is animal performance. Quality can be considered satisfactory when animals consuming the hay give the desired performance. Three of the factors which influence animal performance are:

1. **Consumption**: hay must be palatable if it is to be consumed in adequate quantities
2. **Digestibility and nutrient content**: once the hay is eaten, it must be digested to be converted to animal products
3. **Toxic factors**: high-quality hay must be free of components which are harmful to animals consuming it.

Factors Affecting Hay Quality

Stage of Maturity when Harvested

Of all the factors affecting hay quality, stage of maturity when harvested is the most important and the one in which greatest progress can be made. As legumes and grasses advance from the vegetative to reproductive (seed) stage, they become higher in fibre and lignin content and lower in protein content, digestibility, and acceptability to livestock.

Effect of Stage of Maturity on Digestibility of Alfalfa

Stage	% Digestible
Pre-bud	66.8%
Bud	65.0%
Early bloom	63.1%
Mid-bloom	61.3%
Full bloom	59.4%
Late bloom	57.5%
Mature	55.8%

Analysis of Alfalfa at Various Stages of Maturity

	Percent DM			
Stage	Crude Protein	ADF Acid Detergent Fibre	NDF Neutral Detergent Fibre	RFV Relative Food Value
Bud	>19	<30	<40	>140
Early bloom	16-19	30-35	40-45	124-140
Mid-bloom	13-15	36-40	46-50	101-123
Full bloom	<13	>40	>50	<100

Curing and Handling Conditions

After mowing, poor weather and handling conditions can lower hay quality. Rain can cause leaf loss and can leach nutrients from plants during curing. Sunlight can lower hay quality through bleaching and lowering vitamin A content. Raking and/or tedding dry, brittle hay can cause excessive leaf loss.

Soil Fertility

Adequate amounts of lime, nitrogen, phosphate, potash, and minor elements are needed to produce high yields of hay per acre and to maintain stands of desirable plants for a long period of time. A soil test should be used as a guide in determining the amount of fertilizer and lime needed for economical hay production.

Plant Species

Legumes are normally higher in quality than grasses, but within each group there can be a wide range of quality. When both grasses and legumes are harvested at the proper stage of plant growth, legumes are usually higher in total digestibility, rate of digestion, protein, and many minerals and vitamins. A mixture consisting of an adapted grass and legume is usually of high quality when properly managed. In addition, grasses can improve the drying rates of mixed stands compared to pure legume stands. Perennials, such as alfalfa, orchard grass, timothy, fescue, etc., are usually more economical for hay crops than annuals, although annuals, such as small grain and rye-grass, can be used effectively.

Variety

Using plant certified seed of adapted varieties tested and proved under local conditions is advised.

Weeds generally lower hay quality by adding material lower in palatability and digestibility. Some may be harmful or toxic. Therefore, using clean seed (which is free of weed seed) is especially important when you plant perennial hay crops.

Forage Testing

The most practical way to determine the nutrient content of hay is through forage nutritive analysis. Forage nutritional results can be used to assess quality and to determine amount and type of supplementation needed for the desired level of animal production if hay is stored, so a representative sample should be taken and the analysis is done by a reputable laboratory. Matching hay to different classes of livestock based on nutritional content of the forage and the re-

Tip
- optimum maturity of forages, especially alfalfa, is crucial for top animal performance, health, productivity and lowering feed cost of production.

quirements of the animal can lead to a more efficient and cost effective forage-livestock program.

Visual Estimate

Although not reliable as forage testing, a visual estimate can be helpful in determining forage quality. Hay that is early cut, green, leafy, soft, free of foreign material, and has a pleasant odour will be of high quality. However, colour and visual appearance are not always good indicators of hay nutritive quality.

Haylage

Feeding haylage to sheep is less common than the feeding of dry hay rations. However, more producers, particularly larger TMR operations, have been feeding haylage to sheep and goats, prompting more to consider it as a component of, or an alternative to, their current feeding program.

__Silage__ can refer to corn silage, barlage, wheatlage, haylage etc. (any ensiled product).

__Haylage__ is specifically an ensiled grass or legume.

Almost any legume, grass or pasture forage can be ensiled successfully. Cutting fresh forage at the optimal stage of maturity, and feeding it directly to animals year-round, would supply the highest-quality and most palatable feed possible. In addition, field and storage losses would be the least of all methods of forage utilization. However, fluctuations in seasonal growth and plant maturity make it necessary to harvest and store forages to maximize both quality and productivity. Haying is the most widely used method of storing forages, but harvesting as grass or legume silage or haylage has several advantages over storing as hay:

1. Lower field losses when harvested as silage.
2. More nutrients preserved for feeding.
3. Lower labour costs because of more complete mechanization in harvesting and feeding.
4. Consistent forage quality on a daily basis when properly stored.
5. Greater opportunity to harvest the crop at ideal maturity, as less rain-free weather is needed for harvesting haylage.

Individual crops and mixtures used for making ensiled forage differ with climate, soil type and crop rotation. Almost any legume, grass or pasture forage can be ensiled successfully. Select the harvest time by the growth stage (maturity) of the predominant crop in the mixture.

Forage silages can be separated into three groups on the basis of harvest moisture levels:

1. High moisture or direct cut silage at 70+% moisture.
2. Wilted silage at 60 to 70+% moisture.

3. Low-moisture haylage at 40 to 60% moisture.

Haylage (the most common type of silage used in Canada) is the most sensitive of the ensiled forages to moisture variation. Just a few percentages up or down can ruin your forage stored in this manner. Low-moisture haylage often becomes too dry for good harvesting and storage. Leaves, as well as some of the nutrient value, are lost in the dust created by the harvesting equipment. Whenever large clouds of dust come from the wagon being loaded, it is too dry for haylage and is better suited to hay.

Fine chopping, rapid filling and good sealing of the forage from air are critical. Allowing air into the haylage will cause heating and the growth of undesirable yeast and moulds. Often, the heating will form indigestible products which lower protein and energy values. A haylage with tobacco-brown or black colour and a caramelized odour has undergone some spontaneous heating and has a significantly lower feeding value.

Length of cut should be such that large forage particles do not create difficulties in packing the silo. In such cases too much air will be trapped, causing conditions favourable for excessive heating and mould growth. Poorly chopped material with long stems is also difficult to handle mechanically, especially with silo unloading equipment and feed conveyors. However, chopping forages too finely decreases rumination, cud chewing, and salivation and may cause digestive upset.

The stage of maturity for cutting haylage will depend on the type of crop being harvested, but grasses and legumes, such as alfalfa, should be cut early to preserve as much quality as possible.

Baleage

Baleage, also known as round bale silage, is simply forage that is baled at a higher moisture content than dry hay and then stored in sealed plastic wrap; this type of forage system is very popular in western Canada. Because of the high moisture level and air-tight environment, the forage ferments and is preserved by acid production during fermentation. This method has certain advantages and disadvantages over other forage harvesting and preservation systems.

Baled haylage offers producers a greater flexibility in harvesting their winter feed supply, the potential for improved quality in feed, and less wastage from feeding. Baled haylage requires less drying time than conventional hay (50 to 60% versus 16 to 18% moisture), so that during poor drying conditions, quality feed can still be made. Because of the higher moisture content in baled haylage, there is less leaf loss (five to 12 percent) during harvesting than with dry hay (22 to 26 percent). Since the protein content of the leaves is considerably higher than that of the stalks, less leaf loss means higher protein levels in the finished product. With quality baled haylage, very little wastage occurs at feeding, since the coarse, stemmy material is now softer and more palatable than dry hay of similar makeup.

Higher moisture content in baled haylage means a potential decrease in intake compared to dry hay, but certainly less than with chopped haylage. Some suggest that this is because more chewing is required for baled haylage, generating more saliva production, which in turn acts as a buffer against higher acid levels in the rumen. This buffering effect is important for optimal rumen microbial growth.

The biggest concern from a sheep and goat perspective with spoiled, or poorly ensiled haylage is the risk of listeriosis. Listeriosis is caused by the bacterium, *Listeria monocytogenes*. Clinical symptoms include: depression (inactivity), weakness, paralysis of the tongue and jaw, blindness and drooling. Animals lack co-ordination, lose their appetite, walk in circles and push their heads against fences and other objects. Death sometimes occurs before any, or all of the other symptoms are apparent.

The incubation period is approximately three weeks after ingestion of the feed containing listeria bacteria. It is important to remember, therefore, that when an outbreak occurs, the silage which caused the problem was probably fed three weeks previously.

Although it is not as common as the above mentioned symptoms, listeria abortion may occur in ewes and does, usually in the last third of pregnancy. Abortion occurs 10 to 18 days after the bacteria gain entry to the bloodstream. Following abortion, most ewes/does recover fully.

The bacteria causing the disease will not survive in silage where the pH is below 5.6. Most baled haylage, however, will have a pH higher than 5.6, theoretically increasing the risk of listeriosis. The bacteria will survive in pockets of spoiled haylage, such as at the bag closure and around any punctures that have allowed air in. Remember that spoiled haylage left in the feeders can contaminate good quality haylage, resulting in perpetuation of the problem. Because the ensiling process takes up to three weeks to complete, listeria may be present during this time period, since the pH will not necessarily have dropped below

5.6 during this time. Make sure to wait at least three weeks for proper ensiling to occur before feeding.

Several management practices will help reduce the risk of losses to listeriosis. These include:

1. Always be conscious of the risk of listeriosis.
2. Do a top job of harvesting and storing haylage.
3. Check bags frequently for holes and seal holes promptly.
4. Never feed spoiled haylage to sheep or goats.
5. Wait at least three to four weeks after ensiling before feeding.
6. Start sheep and goats onto haylage gradually (as with all feed changes).
7. Provide plenty of clean drinking water.
8. Use a feeding system that minimizes waste and trampling.
9. Clean up refused feed regularly.
10. Isolate and treat sick animals.
11. Remember that the disease is contagious to humans as well. Use care when handling sick animals.

Corn Silage

Corn silage is a high energy, low protein fermented feed suitable for sheep and goat feeding.

Corn silage is composed of the entire corn plant, typically harvested at a whole plant moisture content of 65 percent. Up to 50 percent of the dry matter of corn silage is grain corn. Corn silage ferments well due to its high sugar content, and packs well in upright and bunk silos. As with any silage fed to sheep and goats, listeriosis can be a concern.

Corn silage can be used across all stages of production, provided that the diets have been properly supplemented and proper feeding management is followed. As an example, ewes of 70 to 80 kg body weight at maintenance could consume two to three kilograms of corn silage per day. Ewes on this restricted intake may be hungry, so insure all ewes can eat at the same time.

During flushing and breeding, intake may be increased up to five kilograms per day. Energy requirements would be met for this stage of production. Early gestation corn silage feeding levels are similar to maintenance intake of two to three kilograms per day. Evaluate carefully the energy intake during late gestation. Additional dry matter in the form of grain may be necessary. During lactation, the energy demands of the ewe or doe are highest. Corn silage may still be used, but an evaluation of intake and energy needs is critical. For the first 30 to 45 days of lactation, ewes or does may consume as high as six to seven kilograms corn silage per day depending on their number of lambs or kids.

Tips for silage feeding
- avoid feeding the top layer of silage from an upright silo; avoid mouldy and spoiled silage; introduce silage gradually.

Economics determine whether corn silage should be used for growing and finishing lambs and kids. Evaluation of costs on minimal roughage, high grain diet versus corn silage/supplementation feeding program is required. If corn silage is fed, the following guidelines should be considered:

- Uniform, finely chopped, high grain content corn silage is preferred.
- Carefully evaluate protein quantity and quality in lightweight lamb diets and consider urea only at 35 kg live weight.
- Feed corn silage two or three times daily to increase intake. Lambs and kids want fresh feed and prefer to eat as a group. Provide plenty of bunk space, 30 cm minimum per animal depending on breed.
- Evaluate corn silage effects on grade and desired level of finish.
- Silage fed lambs and kids will produce more manure than high grain fed lambs and kids.
- From a live weight range of 10 to 20 kg (23 to 45 lb.), lambs should consume one to two kilograms of corn silage per day.
- As with all fermented feeds, introduce slowly, and monitor moisture levels. Lambs may not be able to physically consume adequate dry matter to meet target gains.

The Five Most Common Questions About Making Corn Silage

1. At What Stage Should We Chop?

Kernel milk line has traditionally been used as an indicator of the optimum time to harvest corn for silage. The best milk production results when corn is chopped at around the one-half milk line stage of maturity.

However, it now appears that the milk line is best used to indicate when to start checking whole-plant moisture. Once most of the kernels are dented and the milk line is visible, it is time to chop some corn to measure moisture content.

Pay special attention to making an accurate determination of moisture content. Both the microwave oven and Koster tester methods are acceptable; however, many prefer the Koster tester, as it is easier and safer.

Take considerable care and time to drive off all of the water and reach a stable endpoint weight before calculating sample dry matter content when using the microwave or Koster methods. Another option is to have the sample dry matter content determined by a commercial lab. Analyzing the sample just for dry matter content is usually not very expensive, and using NIRA analysis allows for rapid turnaround.

2. At What Moisture Should We Harvest?

Animals will milk best on corn silage at 65 to 70% whole-plant moisture. This range in moisture also works well for achieving good preservation in horizontal silos.

Tip
- actual whole-plant moisture should be your trigger for when to start chopping.

Harvesting whole-plant corn with more than 70% moisture increases seepage losses, creates more acidity which can lower dry matter intake, and reduces dry matter yield per acre.

Whole-plant corn harvested for storage in up-rights may need to be chopped a bit drier than 65% moisture to minimize seepage. Corn silage harvested at 60% moisture or less has consistently shown reduced fibre and starch digestion along with lower milk production. Corn silage that is chopped at 60% moisture or less will need to be either chopped fine or processed to minimize losses in starch digestion and milk production.

3. At What Length Should We Chop?

The general recommendation for corn silage harvested with a conventional harvester (that is without a processor) is 3/8 inch (9.5 mm) theoretical length cut (TLC). This recommendation may vary between 1/4 inch (6 mm) and 1/2 inch (13 mm) TLC, depending upon whole-plant and kernel moisture, hybrid, and forage harvester.

Evaluate percent coarse particles and degree of kernel and cob processing to determine the proper TLC setting for your chopper. Corn silage that is harvested past one-half milk line stage of maturity or with less than 65% whole-plant moisture may need to be chopped at 1/4 inch (6 mm) TLC. It may be possible to chop corn silage that is harvested at an immature or wet stage and hybrids that exhibit soft kernel texture at 1/2 inch (13 mm) TLC.

The recommended chop length for corn silage harvested with a harvester fitted with a processor is 3/4 inch (19 mm) TLC. Processed corn silage that is harvested at black-layer or with about 60% whole-plant moisture may need to be chopped at 1/2 inch (13 mm) TLC.

Tip
- harvesting corn at the right moisture and particle size is crucial. Plant moisture, rather than kernel milk line, should determine when you start to chop. Watch particle size and kernel and cob breakage to make sure the processor is doing its job. Use additives properly, pack well and cover securely to minimize storage losses.

4. How Can We Tell if the Crop Processor is Set Properly?

The recommended roll clearance ranges from 1/16 to 1/8 inch (1 to 3 mm). You can determine clearance using feeler gauges. If you do not have feeler gauges, lay the blade of your pocketknife flat between the rolls and adjust the clearance until the rolls tighten against the blade.

Chop some corn, shake out the material using a separate box, and visually inspect each screen for degree of kernel and cob processing. We like to see all kernels broken. Pieces of cob, if discernible, should be no larger than the end of your little finger.

If kernel and cob breakage is not complete, tighten the rolls until kernel damage is complete, or consider reducing your TLC. This may be necessary for processed corn silage that is harvested at black-layer maturity or with less than 60% whole-plant moisture.

With processed corn silage harvested at an immature or wet stage that tends to mush, you can set roll clearance to 1/8 inch (3 mm).

5. At What Height Should We Chop?

Silage dry matter yield is reduced about 15 percent as the chopper head is raised from six to 18 inches (15 cm to 46 cm). But estimated milk produced per tonne of silage goes up because the more fibrous and less digestible portion of the plant material is left in the field.

Switching to 18 inches (46 cm) of stubble from six results in estimated milk per acre being reduced only about three percent. Determine your needs for tonnage versus quality to determine the best cutting height.

Matching Forages to the Nutrient Needs of Sheep and Goats

The nutritional needs of ewes for maintenance and the first 15 weeks of gestation are relatively low; most can be furnished by medium to low quality forage. However, nutritional needs increase about one and a half times over maintenance needs during the last four to six weeks of gestation, and good pasture must be available or additional grain must be fed during this period.

Nutritional needs increase to three times maintenance during the first eight weeks of lactation, and decrease to two times maintenance by the third month of lactation. If the ewe is nursing twins, she will need 15 percent more digestible nutrients than for one lamb. Ewes with two or more lambs should be separated from the flock and given extra feed. After weaning, the ewes go back to maintenance level, until flushing. The forage and supplemental feed program should be designed to fit these nutritional cycles, the lambing period, and the cost to benefit structure.

Goats are not able to digest the cell walls of plants as well as cows because feed stays in their rumens for a shorter time. A distinction as to what is meant by "poor quality roughage" is necessary in order to make decisions concerning which animal can best utilize a particular forage. Trees and shrubs, which represent poor quality roughage sources for cattle because of their highly lignified stems and bitter taste, may be adequate in quality for goats, which may avoid eating the stems, do not mind the taste and benefit from the relatively high levels of protein and cell solubles in the leaves of these plants. On the other hand, straw, which is of poor quality due to high cell wall and low protein, can be used by cattle but will not provide even maintenance needs for goats because goats utilize the cell wall even less.

Similar to ewes, does should have access to high quality forage and/or browse during both the last month of gestation and lactation. Developing/breeding bucks, weanlings and yearlings also require high quality forage.

Female kids needed for reproduction should be grazed with their mothers during as much of the milk feeding period as possible and should not be weaned early.

When the quantity of available forage and/or browse is limited or is of low quality, a concentrate supplement may be considered to maintain desired body condition, depending on the cost to benefit ratio.

Dry does and non-breeding mature bucks will meet their nutritional requirements on low to medium quality forage (10 to 12% protein and 50 to 60% TDN).

Forage Testing

Forages furnish essential energy, proteins, vitamins, minerals, and fibres to sheep and goats.

Many factors (for example, variety, maturity, growing conditions and handling practices) affect forage quality prior to the time the forage is fed. As a result, predicting forage quality values from standard books often results in grossly overestimated or underestimated feeding value.

Tip
- never purchase hay until you have received a comprehensive chemical analysis of the hay you are considering buying. You should also, if possible, do a thorough visual inspection of the hay to check for mould, heating etc.

In Canada we are extremely fortunate to have many high quality, certified labs that are inexpensive and provide rapid turn around time on forage analysis.

It is important to sample forages either as close to feeding, or as close to point of sale, as possible. Dry matter measurements are subject to change, especially after harvest and during storage, but other measurements may also change.

Hay immediately after harvest normally goes through a process of further moisture loss known as a "sweat." During this period, hay may heat up due to the activity of microorganisms, driving residual moisture from the hay. Thus, moisture content is likely to be reduced in the days and weeks after harvest. If the hay has been baled at excess moisture, further biological activity may result in moulding, or even (under very high moisture conditions) spontaneous combustion of the hay. However, after hay has equilibrated to the range of 90% DM (10% moisture, depending upon humidity), it is typically quite stable.

"As received" dry matter measurements should be used to adjust quantity (tonnage, yield), not quality parameters, which should be compared on 100% DM basis.

Proper sampling of forage is of tremendous importance to assure an accurate forage test. Remember, a lab test is only as good as the sample provided to the lab. Here is the dilemma: hundreds of thousands of pounds of highly variable plant material must be represented in a single, tiny, thumbnail-sized sample! Often, the sample actually analyzed by the lab is often only half a gram. This sample must not only represent the proper leaf-stem ratio and the legume/grass mix, but also reflect the spotty presence of weeds.

Standardized Protocol to Assure a Representative Hay Sample

1. Identify a Single "Lot" of Hay

Identify a hay lot which is a single cutting, a single field and variety, and generally less than 200 tons. Combinations of different lots of hay cannot be represented adequately by a forage sampling method; different lots should be sampled separately. Do not mix cuttings, fields, or hay types.

2. Choose a Sharp, Well-designed Coring Device.

Use a sharp coring device 3/8 to 3/4 inch in diameter. Never send in flakes or grab samples; it is nearly impossible for these samples to represent a hay lot. The corer should have a tip 90 degrees to shaft, not angled. Very small diameter tips (less than 3/8 inch) do not adequately represent the leaf-stem ratio of the hay. Too-large diameter or too-long probes (for example, more than 24 inches) provide good samples, but give too much forage in a 20 probe composite sample—thus the sampler may stop before 20 cores are completed or the lab may not grind the whole sample. A range of probe tip designs have been used successfully, from serrated to non-serrated tips; it is most important that the tip be sharp (and maintained sharp), and not create "fines" during the cutting action, but cleanly cut across a cross-section of hay. Some probes are power, hand-brace, or auger driven, whereas others are push-type, both of which may work well. Many (not all) probes can be used to successfully represent a hay lot as long as they follow these principles: they easily penetrate the bale, fairly represent the leaf-stem ratio, can be easily sharpened, and produce approximately 200 g (7 oz.) of sample in about 20 cores to a depth of 12 to 24 inches.

3. Sample at Random.

The person taking the samples should walk around the stack as much as possible, and sample bales at random. Both ends of bales should be sampled by walking around the stack. This is sometimes difficult since all of the bales are not available (they may be against walls of a barn or up too high for practical sampling). However, every attempt should be made to sample in a random fashion. Do not avoid or choose bales because they look especially bad or good—If 20 cores are taken, they will not make much difference anyway.

4. Take Enough Cores

A minimum of **20 cores** is recommended for a composite sample to represent a hay lot. This is the same for large (for example, one ton bales), or small two-tie or three-tie bales. This is because core to core (and bale to bale) variation in forage quality is tremendous (for example, five to seven percentage points ADF or CP). Sampling a large number of locations and bales throughout the stack to create a composite sample is a key aspect of representing the full variation contained in a hay lot. It is recommended to take **more** than 20 cores (for example, up to 35) with very large lots (100 to 200 tons), or with highly variable lots (for example, lots that may have non-attached leaves or are from very weedy fields). With small bales, sample one core per bale, from more than 20 bales; with larger (for example, one ton) bales, take two to three cores per bale in the centre of the ends, sampling more than 10 to 12 bales. A larger number of core samples is generally better at characterizing variation in hay in more variable hay lots.

5. Use Proper Technique

Sample butt ends of the hay bale, between strings or wires, not near the edge. The probe should be inserted at 90 degree angle, 12 to 18 inches deep. Do not sample in the same spot twice. Do not use any technique which is likely to misrepresent the leaf-stem ratio. The sides or the top of the bale should not be sampled, since these cores will only represent one flake from a single area of the field, and additionally misrepresent the leaf-stem ratio. With round bales, sample towards middle of bale on an angle directly towards the centre of the bale.

6. Sample Amount: "Not Too Big, Not Too Small"

Sampling should be done so that about 250 g (one pound) of sample is produced. Too-small samples do not fairly represent the full range of variation in the hay lot. Very big samples (common with large length or diameter probes) are excellent at representing the hay but have practical disadvantages. Large samples cannot be easily ground by the labs—many labs will simply sub-sample such large samples before grinding, defeating the entire purpose of good sampling technique. If your lab is not grinding the whole sample, ask why—it could be that your sample is too large. Only work with labs that are willing to grind the entire sample (after a DM sample for field DM is taken). You should also ensure that you are providing a reasonable 250 g sample, so that it can be practically handled by the lab. If a probe is too big or small to produce about 250 g in 20 cores—get a different one.

7. Handle Samples Correctly

Seal the composite 20-core sample in a well-sealed plastic bag and protect from heat. Double bagging is beneficial, especially for DM measurements. Deliver to lab as soon as possible; 24 hour courier service is recommended. Send samples early in the week to avoid weekend delays and reduce chances of moulding. Do not allow samples to be exposed to excess sun (for example, in the cab of a pickup truck). Refrigeration of hay samples is helpful; however, dry hay samples (about 90% DM) are considered fairly stable.

Silage Sampling

The same general care must be exercised in collecting silage samples as in collecting hay samples. Forage probes cannot be used for sampling silage, so one must rely on grab samples.

Many producers will take composite samples of haylage or corn silage as the products are being blown into the silo. The advantage of sampling silage as it is placed in the silo is that the test results will be known when the silage is ready to feed. The sample(s) will be kept in an air tight bag, stored in a refrigerator, until harvesting is complete, when a sub-sample will be taken and submitted to the laboratory as a "fresh, pre-ensiled sample."

Haylages, small grains silages and corn silages should be tested on a regular basis. Most progressive producers will test wet forages once a month or whenever a change occurs.

Upright Silos

If a silo unloader is used, catch at least 12 handfuls of silage as it is discharged from the silo. Do not sample the top or bottom 10 cm (three inches) in order to avoid unrepresentative, mouldy, or otherwise damaged silage. Place the silage in a clean tub or other suitable container, mix thoroughly, and reduce the sample size to approximately one litre.

If an unloader is not used, the same type of hand grab technique can be used from the silage thrown down for feeding. Silage in the silo can only be sampled to the depths one can reach. The sample only represents that portion of silage. Other parts of the silo may have silage of very different quality.

Horizontal Silos

Horizontal silos can be sampled using the hand grab method as described for upright silos. The silo should be well opened before sampling and care taken not to include spoiled silage from the top and sides. Grab samples should be taken from different areas across the entire surface of the open face of the silo. Combine samples, mix thoroughly, and quarter to reduce the size to about one litre.

If you are submitting an ensiled sample, freeze the sample until you are ready to ship it.

Properly labelling your samples is essential if you are to obtain an accurate forage analysis report.

Tip
*- if you are submitting a "fresh" pre-ensiled forage sample, **do not** freeze the sample; keep in the refrigerator until you are ready to ship it. Make sure that you label your sample as "pre-ensiled" as it will affect the analysis.*

Choose a Certified, Independent Laboratory.

The first step in choosing a high-quality hay testing lab is to determine whether the lab participates in a certification and monitoring program. The National Forage Testing Association, a volunteer group set up by hay growers, sends blind samples to labs, and they must match the true mean within an acceptable range of variation. NFTA labs have demonstrated their commitment to good results and are more likely to be interested in accuracy. Certified labs in Canada are:

A&L Canada Laboratories, Inc.
2136 Jetstream Road
London, ON   N5V 3P5
Dave Stallard 519-457-2575

Agri-Food Laboratories
1-503 Imperial Road North
Guelph, ON   N1H 6T9
Papken Bedirian 519-837-1600

Belisle Solution Nutrition
100 Fisher, 2nd Floor
St-Hilaire, QC   J3G 4S6
Jean Ledoux 450-467-6813

La Coop Federee
604 Place Trans-Canada
Lonqueuil, QC   J4G 1P1
Diane Laquerre 450-674-5271

Lakeside Research
Box 800, Hwy #1
Brooks, AB   T1R 1B7
Daniel Leshures 403-362-3326

New Brunswick Agricultural Lab
PO Box 6000
Fredericton NB   E3B 5H1
Lesley Wilbur 506-453-3495

NL Dept. of Natural Resources
Prov. Ag Bldg. 308 Brookfield Rd.
PO Box 8700
St. John's, NL   A1B 4J6
Tom Fagner 709-729-6738

PEI Analytical Laboratories
440 University Ave.
PO Box 1600
Charlottetown, PE   C1A 4N6
Marlene MacNeill 902-368-5622

Wet Chemistry Versus NIR Analysis

The first question you will have to answer when submitting a forage sample to the lab is **how** do I want my forage analyzed? There are two types of analysis available for determining the nutrient content of forages and other feed stuffs: wet chemistry and Near Infrared Reflectance (NIR).

What is Wet Chemistry?

Wet chemistry is the preferred method for analysis of non-traditional feedstuffs such as by-products because it more accurately measures the nutrient content. Analytical procedures are standardized for each nutrient test.

Advantages

- Measures the nutrient content, does not predict it.
- Analytical procedures are the same regardless of the sample being tested.
- Easy to check for errors. Repeat analysis can be done on only the result that is out of line.

Disadvantages

- Cost can be twice that of NIR tests.
- Turnaround time for analysis may be up to one week. However, some labs offer 24-hour turnaround to compete with NIR analysis.
- Different tests are done for each nutrient, allowing more room for human error. A reputable laboratory following approved testing methods standardized by the Association of Analytical Chemistry (AOAC) will minimize these problems.

Tip
- when a sample is not "pure" it is important the label the sample appropriately, for example, a 50% alfalfa, 50% weeds. In most cases, forages that are of mixed varieties should be evaluated via wet chemistry.

What is Near Infrared Reflectance (NIR) Analysis?

NIR relates a sample's reflectance of near infrared light to its chemical composition. It relies on prediction equations of nutrient levels, rather than actual measurements. Before any feed can be analyzed using NIR analysis, hundreds of calibration samples of the same feed type must be analyzed using standard laboratory wet chemistry methods and then tested using NIR. By relating the results from the standard analysis to NIR, a calibration set of data for the NIR instrument is developed. This is critical for accurate results.

Advantages

- NIR costs approximately half the cost of wet chemistry.
- Turnaround time is only 24 hours.

Disadvantages

- Predicts the nutrient content, but is not an actual measurement.
- Prediction equations need to vary for different feeds, growing locations and conditions etc. and must be continually updated.
- Equations for alternative feeds are not readily available.
- Equations are wide ranging. Accuracy depends on matching the equation to the specific feed being tested.
- One light reading is used to predict all nutrients. If one nutrient is out of line, it is difficult to determine if a testing error is the cause. Wet chemistry will then be required to confirm the nutrient in question.

Tip
- for small ruminants, requesting NIR for the "macro" analysis (such as crude protein, the fibres, energies etc.) and wet chemistry for minerals (such as Ca, P, Mg, K and Na) is usually sufficient.

NIR analysis is an inexpensive and rapid alternative best suited to analysis of hay, haylage, corn silage, high moisture corn and grains since prediction equations for these feedstuffs are plentiful.

Certain feedstuffs can be evaluated successfully with NIR while other feedstuffs should be evaluated under wet chemistry conditions.

Feed Type	NIR	Wet Chemistry
Silage (pure)	yes	yes
Silage (mixed)	no	yes
Pure hay	yes	yes
Mixed hay	depends[1]	yes
Grain	yes	yes
Grain mix	depends[2]	yes
Grain mix w/mineral[3]	no	yes
Total mixed ration[4]	no	yes

[1]Label sample mixed hay. Find out if lab can evaluate properly.
[2]Label sample mixed grain and list types.
[3]Use caution to obtain a representative sample.
[4]TMR's can be evaluated via wet chemistry.

Interpreting Forage Analysis Results

Forage quality analysis report forms vary from laboratory to laboratory, but usually contain information on moisture (%), dry matter (DM, %), crude protein (CP, %), acid detergent fibre (ADF, %), neutral detergent fibre (NDF, %), total digestible nutrients (TDN, %), and net energy calculations for lactation (NE_L, mcal/kg), maintenance (NE_M, mcal/kg), gain (NE_G, mcal/kg), and relative feed value (RFV).

In the analysis report in below, test results are given on an "As Fed Basis" and "Dry Matter Basis." The "As Fed" numbers reflect nutrient concentrations in the forage as it was received in the forage lab, including all water present. Because water dilutes the concentrations of all other nutrients, all numbers in the "As Fed" column will be less than those in the dry matter column, with the exception of moisture.

AGRI-FOOD LABORATORIES

AgTest

Unit 1, 503 Imperial Road North, Guelph, Ontario N1H 6T9 (519) 837-1600

Analytical Report Report# 206271 Page 1 of 1

Copy Sent To: Mail

Agri-Food Web Guest Account, Example Feed Report
503 Imperial Rd. N
Guelph, ON
N1H 6T9

Date Received: 16-Oct-2003

Date Printed: 16-Oct-2003

Lab No.: 111101 Feed Type: legume haylage

Sample: 1 - Tripper Test Type: NW-41

Test	Dry Basis	As Is	Expected Range - Dry Basis
Dry Matter %		33.90	34.28 - 59.52
Moisture		66.10	
PROTEIN			
Protein % (N X 6.25)	18.90	6.41	14.63 - 20.57
Soluble Protein %	11.39	3.86	
SP % of CP	60.26	60.26	
ADF - CP %	1.41	0.48	
Digestible Protein %	65.35	65.35	
UIP Bypass Est. % of CP	19.87	19.87	
FIBRES			
Acid Detergent Fibre %	39.44	13.37	28.00 - 39.00
Neutral Detergent Fibre %	52.36	17.75	35.00 - 59.00
Lignin %	6.67	2.26	
MINERALS			
Calcium %	0.93	0.32	0.99 - 1.89
Phosphorus %	0.45	0.15	0.23 - 0.33
Potassium %	2.72	0.92	1.77 - 2.95
Magnesium %	0.26	0.09	0.18 - 0.36
Sodium %	0.05	0.02	
Zinc (ppm)	29.87	10.13	14.00 - 35.00
Manganese (ppm)	45.31	15.36	19.00 - 45.00
Copper (ppm)	7.67	2.60	4.00 - 10.00
ENERGY			
TDN (estimated)%	56.49	19.15	57.20 - 66.10
Net Energy (lac) MCAL/kg	1.27	0.43	1.28 - 1.50
Net Energy (gain) MCAL/kg	0.65	0.22	
Net Energy (maint) MCAL/kg	1.21	0.41	
Non Fibre Carbohydrate	15.74	5.34	
OTHER			
Relative Feed Value	103.36	103.36	
WTDN	58.91	19.97	
WNEL	1.25	0.42	
WNEG	0.56	0.19	
WNEM	1.28	0.43	

This report shall not be reproduced without the written consent of Agri-Food Laboratories.

Authorized by: *Ron Piett*
Asst. Director Technical Services 405

Producers tend to look at the "As Fed" values because that is what they "see" on their farms.

The "Dry Matter" column reports the concentration of a given nutrient with all water removed. There is considerable variation in the moisture content of forages. Removing the water eliminates the dilution effect of the water, thereby enabling direct comparisons of nutrient contents across different forages. For example, suppose that you wanted to compare the protein content of a hay testing 90% dry matter to a haylage testing 40% dry matter. On an as sampled basis the hay tested 14% crude protein (CP) and the haylage 8% CP. The hay appears to have the higher CP level. However, removing the dilution effect of the water reveals that the hay is 15.5% CP (14/.90) and the haylage is 20% CP (8/.40) on a dry matter basis. Thus, removing the dilution effect of the water revealed that per kilogram of dry matter, the haylage is higher in protein. Animals eating the haylage will consume more protein per pound of dry matter than they will from the hay.

Use the "Dry Matter" values when communicating information about the forage analysis, because the moisture contents of forages vary. Nutritionists think and work in "Dry Matter" terms.

Common Forage Analysis Terms

Moisture: expressed as percent, is the water present in the forage analyzed. Dry matter (DM) is the percentage of the forage that is not water. Nutrient concentrations in the "As Fed" column can be determined from the "Dry Matter" column by multiplying the DM concentration of the nutrient by DM expressed as a decimal.

Crude Protein (CP): is the sum of true protein and non-protein nitrogen. It is calculated by measuring the nitrogen concentration and multiplying by 6.25. It is a measure of a forage's ability to meet the protein needs of livestock.

Most protein in forages is true protein, the exception being in nitrate accumulating forages species such as Sudan grass. Since protein is one of the most costly supplements for livestock, high protein forages are desirable.

Soluble Protein (SIP): includes the protein and non-protein nitrogen that are rapidly broken down in the rumen. They are used to synthesize microbial protein in the rumen.

Acid Detergent Fibre CP (ADF-CP): also known as heat damaged or unavailable protein. Typically, heating during fermentation or drying causes a portion of the protein to react with carbohydrates to form an indigestible complex and render it unavailable for digestion. ADF-CP escapes ruminal breakdown and represents the portion of the undegradable protein that is unavailable to the animal and ends up in manure.

Undegradable Intake Proteins (UIP): are the proteins that have a slow rate of degradability and escape digestion in the rumen. UIP is also known as escape or bypass protein and reaches the lower gastrointestinal (GI) tract essentially intact. The undegradable protein is broken down in the GI tract as it would be in monogastrics.

Digestible Protein: is the actual amount of protein that has the potential to be digested.

Acid Detergent Fibre (ADF): is the percentage of highly indigestible plant material present in a forage. Acid detergent fibre is a useful predictor of energy and digestibility in forages. Low ADF values mean higher energy value and digestibility by ruminants. Therefore, low ADF values are desirable. ***In fact, all of the energy estimates presently used in forage testing are calculated from ADF alone***.

Neutral Detergent Fibre (NDF): represents all of the structural or cell wall material in the forage. The NDF of a forage is inversely related to the amount that a ewe/doe or lamb/kid is able to consume; thus, forages with low NDF will have higher intakes than those with high NDF. In general, legumes tend to have lower NDF values than grasses.

Lignin: is the indigestible plant component and has a negative impact on cellulose digestibility. As lignin content increases, digestibility of cellulose decreases, thereby lowering the amount of energy potentially available to the animal.

The Macro Minerals: Calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), and sodium (Na) are all expressed as percent of dry matter.

Energy Terms

Total Digestible Nutrients (TDN): reports the percentage of digestible material in a forage. Total digestible nutrients are calculated from ADF and express the differences in digestible material between forages. This term is used more often with rations for sheep and goats.

The energy term you use (TDN, NE_L, NE_M, or NE_G) depends on how the energy needs for your class of livestock are expressed. For lactating dairy cows, energy requirements are expressed using NE_L. In beef rations for either lactating or dry cows, energy requirements are

Tip
- unless there is a concern about deficiencies or toxicities in trace (micro) minerals, producers ***should not measure the trace mineral in forages.*** *Why? Most trace minerals are bound by " phytates" and are not available to animals; they end up in the manure. Trace mineral and vitamin supplementation should come from a quality premix.*

Phytates
- phytic acid (or phytate when in salt form) is the principal storage form of phosphorus in many plant tissues, especially bran and seeds.

Tip
*- there are **many** other values which may show up in your forage analysis results. If you have questions speak with your laboratory or a qualified nutritionist.*

expressed most often in TDN and sometimes NE_M units. The energy needs of growing livestock are expressed in either TDN or NE units. NE_M and NE_G units must be used together to evaluate the ability of forages to put weight gain on livestock.

Net Energy of Maintenance (NE_M) and Lactation (NE_L): are expressions of energy value of forage, in megacalories (Mcal)/kg; they refer to the forage's ability to meet the energy requirements of ruminants. Like TDN, NE_M and NE_L are calculated solely from ADF. Dairy producers generally use NE_L to balance rations for lactating cows, and some beef producers are more accustomed to using NE_M. For most hays, haylages, and silages, the net energy value for lactation will be very nearly equal in number to the net energy for maintenance.

Net energy for gain (NE_G): is the amount of energy in a forage available for growth (and, therefore, weight gain) after the maintenance needs have been met. The value of NE_G is always lower than NE_L or NE_M for a given forage because the forage is used less efficiently for gain than it is for maintenance. NE_G is used when estimating the forage's ability to put weight on growing animals.

Non Fibre Carbohydrates (NFC): are the non-cell wall carbohydrates consisting of starch, sugar, pectin and fermentation acids that serve as energy sources for the animal. In ruminants, NFC are broken down by the microbial population in the rumen and used as an energy source. The formula for calculating NFC is
100% - (CP% + (NDF% - NDICP%) + Fat% + Ash%).

Relative Feed Value (RFV): is used to compare one forage to another on an energy basis. It is derived by taking into account the digestibility (calculated from ADF) and the potential intake (calculated from NDF) of a given forage.

Due to the inherent variability of measuring ADF and NDF, absolute RFV values should not be used for making direct comparisons or pricing of forages. Rather a range of RFV values should be used to classify a forage. For example, if a RFV of 150 is the target value (which would be typical for a lactating dairy cow), any forage testing between 145 and 155 should be considered to have an equivalent value. A good rule of thumb is to accept anything within at least plus or minus five points of the target value.

Pasture, Forbs, and Browse

Sheep are selective grazers, choosing plant parts which are of higher quality (and more digestible) than cattle when both species have access to the same herbage. Therefore, when grazed alone, sheep should be stocked heavily to avoid too much trampling and soiling of the ungrazed forage. As a general rule, sheep eat more browse than cattle, but less than goats, because sheep are not nearly as selective as goats. Sheep also make better use of rough, steep hill pastures than cattle or goats.

It is better to alternate a day of grazing low quality pasture with a day of grazing higher quality pasture. Grazing ewes on forage that is better than their minimal needs will result in them weighing more and consistently giving birth to more and larger lambs that gain weight faster, but can also be associated with lambing difficulties.

During maintenance periods, ewes can be used to clean up paddocks after lambs or other livestock. Be careful that ewes are not kept on poor quality forage for too long, or a reduced number of lambs may be born the next spring.

Pastures for lambs should be of very high quality because of the lambs' nutritional requirements.

Forward grazing is a management technique enabling the lambs to have access to the best quality forage. If high quality forage is not available for the entire flock, the lambs can be creep grazed on adjacent pastures. Fast rates of gain cannot be achieved with low quality pasture, because the bulk of feed in the rumen will limit the intake by the lambs before enough energy has been ingested to meet their nutritional requirements.

Lambs will consume approximately two to four percent of their body weight in dry matter daily. Most immature, leafy grazable forages will contain about 80 to 85% water. Therefore, lambs will consume from five to 20 kg of green forage daily, depending upon their body weight. The daily performance of lambs is generally improved by the addition of a legume to a cool-season grass pasture.

Goats offer an alternative for utilizing forage and vegetation which is otherwise wasted, while producing products (milk, meat and fibre) which are marketable and in demand by a growing segment of the Canadian population. In addition, goats offer the potential for biological control of unwanted vegetation in pastures and forests, which will reduce dependence on certain pesticides.

Goats consume only the best parts of a wide range of grasses, legumes, and browse plants. Browse plants include brambles, shrubs, trees, and vines with woody stems. The quality of feed on offer will depend on many things, but it is usually most directly related to the age or stage of growth at the time of grazing.

Goats must consume a more concentrated diet than cattle because their digestive tract size is smaller relative to their maintenance energy needs. When the density of high quality forage is low and the stocking rates are low, goats will still perform well because of their grazing behaviour, even though their nutrient requirements exceed those of most domesticated ruminant species.

Goats are very active foragers, able to cover a wide area in search of scarce plant materials. Their small mouths and split upper lips enable them to pick small leaves, flowers, fruits and other plant parts, thus choosing only the most nutritious available feed.

The ability to utilize browse species which often have thorns and small leaves tucked among woody stems and an upright growth habit, is a unique characteristic of the goat compared to heavier, less agile ruminants. Goats have been observed to stand on their hind legs and stretch up to browse tree leaves, or throw their bodies against saplings to bring the tops within reach.

The feeding strategy of goats appears to be to select grasses when the protein content and digestibility are high, but to switch to browse when the latter overall nutritive value may be higher. This ability is best utilized under conditions where there is a broad range in the digestibility of the available feeds, giving an advantage to an animal which is able to select highly digestible parts and reject those materials which are low in quality.

Grazing goats have been observed to:

- Select grass over clover.
- Prefer browsing over grazing.
- Prefer foraging on rough and steep land over flat, smooth land.
- Graze along fence lines before grazing the centre of a pasture.
- Graze the top of pasture canopy fairly uniformly before grazing close to the soil level.

Because of their inquisitive nature and tolerance of bitter or high tannin material, goats may eat unpalatable weeds and wild shrubs that may be poisonous. The absence or the severity of poisoning is related to the quantity of material consumed, the portion and age of the plant eaten, the season of the year, the age and size of the animal, and a multitude of other factors. In addition, several ornamental plants that are grown outdoors or indoors are highly toxic. For example, goats should not have access to, or be fed clippings of yew, azaleas, delphinium, lily-of-the-valley and larkspur.

In a pasture situation, goats are "top down" grazers. This behaviour results in uniform grazing and favours a first grazer/last grazer system using a goat flock as the first group and cattle as the last group. This management is most appropriate with lactating does or growing kids.

Pure stands of annual or perennial grasses can increase the incidence of grass tetany for sheep and goats, especially in the early spring. This can be controlled by providing a mineral mix that contains 20-25% magnesium oxide. Legumes will reduce the risk of grass tetany because of their high magnesium content. It is most convenient to use a complete commercially prepared sheep or goat mineral which will provide selenium and other minerals plus phosphorous, salt and magnesium. **Never use cattle minerals because a good cattle mineral will kill sheep due to its copper content.**

Grazing of forage generally provides the least expensive way of supplying nutrients to the animals. The principles of controlled grazing of goats or sheep are similar to those used for cattle. The primary goal is to have enough control of the animal's grazing pattern that one can dictate the amount of defoliation and the frequency of defoliation. However, good pasture management involves much more than simply turning the animals to pasture. To obtain efficient animal production over a number of years, the needs of the plants as well as the needs of the animals must be taken into consideration. The development of a successful forage systems/grazing management entails:

1. Adjusting the number of animals grazing a certain area (stocking density) of pasture because some forage must be left at the end of the grazing period to maintain adequate plant production. Otherwise, overuse will weaken the plants and re-growth will be slower. Adjusting the stocking rate requires experience because forage growth is not uniform throughout the year or from year to year.

2. Harvesting un-grazed forages as hay or silage at an immature stage of growth when forage growth is more rapid than it can be grazed, in order to provide high quality feed when grazing is not available. Cross fencing will keep animals concentrated on small areas while excess growth accumulate on other paddocks. Under those circumstances, short duration rotational grazing through a series of paddocks, or strip grazing a rapidly growing pasture by allowing animals access to only enough forage to carry them for one day using a movable fence, are alternatives to consider.
3. When high quality forage is in short supply, restricting its use for the supplementation of other low quality pastures, hay or silage. This can be achieved by letting goats or sheep graze high quality forage for a few hours at the end of each day, or by grazing the limited high quality supply every other day.

When the aim is to kill or reduce the amount of unwanted vegetation, then the severity and frequency of grazing are much greater. Goats will actively select major weeds at particular stages of growth. As a rule, effective control of unwanted vegetation can be achieved in two years.

Concentrates: Grains and Proteins

Obviously, forage (pasture, range, browse, and hay) is the most natural diet for small ruminant animals. They are less likely to experience digestive problems if they are consuming high forage diets. Producers new to working with ruminants are less likely to have problems with their goats and sheep if they feed them high quality, forage-based diets. In all situations, forage, especially pasture and range, is the most economical source of nutrients for ruminants.

Feeding grains and proteins, collectively referred to as concentrates, can sometimes be a controversial topic among goat and sheep producers. Some producers feed a lot of concentrates to their livestock, while others do not feed any at all. The decision to feed grain or proteins, and which ones, should be based primarily on economics, including marketing advantages realized by not feeding concentrates or by feeding concentrates.

The purpose of feeding concentrates, either as commodities or commercial feeds, is to provide nutrients that the forage part of the diet is not providing. For example, forage diets often cannot meet the nutritional needs of high producing animals, such as lactating females and lambs and kids with the genetic potential for rapid growth. For this reason, grains and proteins are often provided to enable livestock to reach their genetic potential for milk production and growth.

Concentrates are usually fed to increase milk production and rate-of-gain. If the increased production increases profitability, concentrates make a lot of sense. Conversely, if the increased costs of feed are not offset by increased profits, concentrates are not advisable.

It is essential that you know the "true" cost of feeding a protein commodity as opposed to forages to meet protein needs. For example, soybean meal selling for $280/tonne is a cheaper source of protein than alfalfa hay selling for $120/tonne or more.

Energy is usually the most limiting nutrient in goat and sheep diets. In many cases it is more economical to get energy from a grain source than from hay.

There are very specific times when sheep and goat producers should consider concentrate supplementation, particularly energy sources:

1. Flushing is the practice of providing extra energy and/or protein to breeding ewes and does prior to the breeding season and for the first several weeks of the breeding season. The increased

weight gain may translate into higher fertility and ovulation rates, though many factors will determine the female's response to flushing; thin ewes and does respond best. Ewes and does are usually flushed with a quarter to half a kilogram of grain or protein supplement per day. Flushing can also be accomplished by moving females to a lush pasture prior to breeding. Care must be taken not to provide excessive soluble protein (for example a high quality alfalfa or urea supplements) when flushing ewes and does. Excessive soluble protein can create a toxic environment around the reproductive tract, rendering semen un-viable and potentially killing fetuses in the first trimester.

2. Nutrient requirements increase greatly during late gestation and are affected by expected lambing/kidding rate. Inadequate nutrition during late gestation may result in ketosis, low birth weights, weak lambs/kids, and poor milk production. It is common to feed grain to ewes and does during late pregnancy, especially if a high lambing/kidding rate is expected.

   If high quality forage is being fed during late gestation, whole corn or barley is usually all that is needed to meet the ewe's/doe's nutritional needs. It does not appear that sheep and goats respond to barley processing in the same manner as cattle, perhaps because small ruminants chew their feedstuffs to a greater degree. There appears to be little or no benefit to processing (steam rolling, grinding, pelleting, or dry rolling) grains fed to sheep and goats; in addition, this will add on another cost.

   However, if grass hay is being fed during late gestation, the grain portion of the ration should also include a good source of protein and calcium. It is best to feed a mixed grass-legume hay during late gestation and to save the best quality hay for lactation when protein and calcium needs are the highest.

3. Lactation places the greatest nutritional demand on all mammals, including ewes and does. Young mothers and females nursing multiple offspring are particularly under nutritional stress. Supplementing lactating females on pasture will usually improve lamb and kid gains and improve body condition of females at weaning. It is very difficult for a ewe or doe to raise a good set of triplets on pasture without some sort of grain supplementation. Giving young mothers and triplet-rearing ewes/does access to more pasture is another way of increasing their nutritional intake. Dairy

goats are usually fed concentrates to sustain milk production, while at the same time attempting to maintain or improve body condition. Well-bred dairy goats "put it in the pail" before maintaining body condition, making it a challenge to balance milk production and body condition without feeding concentrates. Even when concentrates are being fed to high producing dairy goats, especially the Swiss breeds of Alpine, Toggenburg, Saanen and Oberhasli, they will likely produce more milk as a result, up to a certain point, before improving body condition in a dairy setting.

Opportunity Cost
- an amount of money lost as a result of choosing one product (investment) rather than another.

4. Creep feeding is supplemental nutrition provided to nursing lambs and kids. Creep feeding is especially beneficial for breeds that have a high percentage of multiple births. Creep fed lambs and kids grow faster. Young lambs and kids can be started on creep feed as early as 10 days. A creep ration does not need to be complex, but it should be fresh and highly palatable, approximately 20% crude protein. Grains which are palatable and easy-to-digest are favoured in creep rations, for example cracked corn, soybean meal, rolled oats. Creep grazing is another method of providing better nutrition to nursing lambs and kids.
5. Drought conditions can shorten the grazing season and create a need for supplemental feeding. One way to conserve pasture resources is to wean the lambs and kids and put them on feed. If hay must be purchased (or has a high opportunity cost), it is usually more economical to supplement goats and sheep with corn or barley and/or a protein supplement.
6. If adequate forage is available, but of poor quality, it may be advisable to feed a supplement. Protein is usually the first limiting nutrient (the nutrient that is the first to be deficient) in dormant forage. Increased protein intake will improve forage utilization.

Here are some general guidelines to follow when feeding grain to goats and sheep:

- **Never** feed ruminant livestock large amounts of concentrates at one time.

  Large amounts of grain will promote the growth of lactic acidic bacteria, which increases acidity in the rumen and could lead to acidosis and enterotoxemia. For goats and sheep, a large amount of grain would be in excess of half a kilogram per feeding.

Tip
- feed small amounts of concentrates multiple times per day.

Tip
- if you have purchased a supplement or complete feed and it contains a large quantity of fines, have your feed company replace it or return your money.

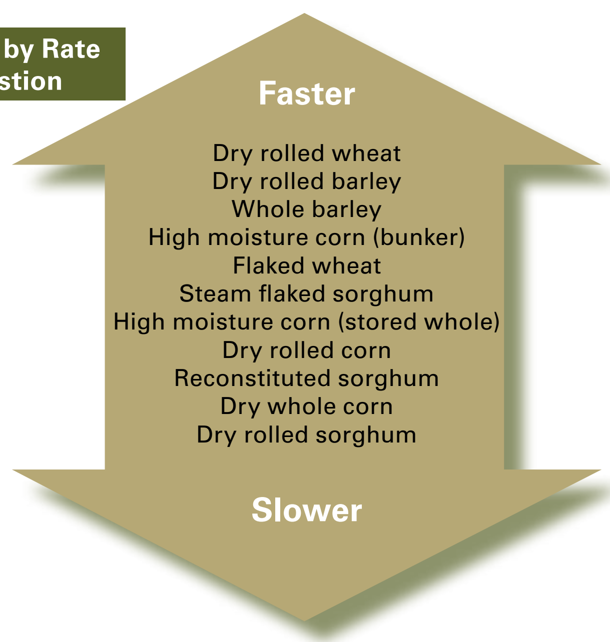
- Do not feed large quantities of finely ground grains. Fine grounding increases the rate of digestion and increases acidity in the rumen.
- Always feed hay before concentrate to start the rumen "ruminating" and buffering so that the pH remains at a healthy level.
- Feed a minimum amount of forage to ensure a healthy rumen. A common recommendation is to feed ruminants at least one and a half percent of their body weight in forage.
- **Never** change rations too abruptly. The rumen bugs need time to adjust to a new diet, usually a one to two week period. This is especially true if you are changing from a forage-based diet to one which contains more concentrate.
- Feed grains whole. Cracking grain increases the rate of digestion and may increase the risk of acidosis. Also, it is not necessary to process concentrates in sheep and goat rations.

What kinds of grains and proteins should be fed to sheep and goats? This question is really economic in nature, although rumen health must be taken into account as well. Sheep and goats can eat corn, barley, wheat and other grains such as rye.

Care must be taken not to process grains for sheep and goats or over feed "hot" grains such as wheat. The diagram below illustrates the rate that certain grains enter into solution in the rumen. The faster they enter, the more dangerous they are in terms of causing acidosis or entertoxemia.

Grain Sources Categorized by Rate of Ruminal Startch Digestion

Adapted from Stock and Britton (1993)



As with the grains, protein supplements fed to sheep and goats will be determined based on economics. In western Canada, the most common commodity proteins are soybean meal, canola meal, corn gluten meal, linseed meal, distillers grains and animal proteins.

The animal proteins are very unpalatable and expensive; in addition many producers will not use them because of the BSE situation in Canada.

Soybean meal and distillers are very palatable and highly nutritious. Canola meal, linseed meal and corn gluten meal can be bitter and should be introduced cautiously but all provide a good source of protein.

Fats and Oils

It is not likely that sheep and goats producers in western Canada will be using ingredients that contain high levels of fats and oils for one reason: cost.

However, opportunities present themselves occasionally in which producers find themselves being offered "culled" product for an extremely low price or even free of charge.

Typical high oil, fat products used in the livestock industry include:

- Raw, roasted or toasted soybeans
- Fuzzy cottonseed
- High oil sunflower seeds
- Rendered fat, often referred to as AV Fat
- Vegetable oil from canola, soy or corn sources
- Commercial bypass fats

All of these can be used in sheep and goat rations **but** the cautions previously outlined must be adhered to.

Tip
- you can kill ruminant animals with fat very quickly. Approach with extreme caution and work with a qualified nutritionist.

By-product Feeds for Sheep and Goats

Recovering by-products for use as animal feed can help food processors save money while preventing pollution. Waste management and water quality have become key environmental and economic issues in agriculture and industry. Today's food manufacturers face increased waste management costs and tighter regulations than in the past. Effective ways of managing waste are important in maintaining water quality, ensuring food safety, and protecting the environment while maintaining profitability.

Offering by-products for use as animal feed is an economical and environmentally sound way for food processors to reduce waste discharges and cut waste management costs. Selling by-products can also produce additional revenue. Livestock producers can save money as well if by-products offer a less expensive source of nutrients than traditional feeds and if they support acceptable animal performance.

Many by-products can be fed to animals. Generally, by-products to be used as feedstuffs should be economical, dense in nutrients, and free of toxins or other substances that may be unhealthy for the animals.

Principal Nutrients in Common By-products Used for Feed

Nutrient supplied	By-product
Protein	Brewers grains
	Distillers grains
	Cull beans
	Feather meal
	Fish meal
	Meat meal
	Blood meal
Protein and energy	Brewers grains
	Distillers grains
	Corn gluten feed
	Wheat midds
Energy	Bakery meal
	Fat
	Snack food waste
	Soft drink syrup
	Soy hulls
	Vegetable, fruit processing waste
Roughage sources	Apple pomace
	Corn cobs
	Cottonseed hulls
	Beet pulp

Factors to Consider in Selecting By-products for Feed

It is vitally important to determine whether the by-products being considered for animal feeds are appropriate to the needs and conditions of specific feeding situations. Many factors must be considered in evaluating the suitability of by-products as feeds.

Moisture Content

Many by-products contain more than 75% water, for example potatoes and apple pomace. The dry matter content of material from some processing plants may vary 50 percent or more during a typical week's processing. Thus, careful monitoring of moisture content and frequent ration adjustments are needed to ensure that the animals achieve the desired nutrient intake. Moisture content is the factor that often determines whether the feeding of wet by-products is economical. It adds to the cost of transporting nutrients to livestock, and the purchase price must be adjusted to discount for high moisture content and moisture variation. Because of transportation costs, most wet by-products are fed in animal operations located close to the food processing plant.

Nutrient Density

The unique advantage of many by-products is that they can be inexpensive sources of valuable nutrients needed by livestock. The greater the nutrient concentration in the dry matter equivalent of the by-product, the more valuable it is to a livestock operator. Energy, protein, minerals, and roughage are the most frequent nutrients or diet components supplied through by-products.

Waste Stream Composition

In evaluating a by-product for its potential as an animal feed, livestock producers must know more about the material than just its moisture and nutrient contents. To determine whether a material is appropriate for a particular animal feeding situation, producers should consider these other factors:

- Types and proportions of by-products generated
- Variability in moisture and nutrient content
- Storability of the material
- Handling characteristics
- Potential for the presence of physical contaminants (sticks, metal items, glass, plastic, etc.)
- Potential for development of moulds and related mycotoxins

Target Animals

In evaluating one or more by-products, livestock producers should ask these questions: Will the by-product supply needed nutrients more economically than other feeds? Will the animals consume diets containing the by- product? Are the characteristics of the by-product compatible with the other diet ingredients and the technical aspects of the feeding system? Is animal feeding and nutrition expertise available to help manage the feeding program so that the by-product can be used effectively?

Handling and Processing

Most by-products are transported in tractor trailers capable of carrying 20 tonnes or more. However, the density of some dry by-products limits the amount that can be hauled on a trailer and may increase transportation costs. In any case, access with a tractor trailer is usually necessary when feeding by-products. In addition, storage facilities to protect the materials from the weather and prevent liquid runoff are needed. Because many dry by-products will bridge if stored in grain bins or tanks, they are often stored in commodity sheds (pole sheds covered on the top and three sides). The feeding system must be of a type that makes it easy to incorporate the by-product into diets

Volume of Material

Large processing plants usually generate enough by-product to ensure an adequate supply, even for large livestock operations. Before a manufacturer and a livestock producer enter into an agreement to feed by-products, it is essential to determine the quantity of material available, the seasonality of the supply, the ability of the animal operation to use the available quantities, and whether feeding the by-products will benefit both parties. From the standpoints of nutrition, safety, and animal health, the inventory of by-product should be turned over relatively quickly, usually within seven days for wet materials. Wet by-products may deteriorate and become contaminated with moulds and mycotoxins if stored longer.

Regulations

Government regulations may be involved in marketing a by-product for feeding to animals. Before marketing by-products, processing plant operators should contact the food and drug protection division at their provincial department of agriculture to determine what regulations, if any, must be considered. Feed definitions, labels and guarantees, transportation regulations, and other legal matters should be investigated before beginning the marketing program.

Cost Versus Benefit

Livestock growers can feed by-products economically only if animals can gain weight or produce milk less expensively using by-products in the diet than if alternative feeds were used. It is important to seek the expertise of a nutritionist when determining whether this condition can be met.

Effects on Feed Consumption

Some by-products, because of their moisture or nutrient content, may limit consumption of the diet, resulting in poor animal performance. One example of a nutrient imbalance causing low feed consumption and performance is the feeding of high-fat by-products. The fat may combine with the calcium in the diet to form insoluble soaps, resulting in a calcium deficiency and decreased feed intake. This problem can be overcome by adding more calcium to the diet. Fat alone, if it exceeds 10 percent of the diet dry matter, may restrict feed intake and performance.

Safety Concerns

For by-products to be useful as animal feeds, they must not present safety or health problems to the animals nor present a risk of contaminating the animal product to be sold. In the production and utilization of by-products, all parties must take care to prevent contamination with pesticides, mycotoxins, and other materials that could be dangerous to the animals or contaminate the animal product.

Categories of By-products and Specific By-product Feeds that May Be Available in Alberta

Forages and Fibrous By-products

Slough Hay

Slough hay is usually higher in nutritive value than cereal straw and may approach brome hay in quality; however, it is more variable in quality. Slough hay harvested after a killing frost will have a nutritive value similar to straw.

Small Grain Hay

Wheat, oats, barley, triticale and rye hay can be used in sheep and goat rations. Harvesting should occur between heading and soft dough stages. Rye hay loses palatability and protein content rapidly after flowering. The nutritive value of these hays should be similar to brome hay when cut at heading to soft dough stage. Energy per acre is maximized by delaying harvest until the soft dough stage. However, protein content is maximized by harvest at late boot to early heading. All these feeds should be checked for nitrate content if drought stressed and/or fertilized heavily with nitrogen.

Soybean Hay

Soybeans can be harvested as a hay crop. Crude protein content can be similar to alfalfa or clover, with moderate TDN. When allowed free access to soybean hay, ruminants will generally not eat the stems, since they are quite coarse. Chopping or tub grinding can be used as a way to improve consumption; however, soybean hay stems are quite low in energy and protein. When soybean hay is stored in round bales, water penetration and spoilage are more of a problem than with grass hay because of the coarse stems. Hay quality does not change drastically with increasing maturity, since more mature soybean hays have a higher proportion of the bale weight as whole soybeans. High levels of soybean seeds in the hay can cause digestive problems due to the high fat content; soybeans can also accumulate nitrate.

Sunflower Silage

Sunflower silage is 80 to 85 percent as valuable as corn silage under normal conditions. Intake may be a problem, especially with high oil varieties; therefore, feeding another forage along with sunflower silage is often advisable. Damaged sunflowers can be most easily ensiled by chopping and incorporating into other forage(s) being ensiled at the same time, such as corn, or small grains. Moisture levels are generally too high when sunflowers are ensiled alone, so ensiling with dry forages or other feeds to prevent excessive nutrient loss is recommended. Waiting until after one or two killing frosts or incorporating ground dry roughage are methods to get ensiling moisture down to 70 percent or less.

Straws, Residues and Fibrous By-products

Ammoniated Straw

Straw is sometimes ammoniated to improve the feeding value by increasing protein content and fibre digestibility. When limited amounts of hay or other roughages are available, ammoniation may be a cost-effective way to increase the value of straw. Ammoniated feeds should be analyzed prior to feeding to determine actual nutrient content. Energy supplementation may still be necessary after ammoniation, depending on the nutrient requirements of each particular set of livestock. Ammoniated straw has a feeding value similar to average-quality grass hay.

Cereal Straw

Straw is a good alternative in wintering rations for sheep and some goats if properly supplemented with energy, protein, minerals and vitamins. Satisfactory supplements include cereal grains such as barley, crop processing by-products such as wheat midds, or high-quality hays. Oat straw is the most palatable and nutritious, followed by barley straw and wheat straw. Rye straw has little feed value. Straw a year or more old is usually more palatable and digestible than fresh straw. Late-planted oats are often susceptible to rust. The resulting straw will be dusty and act as a respiratory irritant but is not toxic.

Chaff, Small Grain

Chaff collected in bunch wagons behind combines is usually of high quality. It contains grain which passes through the combine, weed seeds and hulls, as well as some leaves. Bunch wagons, however, can be an inconvenience when grain is harvested. Approximately 300 to 500 pounds of chaff can be collected per acre.

Chaff, Ammoniated

Chaff may be ammoniated to improve its feeding value. Ammoniation improves the energy availability and protein content of chaff. Procedures are the same as those used to ammoniate straw or other low-quality forages.

Corn Cobs

Corn cobs are low in protein (2.8 percent) but higher in TDN (48 percent) than other crop residues such as wheat straw.

Roots, Tubers and Associated By-products

Beets, Sugar

Occasionally, regional sugar processors must dispose of whole sugar beets due to spoilage. Whole beets are low in crude protein (6.8 percent) but high in energy (75% TDN). If possible, whole beets should be broken up prior to feeding. Producers can utilize extended mixing times with a conventional mixer wagon to break up whole beets. Choking may be a potential problem when feeding whole beets.

Beet Pulp

Beet pulp can be used effectively as an energy supplement; it is relatively low in protein (8 percent) but relatively high in TDN (72 percent). Beet pulp is available wet (pressed shreds) or dry (shreds or pellets. Wet beet pulp contains approximately 75% moisture, which limits the distance it can be transported economically. Wet pulp can be stored effectively in silage bags or in trench or bunker. Dried beet pulp is 88% DM; however, it should be soaked before being fed to animals as it expands significantly.

Carrots

Cull carrots from the vegetable industry are sometimes available as a livestock feed. They are high in moisture (85 to 90 percent) and about 10% crude protein on a dry matter basis. They are highly digestible; however, high levels of carrots in the diet can result in off-coloured fat in finishing lambs and goats. Therefore, levels should be limited to 20 percent or less of the diet (DM basis). The leaf material of the carrot plant can accumulate nitrate.

Potatoes

Potatoes have a feeding value equal to cereal grain (barley) on a dry matter basis. Potatoes are high in energy and low in protein and vitamin A. Chopping potatoes will prevent choking; frozen potatoes should never be fed because of the danger of choking. Acclimate animals to potatoes gradually or they may cause digestive disturbances. Sprouted potatoes contain toxic alkaloids; the long sprouts should be removed before feeding. Feeding green potatoes is not recommended because they contain the alkaloid solanidine.

Potato Waste

Potato waste is the product remaining after potatoes have been processed to produce frozen potato products for human consumption. The product can include peelings, cull potatoes, rejected French fries and other potato products. Due to differences in processing plants, moisture levels can vary considerably from plant to plant (75 to 85 percent). The high water content limits transportation distances to local areas surrounding the processing plants. Potato waste is equal in energy to grains on a dry matter basis. However, it is low in protein and vitamin A.

Onions

Cull onions can be used as a feed for ruminant animals. Onions are high in moisture (approximately 90 percent). On a dry matter basis, onions are 9 to 13% protein, 83 to 90% TDN, 0.35% Ca and 0.40% P. When fed at high levels, onions can cause anemia due to the presence of sulphur compounds which cause haemolysis of red blood cells. The ruminal microorganisms in sheep appear to adapt to higher levels of onions readily.

Turnips

Turnips can be planted to use in grazing programs. Grazed turnips are highly digestible and a good source of protein. Grazed turnips can be used as high-quality forage for grazing lambs, or to flush ewes prior to breeding. Turnips can be grazed as early as 70 days following planting. Introduce livestock to lush turnip pasture gradually over three to five days and be sure the animals are full when turned into the turnip field. After the tops are consumed, animals will consume the tubers. In loose soils, tubers are easily pulled from the ground by grazing animals. However in heavy soils or soils which are compacted, some light tillage or spiking may be used to loosen the tubers.

Grains, Grain By-products and Screenings

Barley Malting By-Products

Barley malting by-products consist of screenings, dried malt sprouts, and in some cases, thin or feed grade barley. Malting plants market these components together or separately, depending on the plant. Barley malt pellets are palatable and can be used effectively in creep or back-grounding rations. Barley malt pellets contain moderate levels of crude protein (14 percent) and are moderate in energy (74% TDN).

Bread and Bakery By-Products

Stale and discarded bread and bakery products can be used in goat and sheep rations as a source of energy and protein. These products vary greatly, depending on the particular product which was discarded. They are generally high in energy, and may contain relatively high levels of fat. These products also tend to ferment rapidly in the rumen. Therefore, levels should be limited to 20 percent or less of the diet to prevent digestive disturbances. Caution should be used when considering feeding bread and bakery by-products because of the potential for high sodium, high soluble carbohydrate, and high fat content can lead to metabolic disturbances.

Corn Gluten Feed

Corn gluten feed is a by-product of the corn sweetener industry. It consists of various combinations of corn bran, corn germ and corn steep liquor, depending on the plant which manufactures it. Corn gluten feed is sold either as a wet product (40% dry matter) or as a dry pellet (88% dry matter). Wet corn gluten feed is equal in energy to corn (DM basis), with dry corn gluten feed being slightly lower in energy due to heat drying driving off volatile fatty acids. Corn gluten feed contains 22% CP. Corn gluten feed is low in calcium and high in phosphorus and sulphur. Corn gluten feed is useful in many different types of rations. The wet by-product has a short shelf life during warm weather. Signs of spoilage include off colours and odours and mould development. However, it may be stored for extended periods in bunker or trench silos as well as plastic silage bags.

Corn Gluten Meal

Corn gluten meal is a very high protein product, also produced by the sweetener industry. This meal is high in bypass (escape) protein and finds limited use in livestock rations because of the high cost.

Dry Edible Beans (Culls and Splits)

Cull beans contain moderate levels of energy (68 to 78% TDN) and protein (22 percent). Raw cull beans should be used as only a small portion of ruminant diets (less than 10 percent of the diet) with severe diarrhea resulting from higher intakes. Roasting increases usefulness to more than 25 percent of the diet because the enzyme inhibitors are rendered ineffective with heating. Care must be exercised in adapting animals to rations containing cull beans. Cull beans should be ground if possible.

Distillers Grains

Distillers grains are a by-product of the ethanol industry. In most cases, ethanol production is corn-based, but other grains (barley, wheat) can be used. The product can be sold as a wet mash (60 to 65 percent) or as a dried (8 to 10% water). The shelf life of the wet material is limited to a few days, especially in warm weather. Signs of spoilage include off colours and odours and mould development. Bunker or trench silos as well as plastic silage bags can be used to store the wet material for longer periods of time. Distillers grains are very palatable and mix well with other ration ingredients. The product can be used to condition or add moisture to dry rations to improve acceptability. Distillers grains contain approximately 26% CP with a relatively high proportion being bypass (escape) protein.

Ergot Contaminated Feeds

Ergot bodies have the potential for constricting circulation in body extremities, causing lameness, abortion and gangrene. Assume a zero tolerance for ergot in rations for breeding animals due to the possibility of abortion. Ergot is more prevalent in grains and hays grown in wet years. Grain screenings may also contain ergot. If the ergot content of contaminated feeds exceeds 0.1 percent, the contaminated feeds should be blended with other grain or forage to reduce the ergot concentration.

Fababeans

Fababeans can be fed whole or processed. They do not need to be heated. Fababeans should comprise no more than 30 percent of the grain mixture.

Field Peas

An annual legume, field peas are grown in combination with small grains as a high protein forage or in a pure stand and harvested for grain. Peas are high in protein (20 to 27 percent) and energy (88 to

90% TDN) and are very palatable. Optimum use may be in diets where nutrient density is important, such as creep rations, receiving diets or supplements. Trials feeding increasing levels of peas in creep rations have resulted in a linear increase in intake. Gain data suggests the most economical use of peas may be at 30 to 50 percent of creep diets. Data from lambs fed field peas in finishing diets indicate that the TDN of field peas is similar to or slightly higher than corn. As a general recommendation, field peas should be rolled for ruminants.

Hull-Less Oats

This is a very nutrient dense grain, high in protein (18 percent) and energy (10% fat, 93 to 95% TDN). Controlling particle size is important in feedlot rations, as feed intake and gain may be severely depressed with high proportions of finely ground hull-less oats in finishing diets. Feed hull-less oats whole if particle size cannot be controlled in the mill. Mixing with corn or barley at less than half the grain component is recommended.

Lupines

Lupine is an annual legume that can be fed as ensiled forage or as a seed meal. Lupine meal is made by grinding or flaking lupine seeds (32 to 42 % CP, 72% TDN, 5% fat) and is an excellent protein source for ruminants. It is used around the world as a protein feed. Sweet white lupines are the preferred variety as others contain bitter-flavoured alkaloids and are unpalatable. Lupine silage contains 13 to 18% CP and 52 to 61% TDN, depending on maturity at harvest.

Rye

Rye is a minor feed grain; however, there are times when it might be available for feeding. Rye can be relatively unpalatable and can also have problems associated with ergot contamination. Therefore, rye should be limited to 40 percent of the concentrate mixture. When rye is limited to this amount and when ergot is not a problem, the feeding value is similar to barley.

Screenings, Corn

Except for their smaller particle size, corn screenings are usually similar to corn grain in nutritive value unless substantial amounts of cob or weed seeds are present. Processing is usually not required.

Screenings, Grain

Screenings are a combination of materials obtained in the grain cleaning process. Screenings may include light or broken grain seeds, weed seeds, hulls, chaff, joints, straw, elevator dust and floor sweepings. Understandably, there is substantial variation in the nutritive value of screenings. The best grades of screenings resemble oats in composition and may nearly equal oats or barley in feeding value. However, some of the poor quality screenings more nearly resemble straw in composition. A large proportion of dark seeds (usually mustard or pigweed) can reduce the palatability of screenings. One might expect fewer viable seeds being voided from sheep than cattle since sheep chew their food more extensively. Ergot may also be a concern when feeding screenings.

Screenings, Sunflower

Sunflower screenings consist of a mixture of groat pieces, light weight seeds, pieces of the heads, sclerotinia bodies (a fungus common in sunflowers) and hulls in variable proportions. Protein and fibre levels may be equivalent to good quality hays or higher, depending on the amount of whole seeds and groats in the screenings. Oil found in broken and/or lightweight seeds increases the energy and protein content. Nutritive value can also be extremely low, with the presence of substantial stalk material and hulls.

Screenings, Wheat

The most common ingredients in wheat screenings are broken wheat kernels and pigeon grass (green and yellow foxtail) seed. This weed seed is an economical energy source for many livestock rations despite the fact that it is generally inferior to feed grains as an energy source. A general rule in ruminant rations is to use less wheat screenings as the proportion of grain in the ration increases. With high roughage rations, up to 40 percent or more of the grain mixture may be wheat screenings. Sheep and goats require less processing of grains then cattle and can rather efficiently use pigeon grass whole. Trials have shown fattening lambs can be fed up to 40% pigeon grass seed in their ration with no reduction in gain.

Smut Contaminated Feeds

Smut contaminated feeds such as corn, corn silage and oats appear to be harmless to livestock. One report has detailed injury to livestock fed large amounts of smut separated from grain. This is not a common feeding practice. There is no need to remove smut from grain or silage corn prior to feeding.

Triticale

Triticale is a hybrid of wheat and rye which is at times available for feeding. Triticale is higher in protein than other cereal grains and similar in TDN to barley. For best results, triticale should be rolled or cracked prior to feeding. Ergot can develop in triticale, so producers should evaluate triticale for ergot content prior to feeding.

Wheat

Wheat (hard red spring or winter) levels should not exceed 30 percent of the grain in ruminant rations. The level of durum should be limited to about 75 percent of the level of spring wheat. Steam rolling can produce a ration which contains less fines, resulting in fewer incidences of digestive disturbances when high levels are fed. However, steam rolling is a relatively expensive method of processing. Sheep and goats can utilize whole wheat. Less protein supplement is required when wheat is included in the ration, a particular advantage for wheat when protein is expensive. Wheat is an excellent livestock feed but is not conducive to self-feeding programs because of its rapid fermentation rate. If self-feeding is the only option, then mixing salt (necessary salt level will vary depending on conditions) with wheat may be a viable option.

Wheat Midds

This by-product has moderate levels of protein (18 percent) and energy (80% TDN) and is a versatile and palatable feedstuff for a variety of livestock diets. Wheat midds are used as an ingredient in many different commercial supplements, creep feeds and cakes. Storage of wheat midds can be a problem. Storage in a bin with an aeration system or in flat storage (quonset) is recommended for best results. Pellet quality can also deteriorate when wheat midds are handled multiple times. The price of wheat midds varies seasonally with demand for feed products. Wheat by-products are lower in calcium and higher in phosphorus than most other grains and grain by-products.

Wild Oats

Wild oats have little value as a feed for livestock. They are often part of grain screenings. Hammer milling is recommended to break the germ and maximize nutrient availability. If wild oats are fed whole, few nutrients are extracted and the physical form may irritate the mouth. Whole wild oat seed is also viable following the digestive process, requiring further processing to prevent weed infestation problems in areas fertilized with viable wild oat seed found in manure.

Oilseeds and Oilseed By-products

Canola

Whole canola seed can be used as a protein and energy supplement. It is a good source of energy because of its high oil content (40% ether extract). Canola should be rolled or cracked prior to feeding. Due to the high oil levels in canola, it should be limited to approximately 10 percent of the ration (dry matter basis).

Canola Meal

Canola meal is a by-product protein meal remaining after edible oil is extracted from canola. The meal contains 40 to 44% CP and makes a good source of supplemental protein for sheep and goats. Expeller canola meal may contain up to eight percent oil compared to a half percent in solvent extracted meal, providing added energy from residual oil.

Flaxseed

Flaxseed can be used as a livestock feed but should be limited to use as a protein supplement because of its oil content. Flaxseed should be ground before feeding to livestock. In rare cases, flaxseed may contain prussic acid. Flaxseed should be limited to 10 percent of the grain in livestock diets.

Linseed Meal

The residual meal from flax processing, linseed meal, is in demand as high-quality protein for livestock. Expeller processing leaves up to eight percent residual oil in the meal compared to solvent processing which removes all but a half percent. Linseed meal is very palatable, but demand from the dairy industry often limits economical inclusion in diets.

Soybeans

Soybeans can provide the total protein supplement for sheep and goats, but growing and finishing lambs should not be fed more than necessary to balance the ration. Raw soybean seeds will swell, and this is one of the limitations of this type of ration. Processing the beans (cracking or rolling) may improve performance. Processed raw soybeans should not be stored longer than one week before feeding since they may become rancid.

High levels of fat can reduce ruminal fibre digestion. Therefore, levels of soybeans should be limited based on fat content. Whole soybeans, either raw, toasted or extruded, have been used successfully in ruminant rations. Heated soybeans can give high producing ewes or does the extra nutrients (CP, escape protein, energy) they need during the early part of lactation. Heating soybeans decreases the amount of protein degraded in the rumen and increases the escape or bypass protein available for the animal. Raw beans degrade more rapidly in the rumen, increasing the amount of ammonia excreted in the urine. Heating also makes the beans more palatable and easier to store.

Green, immature or frost-damaged soybeans can be fed to ruminants without problem. Lambs fed higher levels of soybeans (in corn silage based diets) had lower fibre digestibility due to the high oil levels, which interfere with fibre digestion in the rumen.

Soybean Hulls

Soybean hulls are relatively low in protein but high in energy. Even though soy hulls are high in fibre, they are similar in energy (TDN) to corn grain when fed as energy supplements for animals consuming forage-based diets. The energy from soybean hulls is provided largely by digestible fibre (hemicellulose) rather than starch. Soybean hulls are very palatable and are used in many commercial feeds.

Sunflower Meal

Sunflower meal is another by-product protein meal which remains following oil extraction from sunflowers. The meal contains 32 to 35% CP and can be used effectively as a protein supplement in ruminant rations. Lower (28% CP) or higher (40 percent or more CP) protein levels are the result of adding or removing sunflower hulls from the meal product. Addition of hulls to the meal lowers the energy content of the meal as well, so a nutrient analysis of the meal is appropriate.

Sunflower Seeds

Whole sunflower seeds may be included as a protein and energy supplement. Whole seeds should be limited to 10 to 15 percent of the ration. Whole sunflower seeds do not need to be processed before feeding. Oil type sunflowers are higher in oil (ether extract) and consequently are higher in energy than confectionary type sunflowers.

Liquid By-products

Condensed Distillers Solubles or 'Syrup'

Condensed distillers solubles are a liquid by-product of the ethanol industry. They are sometimes referred to 'syrup' or 'corn syrup.' Condensed distillers solubles are high in moisture and must be handled with pumps and tanks. Condensed distillers' solubles are high in protein and energy and contain 9 to 15% fat on a dry matter basis. They are useful as sources of supplemental protein, phosphorus and trace minerals. They have been used successfully as ration conditioners and are very palatable. The product works well in many different types of rations, but the high moisture level limits the distance it can be transported economically. Since it is a liquid, it also requires investment in liquid handling equipment.

Corn Steep Liquor

Corn steep liquor (also referred to as "steep" or "steep liquor") is a liquid by-product of the corn sweetener industry. Corn steep liquor contains 30 to 35% CP (on a dry matter basis) and is high in energy (88% TDN) as well. Level of use will be dictated by economics.

Desugared Molasses (Concentrated Separator By-product)

Desugared molasses or condensed separator by-product is molasses which has gone through further refinement to remove remaining sugar. It is slightly lower in energy (67% TDN) compared to molasses but is higher in protein (20% CP) and potassium. Research indicates that it increases intake in a wide variety of diets when fed at five to 15 percent of the diet.

Molasses

Beet or cane molasses is used primarily as a source of energy (75% TDN) in animal feed, but it is also included as a palatability enhancing agent, an agent for reducing dust, a binder for pellets and a carrier for NPN, vitamins and minerals. When molasses is used in dry feeds, it should not be incorporated in an amount exceeding eight percent for sheep and goats. Beet molasses may have a greater laxative effect than cane molasses, so lower inclusion rates are strongly recommended.

Whey

Whey is the by-product of cheese manufacturing. Whey may be available in liquid, condensed or dried forms, depending on the equipment at a particular plant. Due to the lower moisture content, dried and condensed whey can be economically transported longer distances than can liquid whey. Liquid whey contains about 93% water, condensed whey contains approximately 36% water and dried whey contains seven to 10% water. On a dry matter basis, whey is approximately equal to corn in energy and to barley in protein. Liquid whey should be delivered on a daily basis and a continuous supply should be provided to prevent digestive upsets. Whey can become unpalatable after 36 hours. Whey that is not fresh is lower in palatability and can cause tooth decay and sore gums.

Feed Additives for Sheep and Goats

Tip
- not all feed additives used by larger ruminants such as dairy cows are legal or suitable to use in sheep and goats. Make sure that the feed additive you are being asked to purchase is registered with the Canadian Food Inspection Agency for use in small ruminants.

Feeding sheep and goats, particularly in the current economic environment, continues to challenge producers and nutritionists.

Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as rumen pH shift, growth, or metabolic modifier. Several feed additives contain nutrients such as sodium in sodium bicarbonate, or protein in yeast culture. Feed additives are not a requirement or guarantee for high productivity or profitability.

Most sheep and goat producers will use very few, if any, feed additives. However, feed additives are heavily marketed and producers should be aware of what they are, what claims are made for individual feed additives and which work and which do not.

Four factors should be considered to determine if you want to use a feed additive: anticipated response, economic return, available research, and field responses. Response refers to the performance changes the user could expect or anticipate when a feed additive is included.

Several examples are:

- Higher milk yield (peak milk and/or milk persistency)
- Higher average daily gain (ADG)
- Better hair/wool growth
- Increase in milk components (protein and/or fat)
- Greater dry matter intake
- Stimulation of rumen microbial synthesis of protein and/or volatile fatty acid (VFA) production
- Increased digestion in the digestive tract
- Stabilized rumen environment and pH
- Improved growth (gain and/or feed efficiency)
- Minimized weight loss

- Reduced heat stress effects
- Improved health (such as less ketosis, reduced acidosis, or improved immune response)

Research is essential to determine if experimentally measured responses can be expected in the field. Studies should be conducted under controlled and unbiased conditions, have statistically analyzed results (determining if the differences are repeatable), and have been conducted under experimental designs that would be similar to field situations.

Results obtained on individual farms are the economic payoff. Producers and nutritionists must have data to compare and measure responses. Several tools to measure results (to evaluate responses on a farm) include milk records (peak milk, persistency, milk components, and milk curves), reproductive summaries, dry matter intake, average daily gains, growth charts, body condition graphs, and herd health profiles that will allow critical evaluation of a selected additive.

Feed industry personnel and consultants may evaluate feed additives using a slightly different approach; they will look at the reliability, repeatability, and relativity of the research conducted on individual feed additives.

Reliability is assessed based on the research data base for a feed additive that has been published in a peer reviewed journal. Factors taken into account include:

- The ability to predict that the product can have a positive response in a wide range of feeding conditions.
- The establishment of a normal curve of response in various studies.
- A minimized risk of not obtaining a positive benefit to cost ratio.

Repeatability represents the statistical data results. Each feed consultant must determine what level of risk she or he will assume when selecting each feed additive. The bottom line is the probability of a profitable response.

Relativity refers to other products, management changes, or on-farm practices that could replace the feed additive being used.

Tip
- many livestock producers are looking for the "silver bullet" to improve such things as production and animal health. Unfortunately there is no "silver bullet" when it comes to animal production. Keep an open mind but do not be gullible about feed additives.

Aspergillus Oryzae (Yeast)

Function: To stimulate fibre-digesting bacteria, stabilize rumen pH, and reduce heat stress.

Feeding Strategy: Include when high grain diets are being fed, low rumen pH conditions exist, and animals are under heat stress.

Biotin (B-complex Vitamin)

Function: To improve hooves by reducing heel warts, claw lesions, white line separations, sand cracks, and sole ulcers and to increase milk yield through a metabolic route.

Feeding Strategy: Herds and flocks with chronic foot problems may require supplementation for six months before evaluation, and company recommends beginning supplementation at 15 months of age.

Beta-carotene

Function: To improve reproductive performance, immune response, and mastitis control.

Feeding Strategy: May be suggested for use in early lactation and during mastitis-prone time periods—not a recommended feed additive for this purpose.

Calcium Propionate

Function: To increase blood glucose and calcium levels.

Feeding Strategy: Feed seven days prepartum to seven days post-partum or until appetite responds; unpalatable.

Protected Choline

Function: A methyl donor used to minimize fatty liver formation and to improve fat mobilization.

Feeding Strategy: Feed two weeks prepartum to eight weeks post-partum to animals experiencing ketosis, weight loss, and high milk yield. Choline **must** be rumen protected.

Enzymes

Function: To increase fibre digestibility by reducing fibre (cellulase and xylanase enzymes) and DM intake.

Feeding Strategy: Increase fibre digestibility by treating 12 hours before feeding. The spray on product is more effective when applied to dry diets, and may be diet specific. Results with enzymes have been extremely variable.

Magnesium Oxide

Function: Magnesium oxide is an alkalinizer (raising rumen pH) and increases uptake of blood metabolites by the mammary gland, raising fat test.

Feeding Strategy: Used with sodium-based buffers (ratio of two to three parts sodium bicarbonate to one part magnesium oxide).

Methionine Hydroxy Analog

Function: To minimize fatty liver formation, control ketosis, and improve milk fat test.

Feeding Strategy: Feed to lactating animals in early lactation receiving high levels of concentrate and limited dietary protein. This feed additive can be extremely expensive.

Niacin (B3, Nicotinic Acid, and Nicotinamide)

Function: These are coenzyme systems in biological reactions they improve energy balance and stimulate rumen protozoa.

Feeding Strategy: Feed to high producing animals in negative energy balance, heavy dry females; feed two weeks prepartum to peak dry matter intake (10-12 weeks postpartum).

Probiotics (Bacterial Direct-fed Microbes)

Function: To produce metabolic compounds that destroy undesirable organisms. Probiotics provide enzymes improving nutrient availability, or detoxify harmful metabolites.

Feeding Strategy: Feed to young animals, lactating animals and animals under stress.

Propylene Glycol

Function: Used as a source of blood glucose, to stimulate an insulin response, and to reduce fat mobilization.

Feeding Strategy: Drench starting at one week prepartum (preventative role) or after calving when signs of ketosis are observed (treatment role). Feeding is not as effective as drenching.

Silage Bacterial Inoculants

Function: To stimulate silage fermentation, reduce dry matter loss, decrease ensiling temperature, increase feed digestibility, improve forage surface stability, and increase VFA (lactate) production.

Feeding Strategy: Apply to wet silage (over 60% moisture), to corn silage, haylage, and high moisture corn and to silage with low natural bacteria counts (first and last legume/grass silage and frost damaged corn silage). Use also under poor fermentation situations.

Sodium Bentonite

Function: This is a clay mineral used as a binder, which shifts VFA patterns, slows rate of passage, and exchanges mineral ions. Field claims to tie up mycotoxins have been reported.

Feeding Strategy: Use with high grain diets, loose stool conditions, presence of mould, low fat test, and dirt eating.

Sodium Bicarbonate / Sodium Sesquicarbonate (Buffer)

Function: To increase dry matter intake and stabilize rumen pH.

Feeding Strategy: Feed 120 days postpartum with diets that are high in corn silage (over 50 percent), wet rations (over 55% moisture), lower fibre ration (under 19% ADF), little hay (under 2.2 kg), finely chopped forage, pelleted grain, slug feeding, and under heat stress conditions.

Yeast Culture and Yeast

Function: To stimulate fibre-digesting bacteria, stabilize rumen environment, and utilize lactic acid.

Feeding Strategy: Use two weeks prepartum to ten weeks postpartum and during off-feed conditions and stress.

Yucca Extract

Function: To decrease urea nitrogen in plasma and milk by binding ammonia to the glycofraction extract of *Yucca shidigera* plant, improving nitrogen efficiency in ruminant animals.

Feeding Strategy: To animals with high BUN and MUN levels.

Zinc Methionine

Function: To improve immune response, harden hooves, and lower somatic cell counts.

Feeding Strategy: To animals experiencing foot disorders, mastitis, and wet environment.

5. Managing the Nutritional Needs of Sheep and Goats

Effective nutritional management involves the consideration and feeding of the correct nutrients to goats and sheep throughout their specific production cycles—ewes and does, rams and bucks, meat lambs and kids, replacement animals, milk, meat and fibre producers—and assessment of the animal's ability to "do well."

Basic Ration Balancing

Balancing a ration by hand to meet an animal's requirements can be a time consuming task. However, it is time well spent if it results in a cost effective ration which produces healthy, productive animals.

Computer programs now available can really speed up the process of balancing a ration; many are available for free from the internet.

Whether you are hand balancing a ration or using a computer, the rule "garbage in, garbage out" still applies. If you use incorrect information (garbage), the result will be garbage. Never make assumptions about feed quality and quantity!

Tip
- sixty percent of the cost of raising an animal is usually tied up in feed costs.

What do we mean by accurate information? To properly balance an animal's ration we need the following information:

1. Recent and accurate forage analysis. Wet forages should be tested about once a month or when a new silo is opened; dry hays need only be tested once, assuming the "lot" remains the same and weathering of the hay is nil.

Tip
- make sure you are aware of the units you are using. The Canadian feed industry works entirely in the metric system. A producer buys either a tonne of feed (or part thereof) or 25 kg bags. Many producers still use the US system to buy and sell grains, hay and other commodities in bushels, pounds and "short tons." A short ton weighs 2000 lb. and when translated to the metric system is approximately 909 kg.

2. An accurate description of the animal for which the ration is being designed. This will include species, breed, sex, age, weight, lactating - early, mid or late lactation, or non-lactating, number of off spring, body condition score, purpose (for example breeding, fibre or milk), accurate dry matter intake of the group, environmental and housing stress, health, any other factor that will impact the nutrition of an animal or group of animals.

3. Ingredient costs (usually $/Tonne).

4. The nutrient requirements of the animals for which you are balancing.

For a complete listing of requirements for sheep and goats, refer to the National Research Council's book titled *Nutrient Require ments of Small Ruminants, 2007*. This book is available online at: http://books.nap.edu/catalog.php?record_id=11654#toc

In addition it can be purchased at most university and college book stores, and livestock supply companies.

There are other nutrient requirement tables for sheep and goats available in books and on-line resources. Most ruminant nutritionists will find a source they are comfortable with and use its tables, with modifications, for the specific flock or herd they are working with.

These tables are guidelines only. Common sense and individual herd/flock conditions should always be considered.

Tips for Ration Balancing

- Ration balancing is only as good as the information used.
- Least-cost rations are most useful to large feeders with a variety of feeds to choose at varying prices. Least cost formulation looks at nutrition and price.
- Dry matter intake has an enormous effect on animal performance. It is extremely important that you have a handle on how much your animals can actually consume.

Methods for Balancing Rations

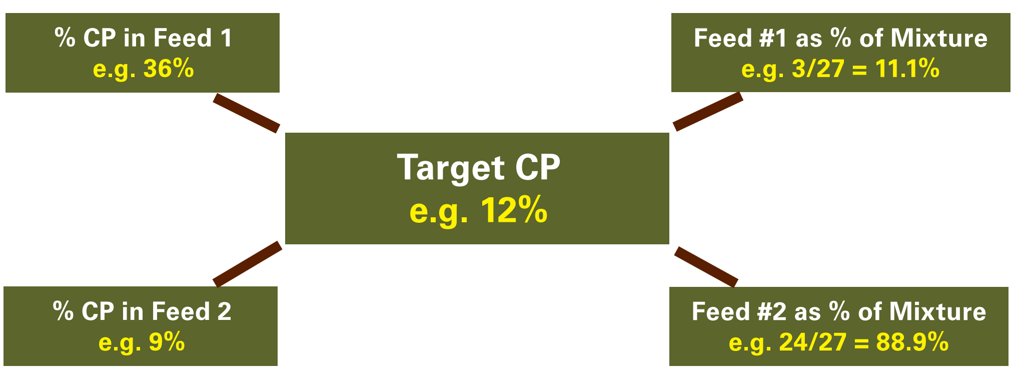
Trial and Error

This basic type of "paper and pencil" balance works for most small flocks.

1. Start by identifying the animals you are balancing for, for example: a 27 kg wether gaining 0.20 kg per day.
2. Select nutrient allowances, for example: 1.4 kg dry matter intake (DMI); 0.9 kg TDN; 0.16 kg of CP.
3. Select feeds and supplements, for example: orchard grass hay, corn, soybean meal.
4. Determine the amounts of each feed.

Nutrient Requirements	Amount Fed	DMI Kg 1.40	TDN Kg 0.89	CP Kg 0.16
O.G. Hay	1.10	0.97	0.52	0.09
Cracked corn	0.34	0.31	0.27	0.03
SBM	0.11	0.10	0.08	0.05
Total	1.54	1.38	0.89	0.17
Deficiencies	0	0	0	0

Pearson's Square



The Pearson square or box method of balancing rations is a simple procedure that has been used for many years. It is of greatest value when only two ingredients are to be mixed.

In taking a close look at the square, notice that several numbers are in and around the square. Probably one of the more important numbers is the number one that appears in the middle of the square. This number represents the nutritional requirement of an animal for a specific nutrient. It may be crude protein (CP) or TDN, amino acids, minerals or vitamins; in the example above it is CP.

In order to make the square work consistently, there are three very important considerations:

1. The value in the middle of the square must be intermediate between the two values that are used on the left side of the square. For example, the 12% CP requirement has to be intermediate between the soybean meal that has 36% CP or the corn that has 9% CP. If barley is used that has 12% CP and corn that has 9% CP, the square calculation method will not work because the 14% is outside the range of the values on the left side of the square.
2. Disregard any negative numbers that are generated on the right side of the square. Be concerned only with the numerical differences between the nutrient requirement and the ingredient nutrient values.
3. Subtract the nutrient value from the nutritional requirement on the diagonal and arrive at a numerical value entitled parts. By summing those parts and dividing by the total, you can determine the percent of the ration that each ingredient should represent in order to provide a specific nutrient level. Always subtract on the diagonal within the square in order to determine parts. Always double check calculations to make sure that you did not have a mathematical error. It also is very important to work on a uniform basis. Use a 100-percent dry-matter basis for nutrient composition of ingredients and requirements and then convert to an as-fed basis after the formulation is calculated.

Computer Programs

There are many computer programs currently available. A large number can be found online and down loaded for free or for a nominal charge off the Net. They can be very useful if you are balancing large number of rations.

Remember, every program has its own set of nutritional "assumptions;", many may be correct, many may be wrong. In choosing to use a program you are agreeing with the developer's "assumptions".

All computer programs are only as good as the person using them. If you lack confidence in your understanding of basic ruminant nutrition, leave the balancing up to a trusted professional.

Following are examples of computer ration balancers and evaluators and useful sites for ration balancing:

http://www.luresext.edu/goats/research/nutr_calc.htm

http://www.sheepandgoat.com/spreadsheets/RationEvaluator2004.xls

http://www.ansc.purdue.edu/compute/balance.htm

http://prechel.net/formula/pearson.htm

Hand Balancing a Ration

Balancing a ration begins with looking at the minimum amount of a nutrient which an animal needs to perform such functions as maintaining its body weight, growing a fetus, lactating or gaining weight at a certain rate, etc.

Nutrients that are usually considered when hand balancing are protein, energy, calcium and phosphorus.

Unless you are using a computer, program balancing the trace minerals and vitamins by hand would take hours. Trace minerals in grains and forages are in phytates (unavailable) form. Vitamins in forages start to break down immediately and are usually gone three months after harvest. Thus, most producers will source a quality vitamin/mineral premix and use this as a supplement.

When you are balancing a ration for **adult animals**, it is best to begin with energy. Energy is usually the number one limiting nutrient for mature animals (after water). All animals that are working - producing milk, producing eggs, running around a track etc. - have a high physiological need for energy and a lower requirement for protein.

When you are balancing a ration for **young growing animals**, it is best to begin with the protein requirement. Growth and muscle development require protein. You may find that this growth ration contains more than the requirement for some nutrients, but as long as the extra amount is not excessive, the ration will meet the needs of the animal.

Before You Begin, Analyze Your Feed

The quality of each feed you use should be based on a feed analysis. Guessing how good your feed is - whether it is really better or worse than you assumed – will cost you money.

Note: Bushel is a volume measurement for grain traditionally used to facilitate fair grain-trade. To facilitate the trading of grain, weight standards for each grain were developed. Corn was assigned a bushel weight of 56 pounds, while soybeans and wheat were assigned bushel weights of 60 pounds. Rye was assigned 56 pounds per bushel, barley 48 pounds per bushel, oats and fescue 32 pounds per bushel, etc.

Although grain is referred to in terms of bushels by some producers, this system is being replaced by metric tons or Tonnes. When purchasing commodities from brokers or the feed industry, the measurement used is Tonne.

Tip
- nutritionists "think" in dry matter terms. Therefore, when nutritionists talk about percent live weight as intake, it is dry matter intake. This applies to all examples.

Several examples of hand balanced rations for both sheep and goats are included in this here. **These are examples only, to be used an educational tool, and not meant to represent rations for use on individual farms.**

Hand Balancing Rations for Sheep

Example Ration One: Ration for Dry, Adult Ewes - Pre-flush

This is often referred to as the maintenance phase - the ewe is in the recovery stage after spending between seven to nine months in the gestation period and lactation. The animal's only nutritional needs are those required to maintain desired body weight. (Remember that the post-lactation female that has been working hard is usually very thin. Feed for the desired body condition score, usually 1 to 2 scores above where she was post-weaning.)

How long this ration will be offered is dependent on the production system, ranging from next to zero days in some accelerated lambing programs and up to 16 weeks in once-a-year lambing situations. Because the ewe is only maintaining her weight, grain feeding is usually not required during this period. In fact, all feeding during this period should be monitored to prevent over-feeding.

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Note: Remember that the amount of DM an animal can consume is a calculation based on its body weight; an animal can only eat so much. This is a critical step in meeting your flock's nutritional needs; a wrong assumption here means that all of the calculations that follow will be wrong. Knowing the average weight of animals in the group you are feeding will go a long way towards making sure the effort you put into ration balancing is correct for your flock.

Ewe Daily Requirements during Maintenance (Dry or Non-lactating Phase)			
Body weight = 175 lb.			
Estimated DM intake per day as % live weight = 1.6%			
Dry Matter (DM) Intake = 2.8 lb. per head per day (175 lb. body weight x 1.6% or 175 x 0.016)			
TDN = 1.6 lb.*	CP = 0.27 lb.*	Ca = 0.0060 lb.*	P = 0.0062 lb.*

** Requirements from NRC tables for the animal type described*

We will be using the grass hay in this example.

Step 1: Calculate the amount of hay dry matter needed to meet the TDN requirement (energy needed by the animal). We start with the hay because forage makes up the largest portion of a ruminant's ration at this stage.

Divide pounds of TDN required by the amount of TDN in the hay. We need to "remove" the percent from the TDN by first dividing by 100.

1.6 lb. of TDN ÷ (54%/100) = 1.6 ÷ 0.54 = 2.96 lb. of hay dry matter

Because the animal, in this example, can only consume 2.8 lb. of DM in a day, from this point on the calculations are limited to 2.8 lb. of DM.

2.8 x 0.54 = 1.52 lb. of TDN supplied by the grass hay. We are short 0.08 lb. of TDN that will have to be met by other ingredients. But it is only 0.08 lb., so how bad can that be? 0.08 lb. represents a 5% deficit in the energy balance for this animal, which means that she will be losing weight during this phase, not a good idea!

Because energy is the first limiting factor for maintaining animal health at this life stage, we balance the ration for energy first.

Note: As you work through the following examples, that sometimes we balance for **energy** first and sometimes for **protein**. Whether it is energy or protein depends on the animals we are focusing on, for example - dry females, lactating females or pre-weaning lambs.

Step 2: Calculate the amount of crude protein (CP) provided by the hay dry matter (calculated above) which will meet the TDN requirement.

Multiply the percentage of protein in the hay by the number of pounds of hay dry matter. Again, "remove" the percent by dividing by 100.

(10%/100) x 2.8 lb. = 0.10 x 2.8 = 0.28 lb. of CP

Step 3: Compare the crude protein requirement of the ewe to the amount provided by the hay.

The ewe requires 0.27 lb. of protein; the hay provides 0.28 lb. of crude protein.

The hay will provide more protein than the ewe requires. Therefore the ewe needs no further supplement to the hay to meet her protein needs.

This is one example where balancing a ration can help you save money. If you have any hay in the barn that was harvested at a later maturity or was weather damaged, you can feed this to your ewes and save the better quality hay for the younger animals and lactating ewes which have a higher requirement for protein.

Tip
- most producers will consult with their local feed supplier and purchase a quality vitamin and mineral premix which will provide all of the macro and trace minerals and vitamins for their flock. Premixes should ideally be bought in such a quantity that they are consumed within a month of purchase.

Step 4: Compare the nutrient requirements for calcium and phosphorus to the amount the ewe will receive from the hay.

Multiply the percent of the nutrient in the hay by the amount of the hay dry matter fed. Again, "remove" the percent.

(0.3%/100) Ca x 2.8 lb. = 0.0084 lb. calcium (required = 0.0060 lb.)

(0.25%/100) P x 2.8 lb. = 0.007 lb. phosphorus (required = 0.0062 lb.)

Step 5: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

The hay provides more than enough calcium and enough phosphorus - the Ca:P ratio is 1.2:1 (0.0084/0.007=1.2:1). In general, the ration should be between 1:1 and 2:1.

If the calcium is too low you can add ground limestone to the grain to increase the calcium in the ration to an acceptable level. You may also consider adding some molasses to the grain mix to prevent the limestone from sifting out. Be cautious; do not guess how much to supplement, calculate it!

Step 6: Compare the amount of hay being fed to the amount of dry matter required each day.

The hay dry matter needed to meet the TDN requirement (2.96 lb.) is above the required DM requirement (2.8 lb.). To correct this, you will need to consider either feeding better quality hay, or reducing the amount of hay fed per day and adding some barley to the ration fed each day. However, you will probably want to feed slightly less hay and add about one-half pound of grain to increase the energy in the ration if is the ewes are in the maintenance phase during the extremely cold winter months. **Do a Body Condition Score**. You must get your hands on them to do this correctly; "eyeballing body condition score just does not work.

Step 7: Do not forget to convert the dry matter of each feed to the **actual** amount fed. If you feed 2.8 lb. of dry matter, the actual amount you feed will be to 3.15 lb. (2.8 lb. dry matter ÷ (89 % dry matter/100) = 3.15 lb. as fed).

Example Ration Two: Ration for Late Gestation Females with Twins

Next to lactation, this period has the greatest nutrient demands, both for fetal growth and the development of the potential for high milk production. Two-thirds of fetal growth happens during the last four to six weeks of gestation, so meeting the nutritional requirements of the ewe is critical. Due to the rapid fetal growth, the ewe's energy requirements increase dramatically—ewes with singles may need up to 50 percent more energy and ewes with twins up to seventy-five percent. Inadequate nutrition (especially energy) during this time will have a detrimental effect on milk production of the ewe, birth weight of the lambs and vigour (survivability) of the lambs.

Ewes should be fed at least 0.75 lb. of mixed grain per ewe daily, if lambing percentage is expected to be average, and up to 1.5 or 1.75 lb. of mixed grain per ewe daily for ewes whose lambing percentage is expected to be above 200 percent. Grain in required because the developing pregnancy reduces the ewe's capacity to meet her daily dry matter (DM) requirement by consuming forage only. There is only so much room in her abdomen and the fetuses often take up much of it, leaving less room for the rumen to fill with feed. Because of her limited ability to consume large amounts of feed, she will have to eat less but get more from it; grain is very useful here since it is more energy dense than hay.

Feeds Available **Assumed dry matter (DM) of all = 89%**				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Ewe Daily Requirements, Late Gestation with Twins		
Body weight = 175 lb.	Dry Matter Intake = 4.4 lb. per head per day	
% live weight = 2.5%	TDN = 2.9 lb.	
CP = 0.49 lb.	Ca = 0.0183 lb.	P = 0.0112 lb.

Note
- if you use poor quality grass hay with this production group, you will probably have to supplement for both energy (e.g. grain) and protein (e.g. soy bean meal). The amount of protein to supplement can be calculated in a similar manner to the amount of energy to supplement. Also, please see the section on balancing using Pearson's Square.

We will use the alfalfa/grass mix hay in this example. First we will determine the **protein** requirement.

Note the switch here from energy in the previous example to protein in this example. Fetal development requires **protein**. If you do not meet the protein requirement, it will cost you later in small newborns with low viability, and ewes with poor milk production.

Step 1: Calculate the amount of hay dry matter needed to meet the crude protein requirement.

Divide pounds of crude protein required by the amount in the hay.

0.49 ÷ (15%/100) = 3.27 lb. of hay dry matter

Step 2: Calculate the amount of TDN provided by the hay dry matter.

Multiply the number of pounds of dry matter needed to meet the crude protein requirement by the percentage of TDN in the hay.

3.27 lb. x (60%/100) = 1.96 lb. of TDN

Step 3: Compare the TDN requirement of the pregnant ewe to the amount provided by the hay.

The hay provides 1.96 lb. of TDN. The pregnant ewe requires 2.9 lb. of TDN. The hay does not meet the TDN requirement.

Therefore, we would need to supplement with a high energy feed (a grain) to meet this requirement. The next step shows how to calculate the amount of grain to feed if the hay is lower in energy.

Step 4: Calculate the difference between the amount of TDN supplied by the hay and the amount required by the animal.

2.90 lb. required – 1.96 lb. in hay = 0.94 lb. of TDN needed to be supplemented

In this example, the grain we will use to supplement the hay is barley.

Step 5: Calculate the amount of barley needed to meet the TDN requirement.

Divide the pounds of TDN needed by the percent of TDN in the barley to get the amount of barley needed to meet the TDN requirement.

0.94 lb. of TDN ÷ (82%/100) = 1.14 lb. of barley is needed to supplement the hay

Step 6: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

Multiply the dry matter of each feed by the percent of the nutrient found in the feed. Add the amounts of each nutrient from each feed to get the total amount of calcium or phosphorus supplied by the two feeds.

3.27 x (0.80%/100) + 1.14 x (0.09%/100) = 0.0272 lb. of calcium (required 0.0183 lb.)

3.27 x (0.30%/100) + 1.14 x (0.40%/100) = 0.0144 lb. of phosphorus (required 0.0112 lb.)

You will notice that the hay and barley meet the requirement for calcium and phosphorus. The calcium: phosphorus ratio of 1.89:1 is within the acceptable limit. In general, the ration should be between 1:1 and 2:1.

If the calcium is too low, you could add ground limestone to the grain to increase the calcium in the ration to an acceptable level. You might also consider adding some molasses to the grain mix to prevent the limestone from sifting out.

Step 7: Compare the amount of dry matter fed from the hay and the barley to the amount of dry matter required by the pregnant ewe.

3.27 lb. hay + 1.14 lb. of barley = 4.41 lb. of dry matter supplied by the ration.

The pregnant ewe requires 4.4 lb. of dry matter each day. Although the ration is slightly over the dry matter required by the ewe, the ration should be adequate to supply dry matter as well as nutrients.

Step 8: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

3.27 lb. hay ÷ (89%/100) = 3.67 lb. of hay fed each day

1.14 lb. of barley ÷ (89%/100) = 1.28 lb. of barley fed each day

When formulating **winter rations**, you will also want to increase the amounts you feed to compensate for the animals' needing extra energy to keep themselves warm.

As a general rule of thumb, increase the amount fed by one percent for each degree of coldness below zero degrees Celsius. Remember to consider wind chill when determining how much to increase the feed.

Example Ration Three: Early Lactation Ewes with Twins

Ewes will produce milk according to the lambs' needs; if the lambs do not nurse then the ewes will not produce that much. Ewes nursing twins will increase their production by 20 to 40 percent, thus increasing their nutritional needs. Place ewes that are nursing singles, twins, and triplets in separate areas so that the nutritional requirements for each group can be met.

Lactating ewes normally reach their peak in milk production around three to four weeks after lambing and produce 75 percent of their total milk yield during the first eight- weeks of lactation.

High-producing ewes require a high amount of energy but are unable to consume enough to prevent weight loss. Expect a ewe in the correct body condition score (BCS) at lambing to lose about one BCS in early lactation as she produces milk for her lambs.

Body fat can only be used for milk production if ewes are receiving adequate protein nutrition; ensure that the ewes are getting the necessary quality and quantity of protein intake.

Because lamb growth is of primary importance, and is dependent on the milk production of the ewe, optimizing milk production is critical. Too often, we see flocks where ewes are not being fed high enough levels of feed for the number of lambs they are nursing. This is particularly true in times of high grain prices. Often, not enough grain is fed during the first four to six weeks of lactation (inadequate energy and not enough protein).

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Ewe Daily Requirements, Early Lactation with Twins		
Body weight = 175 lb.	Dry Matter Intake = 6.6 lb. per head per day	
% live weight = 3.8%	TDN = 4.3 lb.	
CP = 0.96 lb.	Ca = 0.0247 lb.	P = 0.0189 lb.

Have you noticed how much the same animal's DM requirement has increased since we started, in this example from 1.6% of her body weight to 3.8 percent? If you want your ewes to produce like little dairy cows you need to feed them accordingly. If you do not supply adequate nutrition, a ewe will "milk off of her back" for awhile, losing body condition, and eventually you will pay for the feed that you "saved" in reduced lamb performance and ewe longevity. Short term gain equals long term pain.

We will be using the alfalfa/grass mix hay in this example, and again we will start with protein.

Step 1: Calculate the amount of hay dry matter needed to meet the crude protein requirement.

Divide pounds of crude protein required by the amount in the hay.

0.96 ÷ (15%/100) = 6.4 lb. of hay dry matter

Step 2: Calculate the amount of TDN provided by the hay dry matter.

Multiply the number of pounds of dry matter needed to meet the crude protein requirement by the percentage of TDN in the hay.

6.4 lb. x (60%/100) = 3.84 lb. of TDN

Step 3: Compare the TDN requirement of the pregnant ewe to the amount provided by the hay.

The hay provides 3.84 lb. of TDN and the pregnant ewe requires 4.30 lb. of TDN so the hay does not meet the requirement for the TDN.

Therefore, we would need to supplement with a high energy feed or, in other words, a grain, to meet the requirement. The next step shows how to calculate how much grain to feed if the hay is lower in energy.

Step 4: Calculate the difference between the amount of TDN supplied by the hay and the amount required by the animal.

4.30 lb. required – 3.84 lb. in hay = 0.46 lb. of TDN needed to be supplemented

The grain we will use to supplement the hay is barley.

Note

- if you use poor quality grass hay with this production group, you will probably have to supplement for both energy (e.g. grain) and protein (e.g. soy bean meal). The amount of protein to supplement can be calculated in a similar manner to the amount of energy to supplement. Also, please see the section on balancing using Pearson's Square.

Step 5: Calculate the amount of barley needed to meet the TDN requirement.

Divide the pounds of TDN needed by the percent of TDN in the barley to get the amount of barley needed to meet the TDN requirement.

0.46 lb. of TDN ÷ (82%/100) = 0.56 lb. of barley is needed to supplement the hay

Step 6: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

Multiply the dry matter of each feed by the percent of the nutrient found in the feed. Add the amounts of each nutrient from each feed to get the total amount of calcium or phosphorus supplied by the two feeds.

6.40 x (0.80%/100) + 0.56 x (0.09%/100) = 0.0562 lb. of calcium (required 0.0247 lb.)

6.40 x (0.30%/100) + 0.56 x (0.40%/100) = 0.0214 lb. of phosphorus (required 0.0189 lb.)

Challenge Feeding *- a system of feeding which provides more feed than is justified by the level of the animal's production – lactating growing, etc. The animal is challenged to produce more and in many instances does so. If the animal does not respond the level of feeding is reduced.*

You will notice that the hay and barley meet the requirement for calcium and phosphorus; however, the calcium: phosphorus ratio of 2.62:1 is high. In general, the ration should be between 1:1 and 2:1. In most cases, you will not be adding phosphorus to adjust the Ca:P ratio because of costs.

Step 7: Compare the amount of dry matter fed from the hay and the barley to the amount of dry matter required by the lactating ewe.

6.40 lb. hay + 0.56 lb. of barley = 6.96 lb. of dry matter supplied by the ration

The lactating ewe requires 6.6 lb. of dry matter each day. Although the ration is slightly over the dry matter required by the ewe, the ration should be adequate to supply dry matter as well as nutrients.

When you supplement protein, macro and trace minerals and vitamins to animals it is important to be as exact as possible. You have some flexibility when you calculate dry matter intake and energy, taking into account body condition score, challenge feeding and environmental influences.

Step 8: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

6.40 lb. hay ÷ (89%/100) = 7.19 lb. of hay fed each day

0.56 lb. of barley ÷ (89%/100) = 0.63 lb. of barley fed each day

Example Ration Four: Feeder Lambs after 50 Days of Age

Unless you have a special market for light weight, 60 to 80 lb., lambs (for example, to an ethnic market), or if you sell feeder lambs, a period of "hard" feeding a high grain based diet is required to get lambs to weight and carcass grade.

When finishing lambs on high grain diets acidosis, enterotoxemia and urinary calculi can be potential problems.

Acidosis can be prevented by:

- Including at least 10% roughage in the diet.
- Feeding a rumen buffer such as sodium bicarbonate.
- Avoiding quick changes in the type or amount of the ration that is fed. When dietary changes are made, it may take seven to 14 days to accomplish these changes to avoid acidosis.

Urinary calculi can be avoided by:

- Maintaining a calcium to phosphorous ratio of at least 2:1.
- Having salt/mineral available free choice.
- Feeding a urine acidifier such as ammonium chloride.
- Getting lambs to drink adequate quantities of water.

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Daily Requirements, Feeder Lambs after 50 Days		
Body weight = 60 lb.	Dry Matter Intake = 2.4 lb. per head per day	
% live weight = 4.0%	TDN = 1.87 lb.	
CP = 0.31 lb.	Ca = 0.012 lb.	P = 0.006 lb.

If lambs are fed from three to four percent of their body weight daily, they should gain between 0.6 and 1.0 lb. per day.

Note
- if you use poor quality grass hay with this production group, you will probably have to supplement for both energy (e.g. grain) and protein (e.g. soy bean meal). The amount of protein to supplement can be calculated in a similar manner to the amount of energy to supplement. Also, please see the section on balancing using Pearson's Square.

We will be using the alfalfa/grass mix hay in this example, and again we will start with protein. Remember, young stock needs **protein** first.

Step 1: Calculate the amount of hay dry matter needed to meet the crude protein requirement.

Divide pounds of crude protein required by the amount in the hay.

0.31 lb. ÷ (15%/100) = 2.07 lb. of hay dry matter

Step 2: Calculate the amount of TDN provided by the hay dry matter.

Multiply the number of pounds of dry matter needed to meet the crude protein requirement by the percentage of TDN in the hay.

2.07 lb. x (60%/100) = 1.24 lb. of TDN

Step 3: Compare the TDN requirement of the feeder lamb to the amount provided by the hay.

The hay provides 1.24 lb. of TDN and the lamb requires 1.87 lb. of TDN so the hay does not meet the requirement for the TDN.

Therefore, we would need to supplement with a high energy feed, for example a grain, to meet the requirement. The next step shows how you would calculate how much grain to feed if the hay is lower in energy.

Step 4: Calculate the difference between the amount of TDN supplied by the hay and the amount required by the animal.

1.87 lb. required – 1.24 lb. in hay = 0.63 lb. of TDN needed to be supplemented

We will use barley to supplement the hay.

Step 5: Calculate the amount of barley needed to meet the TDN requirement.

Divide the pounds of TDN needed by the percent of TDN in the barley to get the amount of barley needed to meet the TDN requirement.

0.63 lb. of TDN ÷ (82%/100) = 0.77 lb. of barley is needed to supplement the hay

Step 6: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

Multiply the dry matter of each feed by the percent of the nutrient found in the feed. Add the amounts of each nutrient from each feed to get the total amount of calcium or phosphorus supplied by the two feeds.

2.07 x (0.80%/100) + 0.77 x (0.09%/100) = 0.0173 lb. of calcium (required 0.012 lb.)

2.07 x (0.30%/100) + 0.77 x (0.40%/100) = 0.0093 lb. of phosphorus (required 0.006 lb.)

You will notice that the hay and barley meets the requirement for calcium and phosphorus; the Ca:P ratio is 1.86:1.

Step 7: Compare the amount of dry matter fed from the hay and the barley to the amount of dry matter required by the feeder lamb.

2.07 lb. hay + 0.77 lb. of barley = 2.84 lb. of dry matter supplied by the ration

The feeder lamb requires 2.4 lb. of dry matter each day. Although the ration is slightly over the dry matter required by the lamb, the lamb is being "challenge" fed and in most cases will consume the ration offered.

Step 8: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

2.07 lb. hay ÷ (89%/100) = 2.33 lb. of hay fed each day

0.77 lb. of barley ÷ (89%/100) = 0.86 lb. of barley fed each day

Note: Remember that this production group grows fast; what was a good ration at 60 pounds is inadequate at 70 pounds. By knowing the ADG (average daily gain) of the group you can estimate when ration adjustments need to be made. You will be well rewarded for your effort in managing rations at this stage of production and, with a little effort, you can make yourself significant monetary returns.

Example Ration Five: Rams - Maintenance, Breeding Season

Rams also require adequate nutrition to optimize productivity. Poor nutrition may result in poor fertility and reduced vigour. During most of the year, the nutrients necessary to keep rams in moderate condition will come from pasture or harvested forage. Rams should be flushed, similarly to the ewes, in preparation for the breeding season, and supplementation should continue for a month into the season. Rams should also be prevented from getting fat as an over-conditioned ram will be less efficient reproductively. It is easy to forget about the ram; after all you will not need them until breeding season. Fertility can disappear in what seems an instant but it takes time to establish, so start early.

A ram should have a body condition score of 3.5 to 4 before the beginning of the breeding season. Once turned in with the ewes for breeding, the ram spends very little time eating and can lose up to 12 percent of his body weight during a 45-day breeding period—that equates to 30 pounds for a 250 pound ram.

Poor nutrition is a major cause of ram mortality. In many cases, forage alone is not adequate nutrition for placing a ram in proper body condition for the breeding season. At the very least, rams should be evaluated for body condition six weeks before breeding.

Thin rams should receive grain supplementation as a means to increase their body weight and condition. It takes 50 days and approximately two to three pounds of grain per day in addition to a ram's normal diet to move him from a weight of 225 pounds to 250 pounds. Free choice sources of water, salt, and minerals should be available at all times.

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Ram Daily Requirements		
Body weight = 275 lb.	Dry Matter Intake = 8.25 lb. per head per day	
% live weight = 3.0%	TDN = 5.20 lb.	
CP = 0.74 lb.	Ca = 0.025 lb.	P = 0.0132 lb.

We will use the grass hay in this example.

Step 1: Calculate the amount of hay dry matter needed to meet the TDN requirement.

Divide pounds of TDN required by the amount in the hay. We need to "remove" the percent from the TDN by first dividing by 100.

5.20 lb. of TDN ÷ (54%/100) = 1.6 ÷ 0.54 = 9.63 lb. of hay dry matter

Step 2: Calculate the amount of crude protein (CP) provided by the hay dry matter.

Multiply the percentage of protein in the hay by the number of pounds of hay dry matter. Again, "remove" the % by dividing by 100.

(10%/100) x 9.63 lb. = 0.10 x 9.63 = 0.963 lb. of CP

Step 3: Compare the crude protein requirement of the ram to the amount provided by the hay.

The ram requires 0.74 lb. of protein; the hay provides 0.96 lb. of crude protein.

The hay will provide more protein than the ram requires. Therefore the ram needs no further supplement to the hay to meet his protein needs.

Step 4: Compare the nutrient requirements for calcium and phosphorus to what the ram will receive from the hay.

Multiply the percentage of the nutrient in the hay by the amount of the hay dry matter fed. Again, "remove" the percent.

(0.3%/100) Ca x 9.63 lb. = 0.0289 lb. calcium (required = 0.025 lb.)

(0.25%/100) P x 9.63 lb, = 0.0240 lb. phosphorus (required = 0.0132 lb.)

Step 5: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

The hay provides more than enough calcium and enough phosphorus. The Ca:P ratio is 1.2:1; in general, the ration should be between 1:1 and 2:1. You could add limestone to increase the Ca:P ratio.

Step 6: Compare the amount of hay being fed to the amount of dry matter required each day.

The hay dry matter needed to meet the TDN requirement, 9.63 lb., is above the required DM requirement, 8.25 lb. You will probably want to feed slightly less hay and add about one half pound of grain or more to increase the energy in the ration, particularly during the extremely cold winter months. **Remember to Body Condition Score**.

Tip
- nutritionists "think" in dry matter terms. Therefore, when nutritionists talk about percent live weight as intake, it is dry matter intake. This applies to all examples.

Hand Balancing Rations for Goats

The method used to hand balance rations for goats is identical to the one used for sheep except that goat requirement tables are used and the unique nutritional needs of goats are taken into consideration.

Feed additional grain (0.75 to 2 lb. per head per day), particularly if your animals have a history of multiple births. Young replacement does, being bred for the first time, will need additional supplementation so that they can continue to grow and develop during this period. In all cases, the amount of supplementation will vary with the quality and quantity of available forage.

Example Ration One: Doe, Daily Requirements Late Gestation with Twins

Note
- if you use poor quality grass hay with this production group, you will probably have to supplement for both energy (e.g. grain) and protein (e.g. soy bean meal). The amount of protein to supplement can be calculated in a similar manner to the amount of energy to supplement. Also, please see the section on balancing using Pearson's Square.

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Doe Daily Requirements, Late Gestation with Twins		
Body weight = 150 lb.	Dry Matter Intake = 3.60 lb. per head per day	
% live weight = 2.4%	TDN = 2.5 lb.	
CP = 0.50 lb.	Ca = 0.01396 lb.	P = 0.0081 lb.

In this example, we will be using the alfalfa/grass mix hay. We will start by determining the **protein** requirement.

Step 1: Calculate the amount of hay dry matter needed to meet the crude protein requirement.

Divide pounds of crude protein required by the amount in the hay.

0.50 ÷ (15%/100) = 3.33 lb. of hay dry matter

Step 2: Calculate the amount of TDN provided by the hay dry matter.

Multiply the number of pounds of dry matter needed to meet the crude protein requirement by the percent of TDN in the hay.

3.33 lb. x (60%/100) = 2 lb. of TDN

Step 3: Compare the TDN requirement of the pregnant doe to the amount provided by the hay.

The hay provides 2 lb. of TDN and the pregnant doe requires 2.5 lb. of TDN, so the hay does not meet the TDN requirement.

Therefore, we would need to supplement with a high energy feed, for example a grain, to meet the requirement. The next step shows you how to calculate how much grain to feed, if the hay is lower in energy.

Step 4: Calculate the difference between the amount of TDN supplied by the hay and the amount required by the animal.

2.5 lb. required – 2.0 lb. in hay = 0.50 lb. of TDN needed to be supplemented

We will use barley to supplement the hay.

Step 5: Calculate the amount of barley needed to meet the TDN requirement.

Divide the pounds of TDN needed by the percent of TDN in the barley to get the amount of barley needed to meet the TDN requirement.

0.50 lb. of TDN ÷ (82%/100) = 0.61 lb. of barley is needed to supplement the hay

Step 6: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

Multiply the dry matter of each feed by the percent of the nutrient found in the feed. Add the amounts of each nutrient from each feed to get the total amount of calcium or phosphorus supplied by the two feeds.

3.33 x (0.80%/100) + 0.61 x (0.09%/100) = 0.02715 lb. of calcium (required 0.0139 lb.)

3.33 x (0.30%/100) + 0.61 x (0.40%/100) = 0.01243 lb. of phosphorus (required 0.0081 lb.)

You will notice that the hay and barley meet the requirement for calcium and phosphorus. The calcium: phosphorus ratio of 2.18:1 is within an acceptable limit. In general, the ration should be between 1:1 and 2:1.

Step 7: Compare the amount of dry matter fed from the hay and the barley to the amount of dry matter required by the pregnant doe.

3.33 lb. hay + 0.61 lb. of barley = 3.94 lb. of dry matter supplied in all.

The pregnant doe requires 3.7 lb. of dry matter each day. Although the ration is slightly over the dry matter required by the doe, the ration should be adequate to supply dry matter as well as nutrients.

Watch body condition score; if it drops replace some of the hay with barley.

Step 8: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

3.33 lb. hay ÷ (89%/100) = 3.74 lb. of hay fed each day

0.61 lb. of barley ÷ (89%/100) = 0.69 lb. of barley fed each day

When you formulate **winter rations**, you will want to increase the amounts you feed compensate for the animal's need for extra energy to keep itself warm.

As a general rule of thumb, increase the amount fed by one percent for each degree of coldness below zero degrees Celsius. Remember to take wind chill into account when determining how much to increase the feed.

Example Ration Two: Doe Daily Requirements Early Lactation with Twins

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Ewe Daily Requirements, Early Lactation with Twins		
Body weight = 150 lb.	Dry Matter Intake = 4.14 lb. per head per day	
% live weight = 2.76%	TDN = 2.24 lb.	
CP = 0.55 lb.	Ca = 0.0207 lb.	P = 0.0740 lb.

In this example, we will be using the alfalfa/grass mix hay and again we will start with **protein**.

Step 1: Calculate the amount of hay dry matter needed to meet the crude protein requirement.

Divide pounds of crude protein required by the amount in the hay.

0.55 ÷ (15%/100) = 3.7 lb. of hay dry matter

Step 2: Calculate the amount of TDN provided by the hay dry matter.

Multiply the number of pounds of dry matter needed to meet the crude protein requirement by the percent of TDN in the hay.

3.7 lb. x (60%/100) = 2.22 lb. of TDN

Step 3: Compare the TDN requirement of the pregnant ewe to the amount provided by the hay.

The hay provides 2.22 lb. of TDN and the pregnant doe requires 2.24 lb. of TDN, so the hay approximately meets the requirement for the TDN.

Body condition score. You may need to supplement the doe with barley if she starts to lose weight.

Step 4: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

Multiply the dry matter of the hay percent by the nutrient found in the feed.

3.7 x (0.80%/100) = 0.0230 lb. of calcium (required 0.0207 lb.)

3.7 x (0.30%/100) = 0.0111 lb. of phosphorus (required 0.0128 lb.)

You will notice that the hay meets the requirement for calcium but not for phosphorus—the calcium: phosphorus ratio is 1.8:1. In general, the ration should be between 1:1 and 2:1. You may want to invest in a commercial vitamin mineral premix which has a higher phosphorus spec to supplement the phosphorus in the ration.

Step 5: Compare the amount of dry matter fed from the hay to the amount of dry matter required by the lactating doe.

3.7 lb. of dry matter is supplied by the hay; the lactating doe requires 4.2 lb. of dry matter each day. You may want to consider feeding barley if the doe's body condition score is compromised.

Step 6: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

3.7 lb. hay ÷ (89%/100) = 4.15 lb. of hay fed each day

Note
- if you use poor quality grass hay with this production group, you will probably have to supplement for both energy (e.g. grain) and protein (e.g. soy bean meal). The amount of protein to supplement can be calculated in a similar manner to the amount of energy to supplement. Also, please see the section on balancing using Pearson's Square.

Example Ration Three: Feeder Kids after 50 Days of Age

Feeds Available **Assumed dry matter (DM) of all = 89%**				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Daily Requirements, Feeder Kids after 50 Days		
Body weight = 45 lb.	Dry Matter Intake = 1.8 lb. per head per day	
% live weight = 4.0%	TDN = 1.21 lb.	
CP = 0.23 lb.	Ca = 0.009 lb.	P = 0.0045 lb.

In this example, we will be using the alfalfa/grass mix hay and again we will start with **protein**.

Step 1: Calculate the amount of hay dry matter needed to meet the crude protein requirement.

Divide the pounds of crude protein required by the amount in the hay.

0.23 lb. ÷ (15%/100) = 1.53 lb. of hay dry matter

Step 2: Calculate the amount of TDN provided by the hay dry matter.

Multiply the number of pounds of dry matter needed to meet the crude protein requirement by the percent of TDN in the hay.

1.53 lb. x (60%/100) = 0.92 lb. of TDN

Step 3: Compare the TDN requirement of the feeder kid to the amount provided by the hay.

The hay provides 0.92 lb. of TDN and the feeder requires 1.21 lb. of TDN, so the hay does not meet the requirement for the TDN.

Therefore, we would need to supplement with a high energy feed, for example a grain, to meet the requirement. The next step shows how to calculate how much grain to feed, if the hay is lower in energy.

Step 4: Calculate the difference between the amount of TDN supplied by the hay and the amount required by the animal.

1.21 lb. required – 0.92 lb. in hay = 0.30 lb. of TDN needed to be supplemented

We will use barley to supplement the hay.

Step 5: Calculate the amount of barley needed to meet the TDN requirement.

Divide the pounds of TDN needed by the percent of TDN in the barley to get the amount of barley needed to meet the TDN requirement.

0.30 lb. of TDN ÷ (82%/100) = 0.4 lb. of barley is needed to supplement the hay

Step 6: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

Multiply the dry matter of each feed by the percent of the nutrient found in the feed. Add the amounts of each nutrient from each feed to get the total amount of calcium or phosphorus supplied by the two feeds.

1.53 x (0.80%/100) + 0.4 x (0.09%/100) = 0.0127 lb. of calcium (required = 0.009 lb.)

1.53 x (0.30%/100) + 0.4 x (0.40%/100) = 0.0062 lb. of phosphorus (required = 0.0045 lb.)

You will notice that the hay and barley meets the requirement for calcium and phosphorus; the calcium: phosphorus ratio is 2.04:1.

Step 7: Compare the amount of dry matter fed from the hay and the barley to the amount of dry matter required by the feeder kid.

1.53 lb. hay + 0.4 lb. of barley = 1.93 lb. of dry matter supplied by the ration

The feeder requires 1.8 lb. of dry matter each day. Although the ration is slightly over the dry matter required by the animal, the feeder is being "challenge" fed and in most cases will consume the ration offered.

Step 8: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

1.53 lb. hay ÷ (89%/100) = 1.72 lb. of hay fed each day

0.4 lb. of barley ÷ (89%/100) = 0.45 lb. of barley fed each day

Example Ration Four: Bucks – Pre-breeding Season

Bucks also require adequate nutrition to optimize productivity. Poor nutrition may result in poor fertility and reduced vigour. During most of the year, the nutrients necessary to keep bucks in moderate condition will come from pasture or harvested forage. Bucks should also be prevented from getting fat; an over-conditioned buck will be less efficient reproductively.

The buck should have a body condition score of 3.5 to 4 before the beginning of the breeding season.

Feeds Available Assumed dry matter (DM) of all = 89%				
Barley (48 lb. bushel weight)	CP = 12%	TDN = 82%	Ca = 0.09%	P = 0.40%
Hay alfalfa/ grass mix	CP = 15%	TDN = 60%	Ca = 0.80%	P = 0.30%
Grass hay	CP = 10%	TDN = 54%	Ca = 0.30%	P = 0.25%
Commercial vitamin/mineral premix				

Ram Daily Requirements Pre-Breeding Season		
Body weight = 220 lb.	Dry Matter Intake = 5.5 lb. per head per day	
% live weight = 2.5%	TDN = 2.93 lb.	
CP = 0.35 lb.	Ca = 0.0088 lb.	P = 0.0077 lb.

We will use the grass hay in this example.

Step 1: Calculate the amount of hay dry matter needed to meet the TDN requirement.

Divide the pounds of TDN required by the amount in the hay. We need to "remove" the percent from the TDN by first dividing by 100.

2.93 lb. of TDN ÷ (54%/100) = 1.6 ÷ 0.54 = 5.43 lb. of hay dry matter

Step 2: Calculate the amount of crude protein (CP) provided by the hay dry matter.

Multiply the percentage of protein in the hay by the number of pounds of hay dry matter. Again, "remove" the % by dividing by 100.

(10%/100) x 5.43 lb. = 0.10 x 9.63 = 0.543 lb. of CP

Step 3: Compare the crude protein requirement of the buck to the amount provided by the hay.

The buck requires 0.35 lb. of protein; the hay provides 0.543 lb. of crude protein.

The hay will provide more protein than the buck requires. Therefore the buck needs no further supplement to the hay to meet his protein needs.

Step 4: Compare the nutrient requirements for calcium and phosphorus to what the buck will receive from the hay.

Multiply the percent of the nutrient in the hay by the amount of the hay dry matter fed. Again, "remove" the percent.

(0.3%/100) Ca x 5.43 lb. = 0.016 lb. calcium (required = 0.0088 lb.)

(0.25%/100) P x 5.43 lb. = 0.0136 lb. phosphorus (required = 0.0077 lb.)

Step 5: Compare the amounts of calcium and phosphorus provided in the ration to the amounts required by the animal.

The hay provides more than enough calcium and enough phosphorus —the Ca:P ratio is 1.18 :1. In general, the ration should be between 1:1 and 2:1. You could add limestone in to increase the Ca:P ratio.

Step 6: Compare the amount of hay being fed to the amount of dry matter required each day.

The hay dry matter needed to meet the TDN requirement, 5.43 lb., is above the required DM requirement, 5.52 lb. You will probably want to feed slightly less hay and add about one half pound of grain or more to increase the energy in the ration particularly during the extremely cold winter months. **Remember to Body Condition Score**.

Step 7: Convert the dry matter of each feed to the actual amounts fed.

Divide the dry matter amount of each feed by the dry matter percent in each of the feeds.

5.43 lb. hay ÷ (89%/100) = 6.10 lb. of hay fed each day

The Problem with Assumptions

an editorial by Dr. Kathy Parker

The efficiency and effectiveness of any task can be measured in many ways. You may assume that the nutritional management of your flock is efficient because it only takes you 45 minutes to do chores. You may perceive that your feeding program is very effective because the groups have feed available all the time, they are full and there is little mortality. That is okay if that is how you choose to measure efficiency and effectiveness on your farm, but if you choose to judge effectiveness and efficiency by average daily gain, feed consumed per pound of gain, or cost per day of feed then you will have to measure things. How much do the animals weigh? Remember that you do not know what they need if you do not know how big they are. How many pounds of feed are being fed per day? How much does that bucket actually hold? And just how heavy are those round bales? Is that hay really as good as it looks? Making assumptions is a necessary part of any decision making process; while you cannot know everything, you can know something.

Let us use hay quality and quantity as an example. We will assume that each bale of the hay that you bought by the bale weighs 1200 pounds, and that the quality is average. If our assumptions are correct then our results based on those assumptions will be 100% correct.

But what happens when the bales actually weigh 1350 pounds and the quality is better than average? Suddenly your cost per tonne has dropped by 12 percent and the amount you need to feed per day to meet requirements has also dropped. Even if we only consider these two factors, your cost per day for feed has been significantly reduced. Where the wheels fall off is when the bales weigh only 1100 pounds and the quality is less than average. In this scenario the flock will be underfed and under-producing, although they will be full and mortality may not be excessive. It is not that these animals cannot be more productive and efficient; it is just that their potential is limited by the feed you supplied to them. In the end it is your choice; everybody's management style is different, but no matter who you are, you cannot manage what you do not measure.

Body Condition Scoring (BCS)

Body condition scoring is an important management practice used by producers as a tool to help optimize production, evaluate health, and assess nutritional status. This practice helps them evaluate their flock as to the amount of body reserves, particularly fat, an animal possesses. If body condition scoring is conducted at planned intervals throughout the production cycle, nutrition and management can be altered, if needed.

The most critical times to body condition score animals during the production cycle include pre-breeding, mid-gestation, parturition, and weaning. The practice of body condition scoring is used mainly to increase economic returns through increased reproductive performance and to realize more efficient feed costs.

Body condition scoring is done by palpation of the animal; this helps to avoid confusion brought on by coloured animals (think of the black dress) and when long hair or wool is present. Evaluators look at the amount of muscle and fat cover in eight important anatomical points when assigning a body condition score. Once the score is determined, it can be compared to a desired condition score at a particular period of the production cycle for a species. At this time, a producer determines the appropriate nutritional changes or management needed.

Body condition scoring is a subjective practice. Sheep and goats are scored from 1 to 5, with the lower the number, the thinner the animal. They are often assigned half numbers, 2.5 or 3.5, for example. Knowing how to body condition score is useful for assessing individual animals, as well as the herd or flock in general. Herd owners, veterinarians and nutritionists can make the proper adjustments to their feeding or health programs to reach the optimal body condition score for their animals.

To examine the animal, the person scoring must concentrate on the amount of muscle present, skeletal features, and fat cover in eight important anatomical points.

The animal should be standing in a relaxed position. It should not be tense, crushed by other animals or held in a crush. If the animal is tense the evaluator cannot feel the short ribs and get an accurate condition score.

Locate the last rib (the 13th). Using the balls of the fingers and thumb, try to feel the backbone with the thumb, and the end of the short ribs with the finger tips, immediately behind the last rib.

Feel the muscle and fat cover around the ends of the short ribs and over the backbone. Feel the fullness of the eye muscle.

The degree of roundness of the ends of the bones, the amount of tissue between the bones and the fullness of the eye muscle determine the condition or finish of the animal and the condition score.

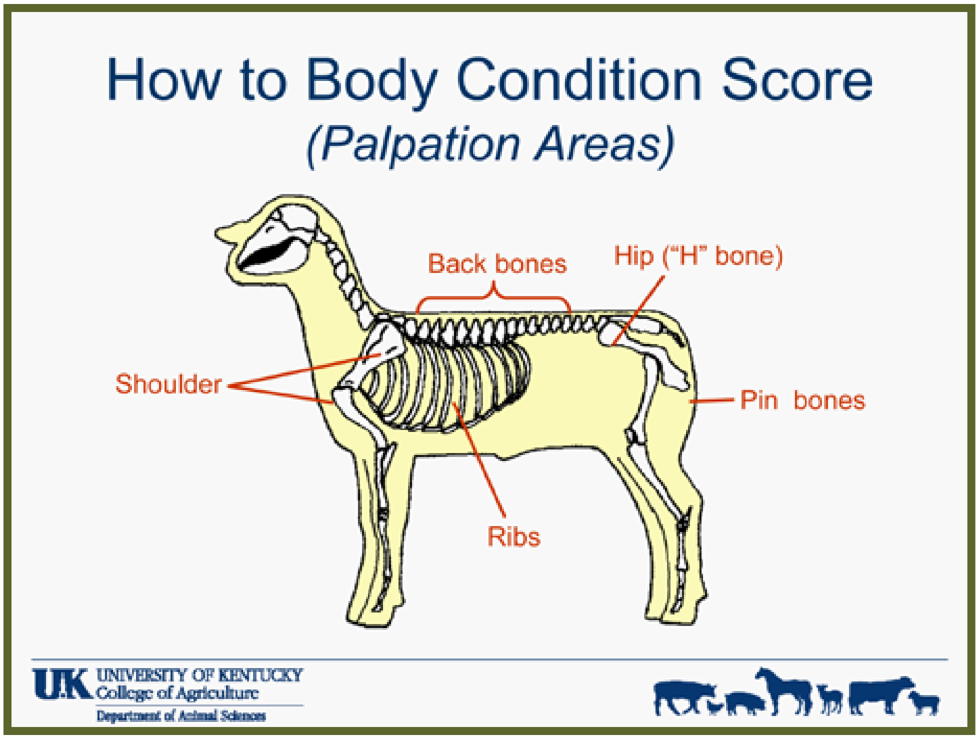
In addition, three factors must be considered when body condition scoring an animal:

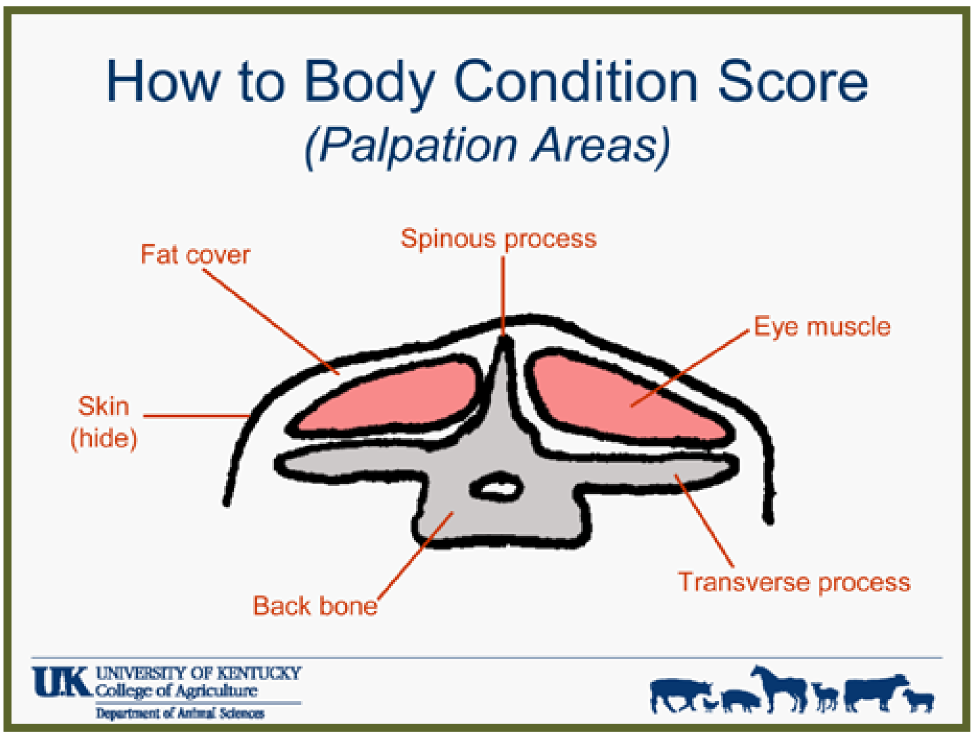
- Gut fill, including stage of pregnancy
- Amount of hair or wool
- Amount of muscle

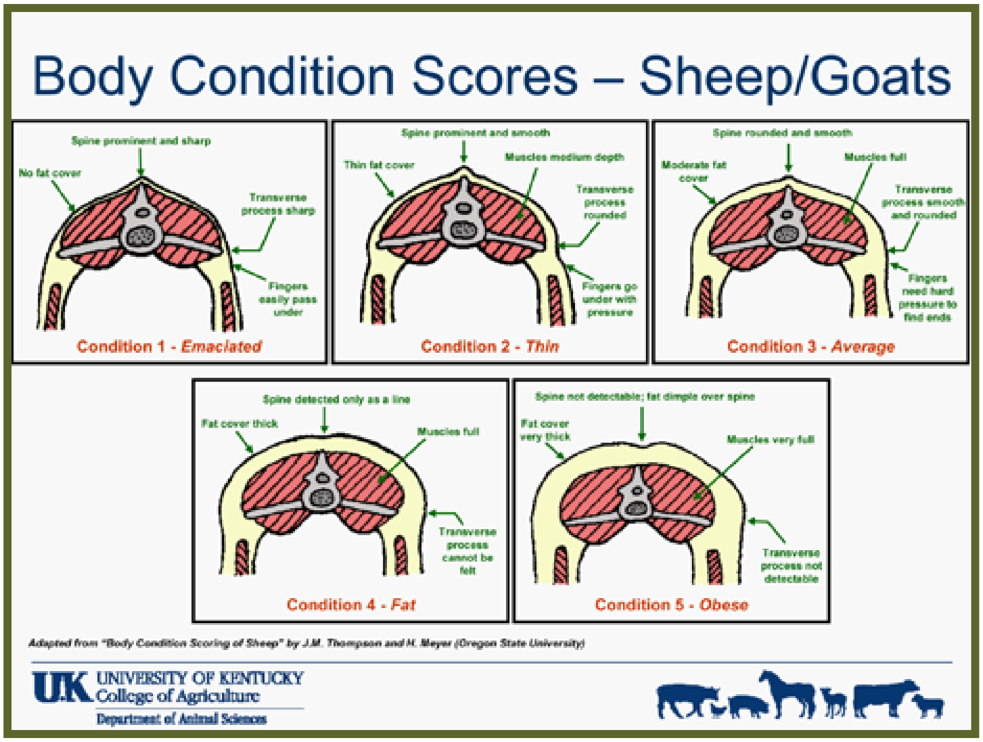
Gut fill (feed and water intake) and stage of pregnancy can influence the body condition score of an animal. Full and/or late gestation animals appear fatter and may mistakenly be scored higher, whereas animals that have very little gut fill may appear thinner and mistakenly be scored lower than their true body condition warrants. Heavily muscled animals typically appear more round, and this can be confused with smoothness due to fat deposition. Similarly, light-muscled animals can be mistakenly viewed as thin. To evaluate expression of muscle, look at the area through the center of the round (or hindquarter), which is least affected by fat. Animals with a lot of bulge and flair tend to be more heavily muscled. In contrast, animals that are angular tend to be lighter muscled.

Following pages:

1. Illustration: How to Body Condition Score (Palpation Areas)
2. Illustration: How to Body Condition Score (Palpation Areas) 2
3. Illustration: Body Condition Scores - Sheep/Goats
4. Condition Scoring Table


How to Body Condition Score
(Palpation Areas)
Back bones
Hip ("H" bone)
Shoulder
Pin bones
Ribs
UNIVERSITY OF KENTUCKY
College of Agriculture
Department of Animal Sciences


How to Body Condition Score
(Palpation Areas)
Fat cover
Spinous process
Eye muscle
Skin
(hide)
Back bone
Transverse process
UNIVERSITY OF KENTUCKY
College of Agriculture
Department of Animal Sciences



Score	Spinous process	Rib cage	Loin eye
BCS 1 Very thin	Easy to see and feel, sharp	Easy to feel and can feel under	No fat covering
BCS 2 Thin	Easy to feel, but smooth	Smooth, slightly rounded, need to use slight pressure to feel	Smooth, even fat cover
BCS 3 Good Condition	Smooth and rounded	Smooth, even feel	Smooth, even fat cover
BCS 4 Fat	Can feel with firm pressure, no points can be felt	Individual ribs can not be felt, but indent between ribs can still be felt	Thick fat
BCS 5 Obese	Smooth, no individual vertebrae can be felt	Individual ribs cannot be felt. No separation of ribs felt	Thick fat covering, may be lumpy and "jiggly"

Condition Scoring Table, from Body Condition Scoring, University of Kentucky

6. Working with the Feed Industry

Services the Feed Industry Does and Does Not Offer You

Canada has a very well established feed industry which plays a vital role in livestock production.

Many of the services provided by the feed industry are not readily obvious to most livestock producers:

- Feed companies source large quantities of commodity on the futures market at the best possible price.
- Feed companies test all commodities to verify their chemical analyses and to make sure they are free from moulds and mycotoxins. Most feed companies send all ingredients in for chemical analysis at least once a week and adjust their mill data base accordingly.
- Feed companies perform feed processing which would be very difficult to accomplish at the farm level. For example, pelleting, extruding, roasting, steam rolling, micronzing etc.
- Many feed companies will work with individual producers to set up payment packages that will reward those who keep their accounts current and paid. They will also work with producers who are experiencing financial stress to develop payment packages within the producers' means.

- Canadian feed companies work closely with the Canadian Food Inspection Agency to ensure our livestock feed industry is one of the safest in the world.
- Feed companies keep "retainer" samples of all feeds made for three to six months.
- Nutritionists at feed companies will study new ingredients and feed additives to determine if they will be of any benefit for their customers, either financially or from an animal health and welfare view point.
- Feed company nutritionists are constantly updating their knowledge by attending conferences and courses. Animal nutrition is a very dynamic field with new concepts being adopted regularly; this is particularly true in ruminant nutrition.
- Feed companies will run "best cost" linear programs to develop nutrition formulas that are cost effective but provide the proper nutrition for all species. Many feed companies will run three different lines of feed for a given species: one that is as inexpensive as possible, one that is middle-of the road, and one that is the "Cadillac" version of a feed with all of the bells and whistles.
- Most feed companies will work with consulting nutritionists to manufacture custom formulations.
- Some feed companies have their own forage testing labs. It imperative to make sure that the lab your feed company is using is certified.
- Progressive feed company representatives (feed reps) will visit farms regularly and make themselves acquainted with a producer's setup and goals.
- Feed reps will also perform the following services:
  Forage sampling and testing.
  Manure screening and scoring.
  Body condition scoring (BCS).
  Penn State shaker box test.
  Ration balancing.
  Book" feed for a given period, for example, three to six months at a set price. This is done only under specific circumstances.

The Penn State Shaker box test is a set of stacked boxes that are used by nutritionists to determine the eNDF (effective fibre) in a ration. http://www.das.psu.edu/dairy/nutrition/forages/tmr

- A progressive feed rep will communicate well with the producer's veterinarian and other services providers to ensure a "team" approach with all other consultants.

  There may be an advantage in submitting your forages through your feed company. Most feed companies negotiate discounts with forage testing labs because of the volume of samples they submit annually, so there may be a cost saving here.

  Make sure that the lab your feed company uses is independent and certified.

Tip
- many feed companies will tell you that they will test your forages for free. ***Nothing is ever free.*** *If you are not paying "up front" the charge will be hidden in your feed bill.*

What Are Your Legal Rights When You Are Dealing with The Feed Industry?

A feed company **must** supply you with a complete list of ingredients in a feed if such a request is made. However, they do not have to give you the exact weight of each ingredient; what they will do is list the ingredients starting with the largest and ending with the smallest.

Every time you purchase feed either in bags, bulk or in a tote, a CFIA standard tag **must** be supplied to you by your feed company (see next section).

There are certain guidelines outlined in the Canada Feed Act which specify the range nutrient specifications must fall in as guaranteed on the label. If you are concerned that what you purchased from your feed company is not what you received, have samples taken by a CFIA inspector for testing.

What Role Does The Canadian Food Inspection Agency (CFIA) Play in The Canadian Feed Industry?

The Canadian Food Inspection Agency is the federal body that overlooks the Canadian livestock industry and the agricultural industries that service them. Their duties are listed below.

The CFIA verifies that livestock feeds manufactured and sold in Canada or imported are safe, effective and labelled appropriately. Effective feeds contribute to the production and maintenance of healthy livestock.

Tip
- if you have a concern regarding a commercial feed product or commodity feed contact your local CFIA inspector to obtain a sample and have it sent to the appropriate lab for testing. If you take a sample yourself and further action is necessary, it is essential that the feed in question be tested properly by a third party.

CFIA activities include:

- Evaluating and approving ingredients for use in livestock feeds.
- Establishing standards and policies for the exemption of feeds from registration.
- Evaluating and registering specialty products of specific safety or efficacy concern.
- Monitoring feeds for the presence of residues of chemicals, pesticides, contamination by heavy metals, mycotoxins and salmonella, as well as verifying drug guarantees in feeds.
- Investigating both detections of feed related contamination of meat, milk or eggs and producer complaints.
- Reviewing labels of medicated feeds for compliance so that all applicable cautions and warnings are provided for safe use.
- Inspecting commercial feed mills and farms involved in the production of medicated feeds.

The key acts and regulations the CFIA enforces are:

- Feeds Act
- Feeds Regulations, 1983
- Schedule IV / Schedule V of the Feeds Act
- Health of Animals Act
- Health of Animals Regulations - Food for ruminants, livestock and poultry

Information the CFIA provides for feed and ingredient suppliers and the livestock sector includes:

Feed Ingredients:

- Approved feed ingredients
- Compendium of medicating ingredient brochures

- List of registered processing aids for rendering plants, blood processing, meat processing, and fish processing plants for use in the production of feeds
- Registration check-lists
- Feeds enhanced feed ban / specified risk material

Reading a Feed Label

Labels must conform to various regulations, and include various information regarding medications, weight, purpose, guaranteed analysis, where the ingredient list can be obtained, company name and address

A commercial feed in Canada is required to carry the following information:

Brand Name, if Any

This is an optional requirement. The brand name should be appropriate given the purpose of the feed and should not be misleading or constitute an implied claim (for example "Hoof Healer").

Feed Name

The feed name must reflect the purpose of the product and must not be misleading or make a claim. It must include the type of feed (for example, protein, supplement, complete feed or premix) and the intended species and class of livestock.

Feed Form

If the feed is medicated, the feed form if other than a mash (for example, pellet, crumble or extruded) must be indicated. If the feed is non-medicated, the form may be indicated.

Medication: Level and Claim

The name and actual amount of the medication(s) must be present as well as the applicable claim(s) in direct association with the feed name and must be at a level and for a purpose as set out in the Canadian Medicated Ingredient Bulletin (CMIB).

Added Selenium

The statement indicating the amount of added selenium is required to appear directly above the guaranteed analysis section. The added selenium level is not permitted in the guarantee section of the label as there is no way to differentiate between intrinsic and added selenium. Selenium is monitored closely by the CFIA because it is a heavy metal with environmental issues.

Guaranteed Analysis

There are three basic nutrients that must be on all labels:

1. If the product is intended to supply protein, minimum crude protein. If a source of non-protein nitrogen is used, the maximum amount of "equivalent protein from non-protein nitrogen" needs to appear.
2. Minimum crude fat.
3. Maximum crude fibre.

Depending on whether a feed is a protein blend, complete feed, supplement or premix the feed tags will be slightly different.

Protein blends need only the three basic guaranteed analyses listed above.

Complete feeds need to list minimum crude protein, equivalent protein from non-protein nitrogen, minimum crude fat, maximum crude fibre, sodium (actual), calcium (actual), phosphorus (actual) and vitamins A, D, and E (minimum).

Supplements must list minimum crude protein, equivalent protein from non-protein nitrogen, minimum crude fat, maximum crude fibre, sodium (actual), calcium (actual), phosphorus (actual), magnesium (actual), potassium (actual), sulphur (actual), iron (actual), zinc (actual), iodine (actual), copper actual, manganese (actual), cobalt (actual), fluorine (actual) and vitamins A, D, and E (minimum).

Premixes must list sodium (actual), calcium (actual), phosphorus (actual), magnesium (actual), potassium (actual), sulphur (actual), iron (actual), zinc (actual), iodine (actual), copper actual, manganese (actual), cobalt (actual), fluorine (actual) and vitamins A, D, and E (minimum).

Ingredient Statement

In Canada every feed tag has the statement "A list of ingredients used in this feed may be obtained from the manufacturer or registrant."

Feeding or Mixing Directions

Directions are expected to be fully explanatory. This section should indicate minimum and maximum amounts to feed.

If the product contains added selenium and is intended for lactating or dry dairy cattle, a table of maximum intakes for the product is required.

Measurements must be in metric but may be followed with imperial measurements.

If it is a macro-premix or a supplement it must have mixing directions for use with grains or other ingredients.

Warnings and Cautions

Warnings relate to human health hazards.

Cautions give any precautionary warnings such as those with medicated feeds like Lasalocid (Bovatec): "The safety of lasalocid in unapproved species has not been established." Another commonly seen warning is "Caution: Do Not Feed to Sheep" found on feeds with high levels of supplementary copper and "Caution: Use as Directed" seen on feeds with high levels of urea.

Notes

If required by the Medicated Ingredient Bulletin for medication level/ claim.

Prohibited Material Label

Since August 1997, Canadian feed companies have been prohibited from feeding ruminant derived meat and bone meal back to ruminants, including sheep and goats. This rule was put in place to reduce the incidence of new Bovine Spongiform Encephalopathy (BSE) in Canada.

Any labels of feeds for horses, swine, poultry or game birds that contain “prohibited material” must bear the required statement “do not feed to cattle sheep, deer or other ruminants.”

Manufacturer’s or Distributor’s Name

The name and address of the company selling the feed must be on the tag.

Net Weight of Unit

Net weight refers to bag weight (25 kg) or bulk amount (1000 kg).

ID Code

Micro-premixes and milk replacers must be labelled with an identification code.

Registration Number

Certain livestock feeds must have a registration number and this must be listed on the tag.

Your Obligations when You Are Working with Purchased Feeds

Maintaining a safe livestock industry is not just the responsibility of the feed industry and the CFIA; producers play a large role too.

With the discovery of Bovine Spongiform Encephalopathy (BSE) in a beef cow in 2003, the protocol around manufacturing and handling animals feeds and ingredients has received a great deal of attention.

Within the feed industry, companies have been prohibited from feeding ruminant derived meat and bone meal back to ruminants, including sheep and goats. Unfortunately, this does not prevent individual producers from feeding feeds intended for monogastrics to ruminants. This is an extremely dangerous practice and only puts Canadians and the Canadian livestock industry at risk.

All feed should be clearly labelled and instructions on which feed should be fed to which animals clearly laid out, particularly if there are multiple feeders. Develop written protocols for on-farm mixing of feed, including record keeping, feed errors and flushing of feed equipment.

Do not forget that dogs and cats are monogastric animals and their commercially prepared foods could be risky for small ruminants.

Many producers originating from Europe have chosen to request absolutely no animal proteins in their feeds due to their experiences with BSE in Europe.

Apart from the BSE issue, feeding feeds designed for one species to another species has other inherent risks, particularly in sheep and goats.

Probably the best known of these is sheep's sensitivity to copper; most breeds of goats are much more tolerant to copper than sheep and cattle are more tolerant yet.

Feeding a medicated feed to one group of animals when it was medicated for another can have disastrous results, as can feeding young ruminants feeds that contain non-protein nitrogen.

Clearly, it is incumbent upon all livestock producers to use all livestock feeds wisely—to protect themselves, their industry and the consuming public.

7. Feed Cost of Production

To gain an accurate picture of your costs, you should monitor feed use, animal numbers, and your income every month. You can also monitor feed inventories and all these numbers will not only give you what you need to calculate feed costs, but will enable you to plan your feed requirements for the next cropping season.

Do not lie to yourself. Price all ingredients accurately, including your home grown forages; update ingredient prices regularly. Remember, most feed ingredients are priced on the commodity market: when grain prices go up, by-product feeds such as distillers grains follow; if oilseed values go up, protein meals will not be far behind.

There are really no good feed-costing guides out there. Many progressive producers track feed and production costs, but there is little consistency in their methods of calculation. This, along with differences in feed quality and input prices, make it very difficult to compare productivity and costs between farms.

If you have trouble estimating your current feed costs, why not ask your local agricultural office, banker or accountant for some help? They should have the skills to develop a comprehensive spreadsheet that you can maintain to come up with the final figures.

Until you have a handle on what your feed costs of production really are, you have little hope of reducing them.

Getting the most for your feed buck often involves fine-tuning herd management, not just seeking cheap feeds.

- ***Cull the losers.*** Of all the changes that should be made, culling unprofitable animals should be first on the list. Many producers keep losers around in the hope that they will do better. With high feed costs, keeping break-even animals around is a luxury nobody can afford.

  Remember the higher producing animals are the ones that save you money because the cost of nutrients for body maintenance per kilogram "product" (whether that be milk, meat, offspring or fibre) goes down as production goes up.

  In simpler terms, it would pay you to feed a smaller flock or herd of high producers than a larger flock or herd with a group of losers.

- ***Feeding fewer nutrients can be costly.*** Be sure that you know what it costs in lost production before you make the choice to intentionally reduce the nutrient density in your flock's ration. Often, the cost of lost production far exceeds any savings in feed.

- ***Feed additives are there for a reason.*** When feed costs rise, some of the first ingredients to get tossed are additives going into the ration, such as buffers, yeast cultures, niacin and chelates. A feed additive is in a ration because we have determined it has a beneficial effect on production, animal health or both. In addition, that additive must be offering us a cost return, be it in higher milk or milk components, better feed efficiency, or lower vet bills.

  With this in mind, can you afford to remove the additive? If all of the previous criteria have been met, the answer would obviously be no.

- ***There are other ways to reduce feed costs:***
  - Feed leftovers to the young stock groups
  - Ensure that there is feed and fresh water available to the does/ewes 24 hours a day.
  - Clean the mangers daily.
  - Make sure that the farm's "feeder" is extremely reliable and uses accurate scales.

Tip
- your ability to reduce feed costs will be directly related to your ability to produce and make the best use of forages grown for the specific production group.

- Run dry matter tests on all wet ingredients once a week to ensure that you are not under-feeding or over-feeding.
- Analyze all forages; feed a well-balanced ration.

You can reduce the loss in production due to poor-quality forages by formulating rations with higher supplement levels, but it is unlikely that you will regain 100 percent of lost production because of the reduction in dry matter intake. The lower the quality of your forages, the longer it remains in the ruminant digestive tract, which in turn leads to depressed dry matter intake and a decrease in animal productivity. In addition, you can be guaranteed that your feed costs will be considerably higher.

Forage quality is an important management tool. Those who produce and feed high-quality forages are rewarded with increased animal performance, reduced feed costs, and a rising return on the time and money they invest in this critical feed ingredient.

It is not enough to grow quality forages; you must also preserve that quality by harvesting the plants at their optimum maturity; this is especially critical with alfalfa, to gain top productivity.

8. Bunk Management

How you feed small ruminants is just as important as **what** you feed them. There are many different feeding systems in Canada:

- Component or individual ingredients fed separately.
- Total mixed rations (TMR); this will be found mainly in large commercial operations.
- Computer feeders.

Regardless of the system used, some factors are fundamental to managing the way animals are fed:

- Ideally, feed should be available to 24 hours a day.
- It is **critical** that feed bunks etc. are kept clean! If you had to eat breakfast, lunch and dinner off of the same plate and it was never washed, it would have a huge impact on your desire to eat.
- Never add fresh feed on top of old feed.
- Feeding areas should be designed such that animals cannot defecate or urinate into or on them.
- TMR's should contain 48 to 52% dry matter. Many producers add water or wet brewers grains to moisten TMRs.
- The feeding surface of bunks can have a huge impact on DMI; rough cement and splintered wood can impact on DMI and reduce animal production significantly. Surfaces should be tiled or painted with an epoxy like substance.
- All animals should have adequate bunk space available at all times. How much will be dependant on the size of the animals in question.
- Refused feed should be weighed and monitored for its content (it should resemble the original feed). The amount of refused feed

should be approximately two to four percent of the total amount of feed fed out.

- Frequent feedings decrease fluctuations in rumen pH, stabilize the rumen environment and improve DMI.
- Frequent feeding maintains fresher, more palatable feed, particularly in the summer months.
- In Canada, most TMR feeders feed out twice a day.

The Six Most Common Mistakes of New TMR Mixers

As sheep flocks and goat herds become larger, many producers will convert to feeding their animals using TMRs. This type of system was adopted by the dairy and beef industry about 30 years ago and has been extremely successful in fine tuning nutrition, allowing the use of commodities and maximizing production.

That is not to say that TMR feeding is not without its challenges, particularly if a producer is new to the TMR feeding system.

Mixing Times

Most mixers call for three to 10 minutes of mixing time after all ingredients have been added. Over mixing will cause separation of ingredients (especially if the mix is dry) and reduced forage particle size and will pulverize the feed, leading to digestive upset.

Moisture Testing

TMR programs force animals to eat a specific amount of forage. This has its obvious advantages, but it also has disadvantages; the disadvantage can occur if the moisture content of the forage is not watched constantly.

For example, if the TMR calls for 2.27 kg of haylage at 50% moisture, this provides 1.14 kg of dry matter. But, if the moisture of the haylage changes to 60 percent, this would provide 0.91 kg of dry matter. This would leave the ration considerably deficient in fibre.

Producers who are most successful with TMRs check moisture of wet silage and wet commodities about once a week. Some large operations test dry matter daily.

Free Choice Forage

Feeding hay separately can cause more problems than it prevents. The problem occurs when animals are given a choice between the TMR and baled hay. In order to meet fibre requirements, animals must consume specified amounts of baled hay. If an animal does not eat any hay, its ration will consist entirely of the TMR. This TMR probably contains 16 to 17% ADF, so once again we are in an acidosis-prone situation. If an animal over-consumes hay and does not eat its TMR, it is short-changing itself in terms of proteins and dense energy feeds.

Topdressing

Topdressing can have its place with some TMRs but there must be excellent communication between the nutritionist and the producer.

New TMR users are reluctant to believe an animal can get all the corn or protein she needs out of the TMR. Therefore, they have a tendency to overdo the top-dress. Once again, the TMR becomes unbalanced and the forage-to-concentrate ratio actually consumed is not what is listed on the ration report. To avoid these problems, top-dress only the amount called for on the ration report.

Changing Batch Size

This mistake usually begins when animals do not eat the amount of feed listed on the ration report. The producer decides that corn and protein are the most important and makes sure the animals get all of the corn and protein called for; he then cuts back on forage. This is possibly the biggest "no-no" for TMR users.

The greatest advantage of a balanced TMR is that every bite contains the correct amounts of forage and concentrates. If the animals are not eating the projected amount, never cut back on one ingredient. Keep everything in the same ratio and cut back on the total pounds of TMR fed. Have your nutritionist reformulate your ration so it is closer to actual consumption.

Mixing Errors

Errors in mixing cause the bunk ration to be different from the formulated ration. A good way to stay on top of the mixing errors is to take samples of the TMR routinely as it leaves the mixer. The analysis of these samples should be close to what is listed on the ration report. Taking samples toward the beginning, middle and end of the TMR load-out helps you check on separation during mixing and unloading.

Avoid mixing errors by occasionally verifying the accuracy of your scale by weighing an object of known weight such as a feedbag. Also, resist the temptation to take a shortcut and skip using the scale on some ingredients.

Ad Lib Feeding

Ad lib, or free choice, feeding of forages, particularly hay, is generally acceptable.

Corn silage as a free choice feed can lead to over-conditioning and should be monitored carefully.

The same is true for the grains, specifically corn and barley. In addition, the over-consumption of grain can lead to acidosis. Barley is particularly soluble in the rumen and should be introduced carefully and never fed free choice; the same holds true for wheat.

It would be rare to see producers feed protein supplements free choice; they are expensive and such a feeding regime would be extremely wasteful and inefficient.

Many producers feed vitamins and minerals free choice. This has the advantage of being easy to manage but also has drawbacks. Free choice vitamins and minerals will be consumed readily by some animals and not at all by others. It is better to feed vitamins and minerals mixed in with grains, proteins or silages, to ensure all animals receive a minimum amount.

Providing free choice salt licks (white, containing iodine; blue containing iodine and cobalt; or red containing trace amounts of minerals) is acceptable and often recommended.

Feeding premixes high in calcium is **not** recommended in specific production groups due to the opportunity for urinary calculi to form.

Free choice sodium bicarbonate can be offered, but **not** to ewes and does approaching the end of their gestation, due to its cationic properties and the potential for hypocalcaemia.

Of course, if the **wrong** premix is fed ad lib, for example a cattle premix, the results could be disastrous.

9. Nutritional/Metabolic Diseases in Sheep and Goats

Nutritional diseases of small ruminants are diseases associated with both forage and concentrate consumption and are often related to deficiencies or toxicities.

Metabolic diseases of sheep and goats are caused by productivity practices where the body reserves of certain nutrients such as calcium, magnesium or energy cannot meet the metabolic needs.

These diseases are very important in situations involving high producing animals, for example in animals kept for milk production.

The difference between production-related metabolic diseases and nutritional deficiencies is often subtle. Typically, nutritional deficiencies are long-term conditions that can be corrected through dietary supplementation. Metabolic diseases are generally rapid onset in nature and dramatically respond to the administration of the deficient nutrient, although affected animals may require subsequent dietary supplementation to avoid recurrence. An important aspect of dealing with production-induced metabolic diseases is accurate and rapid diagnosis.

In sheep and goats, nutritional/metabolic diseases include enterotoxemia, urinary calculi, ketosis, and copper toxicity. All these can produce an acute, temporary, but potentially fatal deficiency. Correcting the diet for animals during particularly nutritionally stressful periods, such as from late pregnancy to peak lactation, is crucial in preventing these diseases. If these diseases occur frequently, it is essential to seek professional veterinary and nutritional advice.

The following metabolic diseases do not represent all of the nutritional/metabolic diseases that can occur in sheep and goats but are rather a selection of the more common ones.

Bloat

Bloat occurs when rumen gas production exceeds the rate of gas elimination. Gas then accumulates causing distension of the rumen. Bloat can be a medical emergency, and timely intervention may be necessary to prevent losses. It is a common cause of sudden death.

Bloat is usually results from nutritional causes. There are two types of bloat: frothy and free gas:

1. **Frothy Bloat**: commonly called pasture bloat, is usually associated with the consumption of lush legumes such as alfalfa, but may also occur in sheep and goats grazing lush cereal grain pastures or wet grass pastures or consuming grain that is too finely ground. Animals with frothy bloat can be treated with anti-foaming agents such as cooking oil, mineral oil or various commercial products.
2. **Free Gas Bloat**: commonly called feed lot bloat, is associated with grain feeding and occurs when animals are not given enough of an adjustment period after feed is changed. Many of the same factors causing acidosis are associated with free-gas bloat. Simple passage of a stomach tube may be effective in relieving free gas bloat.

The signs of bloat are:

1. Rumen extended and tight (the rumen, the first stomach which is involved in the cud regurgitation and storage processes, is located on the left side of the goat's or sheep's abdomen).
2. Off feed.
3. Standing around.
4. Head down.
5. Depression.
6. Not belching—if you listen, goats and sheep belch quite a bit.
7. Not chewing cud.
8. Normal rumen sounds absent (gurgling gastric sounds).
9. Grinding teeth.

Late stages of bloat signs:

1. Small ruminant in extreme distress.
2. Loud crying.
3. Gasping for air.
4. Darkened (blue) tongue.
5. Sheep or goat down.

Why does bloat kill and kill quickly? The rumen expands to the point that it compresses the abdominal blood vessels, the heart, and the lungs. Too much gas, produced too quickly, can compress the esophagus, preventing normal belching; death typically occurs from respiratory failure.

Copper Toxicity and Deficiency

Sheep

Copper is a required mineral for all farm animals and is also potentially toxic to all of the food-producing animals. Sheep are the most susceptible of all food-producing animals to copper toxicosis.

Further, the copper status of sheep is influenced by the breed or crosses of breeds, the age and health status of the animal, the levels of other minerals consumed, and even the levels of some feed additives in the diet.

The presence or absence in the diet of sheep of other minerals and some ionophores (monensin, lasalocid used as an anti-coccidial) affects the copper metabolism of sheep.

The levels of molybdenum and sulphur in the diet are of particular significance as they act as antagonists to copper These compounds bind with copper and prevent gut absorption and increase excretion of absorbed copper in the liver and body tissues. Molybdenum is often added to sheep diets to try to help prevent copper toxicity. However, molybdenum added at too high of levels can actually result in sheep having a copper deficiency.

Sheep absorb copper from the diet in proportion to the amount of copper offered, not to the body's need as with the absorption of other minerals. Any excess absorbed copper is stored in the cells of the liver, eventually reaching toxic levels. Levels in the liver above 500 ppm dry weight are usually considered toxic. This storage in the liver can take months or even years to reach a toxic level; further, the elimination of copper from the body through the kidneys is slow. This is the chronic form of copper toxicity in sheep. The acute form of copper toxicity occurs quickly, shortly after ingestion of high amounts of copper.

To be released from the liver, copper needs a "stress." This stress can be weather, poor nutrition, transportation or handling. The liver cells rupture, releasing copper into the blood stream. There are suggestions that excess liver copper can cause death and rupture of liver cells. Once the copper is in the blood stream in sufficient concentration, it causes haemolysis, or in other words, a breakdown of the red blood cells. Up to 60 percent of the RBCs circulating in the blood can be damaged. Their haemoglobin is released into the blood serum to be converted to methaemoglobin, a form of haemoglobin that cannot carry oxygen to the tissues. A sheep at this point is anaemic, with very pale mucous membranes, and lethargic. The visible membranes rapidly yellow as jaundice sets in throughout the body.

Prevention and Treatment

Prevention of copper toxicity is the most practical method of dealing with copper toxicity. There are a number of strategies that can be used; they entail trying to decrease intake or absorption or copper and include:

1. Do not feed swine, cattle, horse or poultry feed to sheep; they contain high levels of copper by design.
2. Communicate with feed company representatives that are supplying feed. It is important that mixers and augers are clean, and that feed delivery trucks are cleaned before being loaded with sheep feeds, especially if the company mixes and handles swine feeds.
3. Test feeds and forages for levels of copper, molybdenum and sulphur, particularly if you are in an area known for deficiencies or high levels in any of these elements.
4. Avoid grazing sheep on pastures where swine or poultry waste is applied.
5. Consider adding molybdenum to the diet at a rate of three ppm.
6. Have post mortems done on dead animals; this is a good routine management practice.

Treatment of sheep with copper toxicity should be done under the advice of a veterinarian; prevention is the best course of action.

What Should You Be Looking for in a Sheep Premix?

How do you choose one? The following is a list of items to consider when comparing supplements in order to choose the right one for your situation:

1. **Mineral Content**: take a look at the guaranteed analysis located on the tag to find what minerals are guaranteed to be present and in what amounts. Also consider the amount of desired consumption when comparing mineral concentrations. A product designed to be consumed at a rate of 14 grams per head per day needs to be twice as concentrated as a product designed for a consumption rate of 28 grams per head per day. Be sure to compare "apples to apples" when looking at mineral tags side by side.

2. **Mineral Form**: it does the animal no good if we provide minerals in a form that it cannot utilize. Ask your feed company for a list of the ingredients present in the premix.

   As a general rule of thumb, the sulphate forms of most minerals are more bio-available than the oxide or chloride forms. Therefore, as an example, zinc sulphate would be more desirable than zinc oxide on the list of ingredients; however there are exceptions. For instance, magnesium oxide is a highly available form of magnesium. As the bioavailability of the mineral decreases, the total amount of mineral needed increases.

3. **Palatability**: are there ingredients included which would increase palatability like molasses, salt or fat? Many minerals are bitter and unpalatable to sheep in their natural forms, especially magnesium, and need to be mixed with other ingredients that encourage consumption.

   Added flavourings is of little help in encouraging consumption. They are usually included in a feed for the benefit of the human handling the feed; in addition they wear off quickly.

   When utilizing complete mineral supplements it is important to remove all other forms of salt unless the label specifically states otherwise. This is because salt is used to encourage consumption and if the sheep obtain salt from other sources, they will not receive the desired levels of essential minerals and vitamins provided by the complete supplement.

Another factor affecting consumption is block hardness. Is the block so hard that the animals cannot consume the desired amount? Hardness is often used to regulate consumption in mineral blocks. Blocks can become harder when exposed to high heat or stored for an extended period. An opposite problem is over-consumption of mineral supplements. Is the mineral supplement block in question too soft so that sheep are eating too much?

Be sure to periodically check the consumption rate per head per day after a period of acclimation (one to two weeks) to make sure that sheep are eating proper amounts of supplement. Wait for a few weeks, because it is not unusual for over-consumption to occur when minerals are first offered after a long absence without them. Sheep will typically consume from 15 to 50 grams of mineral supplement depending on the product (always read and follow label directions). If they are not consuming recommended levels, either make management adjustments or consider another mineral product.

4. **Weather Resistance**: how weather resistant is your mineral choice? Will it dissolve in rain or snow? Will it blow out of feeders on windy days? Wastage can be a large production cost that must be considered.
5. **Feeding System**: what is your current feeding system? Would loose minerals or blocks be the best choice? What feeding equipment do you have available? Do you need something that you can put out for weeks at a time or are more frequent checks not a problem?

Goats

The exact amount of copper required in the goat's diet is currently unknown and is dependent upon several factors, including the breed. However, the goat needs far more dietary copper than was originally thought. Testing can reveal enough copper in tissue or blood samples and the goat can still be copper deficient. This is due to the complex interaction of minerals in the goat's metabolic system. Copper is essential in the proper development of the central nervous system, correct bone growth, and hair pigmentation. Copper-deficient goats have difficulty conceiving kids and, if they are bred, abortions are not uncommon. Copper supplementation can sometimes help but it cannot always eliminate these health problems.

Copper deficiency can be the result of low levels of the mineral in the soil and in forages raised on the soil; this is primary copper deficiency. However, both the feed and the soil can have adequate copper but its absorption can still be interfered with by minerals known as copper antagonists: lead, iron, manganese, various sulphates, cadmium, and molybdenum. This is secondary copper deficiency.

Congenital copper deficiency is the term used to describe the kid who did not receive sufficient copper in utero. Often born swaybacked, the kid stands unsteadily or cannot stand, displays muscle tremors and head shaking, and may grind its teeth. The kid can see, hear, and can sometimes nurse, but it has low blood sugar (hypoglycemia) and subnormal body temperature (hypothermic). Bone abnormalities are common, particularly in the long (leg and back) bones of the body. Complete recovery from congenital copper deficiency does not often happen because problems that occurred during fetal development may not be correctable. With intensive nursing, swaybacked kids may survive for days or weeks, but they usually do not live long.

Insufficient weight gain, poor appetite, and weight loss are seen in copper-deficient goats of growing age. Adults display more subtle signs of copper deficiency. They are generally unthrifty, anemic, poor milk producers, and sometimes have diarrhea. But the most visible sign of copper deficiency in adults is loss of hair color. Copper is essential for melanin production that causes hair pigmentation; hair discoloration may occur when the copper-containing enzyme is missing.

The steps to prevent copper toxicity/deficiencies in goats are the same as those listed for sheep above.

What Should You Be Looking for in a Goat Premix?

For years goat producers have had to make do with available mineral supplements since very few, if any, goat-specific products were available. Most went through a phase of feeding sheep and goat minerals but then quit after copper deficiency problems or warnings from fellow goat producers. After that, the next logical progression was to use cattle or horse mineral.

Relatively speaking, the mineral needs of goats are similar to that of cattle, with some variation across breeds. Both species require the same minerals in roughly the same proportions. As an example, a 450 kg beef cow requires roughly 10 to 40 grams of calcium per day and a 90 kg meat doe requires roughly 0.5 to 25 grams of calcium per day. The cow requires roughly 30 to 90 mg of copper and the doe requires roughly 25 to 55 mg of copper.

As you can see, they have similar needs. However, **the key difference is that cattle consume a much greater amount** (averaging 50 to 225 grams of mineral supplement per head per day) than goats (seven to 28 grams of mineral supplement per head per day). Even though the mineral requirements of cattle and goats are very similar, the expected intake of supplement of each is drastically different. Because goats eat so much less than cattle, they need a much more concentrated mineral supplement than cattle.

Most cattle supplements are designed for 50 to 225 grams consumption rates, depending on the type of supplement (for example, loose mineral, cooked block, pressed block). Conversely, a goat can be expected to consume from nine to 28 grams of mineral supplement, depending on the size, breed and mineral nutrition status of the goat. A doe cannot be expected to consume as much as a cow and therefore her mineral must be much more concentrated than that of a cow.

Enterotoxemia

Enterotoxemia is one of the most common and costly disease problems in the sheep and goat industry worldwide. Preventative measures are generally recommended over treatment.

Enterotoxemia, also known as "overeating disease" or "pulpy kidney" disease, is caused by two bacteria, *Clostridium perfringins* Types C and D. These bacteria are normal inhabitants of the intestinal tract of small ruminants and do not usually cause a problem. However, there are certain conditions which trigger excessive bacterial growth in which lethal amounts of toxin are produced, resulting in death of the animal.

Enterotoxemia is most commonly associated with heavy concentrate feeding or an abrupt change in the diet, usually to a better feed. Feeding concentrate before forage can also cause enterotoxemia.

The rumen micro-flora can only handle gradual changes in forage to grain ratio. If the proportion, quantity or type of grain changes too quickly, then lactic acidosis will develop. This lowers the pH of the rumen, and when the pH drops below 5.5, protozoa and bacteria start to die. The lactic acid is then absorbed into the body, creating general acidosis. If the pH is low enough, the rumen gets "burned" and if the animal survives, it often gets secondary rumen and liver infections from bacteria or fungi. Fibre (for example, hay or silage) is important in all ruminant diets as well, as it stimulates the animal to chew, thus producing alkaline saliva which serves to buffer the rumen. Animals eating diets with little fibre or chopped too finely are more at risk of lactic acidosis.

Simple indigestion may be the first indication of a feeding problem. The animal backs off its feed, usually only for one feeding. If the lack of appetite lasts longer than 24 hours then something else is wrong.

Chronic feeding problems will appear as:

- Variable appetite.
- Chronic laminitis is identified by fast growing toes with "rings;" the quality of the horn is poor and flaky; animals will be lame and prone to foot abscesses.
- Milk fat is depressed because fibre is necessary for the rumen flora to produce the correct volatile fatty acid to make milk fat (acetate).

With severe lactic acidosis, the protozoa die, the rumen becomes static and the animal becomes depressed and dehydrated. Diarrhea smells acidic and is yellow in colour. In very severe cases, there is no diarrhea because of total gut stasis. The goat may appear "drunk" and ataxic. It will go down and present symptoms which look very similar to milk fever, such as lowered body temperature and dilated pupils.

Animals with enterotoxemia are frequently found dead, without symptoms. Unfortunately it is often the most aggressive, productive animals that are affected.

In severe cases, treatment is heroic and may involve a rumenotomy in which the rumen is surgically emptied out and the rumen contents from healthy animals are put in. Supportive therapy includes IV fluids, alkalinizing solutions for the rumen (only done with caution), antibiotics and nursing care.

Fortunately, there is an effective, inexpensive vaccine to control the disease; talk to your veterinarian.

Management which will aid in prevention of the disease:

1. Rations should be formulated and balanced correctly for the correct production group.
2. Avoid sudden changes to the diet. There should be a gradual transition of two to three weeks when going from roughage to a highly concentrated ration.
3. Forage should be fed before grain.
4. Feed at regular intervals.
5. Divide the daily feed into at least three separate feedings.
6. Mix rations properly.
7. Providing adequate feeder space.
8. A total mixed ration (TMR) helps keep the rumen flora happy by not overwhelming them with carbohydrate at any one time.
9. For small holders with a few animals, grain security is an important issue.

Feeding for Fertility

The relationship between nutrition and reproduction is a topic of concern among producers, nutritionists and veterinarians alike.

Early research confirmed that nutrition played an important role in reproduction, but in most cases severe nutritional deficiencies were required to cause reproductive problems. Therefore, nutritional recommendations have been based on production only, assuming that reproduction will follow along.

Today, however, it is accepted that nutrition programs and management are highly implicated in the occurrence of breeding problems in all ruminants.

In a given production year we ask the following of every ewe and doe:

- That she give birth to live, viable, multiple lambs or kids
- That she remain healthy during the transition period and beyond
- That she maintains high peak milk production with good components
- That her loss of body condition is controlled
- That she has high fertility at first breeding

Achieving reproductive efficiency through nutrition and feeding management involves:

- Dry and transition nutrition and management
- Body condition (BCS) monitoring
- Bunk management to maximize dry matter intake
- Proper protein nutrition
- Mineral and vitamin balancing

BCS and Reproduction

In Canada we use the 1 to 5 scale, with 1 being emaciated and 5 being obese. (Refer to *Body Condition Score* in Chapter 5.)

Flock energy status impacts:

- Health of the lambs and kids
- Milk production
- Dry matter intake (DMI)
- Reproduction
- Health of the ewe or doe

Ewes and Does before Parturition

A good pre-partum management system will:

- Provide nutrition for the developing fetus
- Maintain proper BCS
- Prepare the digestive tract (rumen) for the next lactation
- Improve feeding for fertility
- Heal and prepare the udder for the next lactation
- Reduce metabolic, infectious, and reproductive disorders
- Improve future reproductive efficiency

Maintaining a positive energy balance is critical to the dry ewe or doe.

As small ruminants approach parturition they have a high energy demand related to fetal needs, colostrum production and mammary gland draw; DMI drops up to 30 percent; depressed feed intake puts the animal at risk for a number of metabolic disorders.

Ewes and does which develop metabolic disorders at or around parturition are significantly more likely to:

- Develop secondary disorders during the next lactation
- Have lower production and impaired fertility when compared to animals that are problem free

Milk fever is a significant risk factor for several other disorders, including retained placenta and mastitis.

Subclinical milk fever and/or ketosis or a combination of the two can impact enormously on an animal's reproductive efficiency.

Older, higher producing animals are most susceptible to milk fever/ketosis; the economic impact can be significant in terms of both lost production and loss due to premature culling.

At the barn level:

- Strive for the optimum BCS at drying off.
- Limit calcium and phosphorus during the close up dry phase.
- Avoid or limit legume forages due to their high calcium and potassium levels.
- Balance anion and cations in the ration and use anionic salts if necessary (always measure urine pH).
- Supplement vitamins A, D and E in the pre-partum ration.
- If oral supplementation is not guaranteed, inject vitamins A, D and E plus selenium.
- For "at risk" animals, calcium and/or sugar products are administered either as a drench, IM or IV.

- Monitor the "fresh" animals to make sure they have vigorous appetites.
- Watch for depressed animals that may be suffering from sub-clinical milk fever, ketosis and other disorders.
- Record body temperatures to get an early start on animals that may be suffering from metritis or other infections.
- Observe uterine discharge for odours and physical condition.

Protein Nutrition and Reproduction

The effect of protein nutrition on reproduction is still not completely clear. In the last decade, the *Degradable Protein System* was adopted for diet formulation for dairy cows. The objective of this system is to provide sufficient soluble/degradable protein to maximize rumen microbial fermentation and growth with undegraded intake protein supplying amino acids to the small intestine above microbial supply.

This balance of protein types would prevent excess ammonia production in the rumen which leads to elevated blood urea nitrogen (BUN) levels. Increased BUN (blood urea nitrogen) or MUN (milk urea nitrogen) levels creates a "toxic" environment around the reproductive tract.

The result is decreased viability of the sperm cells, the ovulated egg and the embryo itself. Decreased fertility results, with increased numbers of services required to produce conception, and increased days open.

What you see at the barn level are animals considered pregnant coming back into heat some weeks later. This can happen with AI and natural service flocks. It can happen in confinement or on pasture, particularly rich, alfalfa pasture.

For lactating ewes and does, guidelines for the proper balance of protein types have been extrapolated from dairy cow nutrition, (more work needs to be done on this for ewes and does).

Presently, the guidelines for the proper balance of protein types in lactating ewes and does are:

- Sixty to sixty-five percent of the dietary crude protein should be degradable crude protein.
- Of the degradable protein, forty to sixty percent should be soluble crude protein.
- Thirty-five to forty percent of the diet protein should be undegradable intake protein.

Minerals, Vitamins and Reproduction

Micronutrients, minerals and vitamins, are also important in achieving efficiency and profitable levels of production. There has been a trend to over-supplement some trace minerals; this can lead to toxicities (liver damage) and deficiencies of other trace minerals competing for receptor sites in the gut. It is essential that all vitamins and minerals be supplemented at a good but not toxic level.

Two micro-minerals associated with enhancing reproductive performance are zinc and selenium. Both are involved with membrane integrity and influence udder and the reproductive tract health. In this way they enhance the uterine environment and support increased fertility.

Selenium and vitamin E work together to decrease the incidence of retained placenta (RP) and metritis and increase the rate of uterine involution.

The water soluble vitamins niacin, biotin and choline are usually manufactured in the rumen. However, in high production animals this synthesis may not be adequate. Of late, rumen protected products have been available and are getting very favourable reviews.

Niacin, part of many metabolic pathways, helps over-conditioned animals which are prone to many metabolic diseases.

Biotin has been very successful in aiding membrane integrity at the hoof level, resulting in healthier hooves.

Choline is involved in the smooth transition from the dry phase to the milking phase.

Other Considerations on Herd Fertility

- Moulds and mycotoxins in feed. There is no place for mouldy feed on the modern farm.
- **Stress** (housing, handling, lameness, diseases and their effects on animals hormones).
- High production and its effects on the production of luteinizing hormone, progesterone, estrogen, and follicular development.
- Photo-period and environmental light.
- Temperature and humidity.

Foot Problems

Foot problems, both infectious and non-infectious, have a **huge** impact on reproduction. Why?

Animals with sore feet:

- Do not eat, go down in bedding and are reluctant to get up.
- Are reluctant to show heats (even if they are cycling).
- Are more prone to reproductive and metabolic disorders.
- Are likely to be prematurely culled from the herd.

Grass Tetany

Grass tetany is a metabolic disease caused by a lower than average blood magnesium (Mg) level. It can affect all ruminants. In sheep and does, it most commonly occurs, in acute form, within four to six weeks of lambing or kidding.

Affected animals exhibit sensitivity to touch and trembling of the facial muscles; some are unable to move, others move stiffly; extreme cases collapse and show repeated tetanic spasms with all four limbs rigidly extended. Low blood magnesium can be caused by low levels of magnesium in lush spring grass or by mineral imbalances such as high potassium and nitrogen or low calcium in the diet. Ewes and does with grass staggers are often low in calcium as well as magnesium. It is therefore wise to use a combined treatment of calcium borogluconate and magnesium hypophosphite.

Grass tetany is most commonly seen in animals grazing lush spring pasture grasses. There is very little magnesium stored in the bones: absorption of Mg is dependent on the magnesium status of the animal, which is based on dietary intake. Absorption of magnesium is also influenced by the amount of calcium, phosphorus and potassium in the diet.

Drought, heavily fertilized crops or pasture (fertilized with nitrogen and potassium or manure) and acidic soils all can reduce the absorption of magnesium in the animal's system.

Prevention of the disease is possible through ration supplementation. Livestock must receive adequate levels of calcium and magnesium through limestone and magnesium oxide. Consistent intake of mineral supplements on pasture can be difficult.

Treatment, if animals were found soon enough, would include injections of a combination of calcium and magnesium sulphate. Contact your veterinarian immediately.

Goitre

When an animal does not get enough iodine in its diet, it develops a disease condition known as goitre.

The goitre or swelling of the thyroid gland is caused by the thyroid gland enlarging as it tries to produce the thyroid hormones needed by the animal.

From its position at the base of the brain, the pituitary gland monitors the levels of hormones in the blood. If a low level of thyroid hormones is detected, the pituitary gland sends out its own hormone called thyroid stimulating hormone or TSH, which stimulates the thyroid gland to step up production of thyroid hormones. The thyroid gland cannot do this since it is missing one essential ingredient, iodine, but the pituitary gland does not know this. It keeps secreting TSH, which after a time will cause the tissue of the thyroid gland to change and the entire gland to enlarge. Surprisingly, a toxic level of iodine will also cause an enlarged thyroid and hyperthyroidism due to a malfunction of the thyroid hormone producing system.

Soils in western Canada are deficient in iodine, so forage and grain grown here are deficient in iodine. To prevent goitre in livestock and people, salt is fortified with iodine (iodized); iodized salt is necessary to prevent goitre. Make sure that any salt you buy for your sheep or goats has iodine as an ingredient on the feed tag.

A minimum amount of I-salt should be "forced" into the rations of sheep and goats by including it in a premix, concentrate or supplement. Free choice salt should be available at all times for animals that want or need more. Sometimes water in western Canada can be high in sodium, and this can reduce salt intake.

Milk Goitre in Young Kids

Owners of Nubians, Boers and a few other breeds of goats are familiar with the large throat swellings that occur on the sides of the neck just under jaw line, and sometimes, including the area under the jaw in young kids. These soft swellings, called "milk goitre," will begin to appear at about a week of age, increasing in size until about four months of age, then will regress by the time the kid is six to nine months old.

The explanation for these swellings most often offered is that milk goitre is caused by the rich milk of their dam. On the surface this makes sense since the kids have goitres while nursing, and the goitres then decrease in size about the same time that they are weaned. However, milk goitre can also appear in kids raised on pasteurized goat milk or milk replacer. Milk goitre should not be treated the same as regular goitre. It requires no treatment, and regresses on its own as the kid matures. Many goat owners misunderstand milk goitre and treat milk goitre as they would regular goitre; this can cause iodine toxicity.

Heat Stress

Ruminants do best when the air temperature is between five and 24 degrees Celsius. When it gets hotter than that, the animals' efforts to maintain normal body temperature may result in reduced feed intake, 10 to 25 percent lower milk production, decreased milk fat percentage, decreased fertility, depressed immune system, higher maintenance requirements, and overall less efficient production.

The most important thing to provide for your animals is a cool, comfortable environment:

- Provide shade and water for pastured animals
- Improve ventilation
- Use tunnel ventilation where possible
- Use mixing fans over feeding areas
- Use sprinkling systems over holding pens and exit lanes
- Do not overcrowd pens

Once the environment is as comfortable as possible, you can also look at nutritional changes to help improve hot weather productivity:

- Water is the most important nutrient for all animals. During periods of heat stress ruminants' water requirements increase 1.2 to 2.0 times. Provide animals with an unlimited quantity of fresh, clean water in an area close to the feeding area to encourage eating and drinking. At the very least, provide shade over the area to encourage consumption. Should you provide cool water? No, ruminants prefer warm water (21 to 27 degrees Celsius) over cold water.

- Look at both quantity and form of protein when feeding heat-stressed animals. Too much or not enough crude protein increases body heat production. Ensure that bypass and degradable protein are both balanced.

- Excess fibre should not be fed during the hot summer months, but a minimum amount is needed to maintain DMI, milk production and normal rumen fermentation. High quality forages are needed year round.

- A dense ration, high in energy is recommended during times of heat stress.
- Ruminants sweat, and when they do they lose potassium rather than sodium. However, both sodium and potassium are important in heat-stressed animals.
- Buffers and fungal or yeast cultures may have some benefit in times of extreme heat. Their action is related to rumen buffering and reduced acidosis, as well as improved fibre digestion.

Feeding Management Strategies

- **Increase the number of feedings**. Feed will be fresher and consumption will be encouraged. If you are feeding once a day, increase it to twice or more.
- **Time feeding** correctly. During the hot weather animals eat mainly at night; make sure that fresh feed is provided at night.
- **Keep bunks clean**. Remove refused feed every day. Check and clean any mouldy and/or heated feed from corners and edges of feeding areas at least three times per week, more often if feeding animal proteins or fats. A decaying feed smell may reduce DMI even if fresh feed is put on top.
- **Avoid drastic ration changes.**
- **Avoid small particle size in TMRs or TMRs that allow sorting.**
- **Add liquid molasses or brewers grains to encourage consumption**.

Listeriosis

Listeriosis is also called circling disease; *Listeria monocytogenes*, the bacteria that causes it is widely distributed in nature and is found in soil, feedstuffs, and feces from healthy animals. It is most commonly associated with the feeding of mouldy silage or spoiled hay, but because the organism lives naturally in the environment, listeriosis may occur sporadically.

Listeriosis usually presents itself as encephalitis, but may also cause abortion in ewes and does; retained placentas usually result. Sheep and goats with the neurological form of the disease become depressed and disoriented; they may walk in circles with a head tilt and facial paralysis.

This bacterium can live almost anywhere—in soil, manure piles, and grass. *Listeria* thrives in aerobic conditions where the pH is 5.4 or higher. It does not do well in very acid conditions. Therefore, the top layers of silage or improperly preserved silage may harbour large numbers of organisms. Because of this, it is important to make sure that silage is tightly packed to ensure proper fermentation. Wet bales of hay may also harbour the bacteria.

Healthy animals are not usually affected by *Listeria*. However, sheep and goats are more susceptible to this disease than are other animals; up to thirty percent of a flock or herd may be affected in an outbreak.

Recognition of symptoms is important for successful treatment. Most animals will recover if treated with a broad spectrum antibiotic started early.

Milk Fever

Milk fever, also known as parturient hypocalcemia, is a metabolic disease in ewes and does following kidding, characterized by poor milk production, poor appetite, lethargy and low blood calcium levels. A hyperirritability characterized by tetany may occasionally occur.

Much research has been done on milk fever in dairy cows but more research is still required in sheep and goats.

Following kidding, most ewes and does have a lowered calcium level in the blood (hypocalcemia). This is partially due to the drain on available calcium by the production of colostrum prior to lambing or kidding. (Colostrum contains twice as much calcium as milk).

Calcium is supplied from two sources:

1. Dietary calcium
2. Mobilization of calcium from the bone

Normally, calcium requirements following parturition are provided primarily from the diet since mobilization of calcium from the bone does not provide significant amounts until about 10 days after parturition.

A loss of gastrointestinal function for any reason, before or at parturition, may cause a severe drop in the blood calcium level and signs of milk fever may develop.

Older animals' bones are less "dynamic" bones than those of younger animals and, therefore, have less access to the calcium in them. In addition older animals have more digestive upsets at parturition and are more prone to milk fever.

A high level of calcium in the ration during gestation places almost complete reliance on the dietary source of calcium.

By keeping the pre-partum diet low in calcium, the ewe or doe is set up to manufacture calcium-binding protein in the gut which puts her in a much better position to obtain calcium from the diet after parturition. In addition, she will try and use more of her own stored calcium in her bones. The results are that if a gastrointestinal dysfunction occurs at parturition, the effects are not severe since part of the calcium requirement is supplied by mobilization from the bone.

It is usually the high producing, older animals that are affected, shortly after parturition. There is a genetic component to milk fever which allows it to run in family lines.

The female shows lethargy, poor appetite and poor milk production. She may exhibit tremors or be hyper-irritable and may show muscle twitching of the lips, eyelids and ears. Trembling or twitching of other muscles of the body may also occur. Milk fever presents similar symptoms to pregnancy toxemia but can be differentiated by the affected animal's response to calcium therapy.

Often the problem involves many animals in the milking herd because they are all being exposed to the same diet. Usually, there is excessive calcium in the gestation diet from a mineral source and/or high quality legume hay. Correction of the calcium imbalance is necessary. A low calcium level during late pregnancy will help to control the problem.

Long term under-nutrition is required for primary hypocalcaemia to develop. All milking ruminants require calcium rich diets after parturition. Alfalfa hay can provide this. Cereal crop forages such as wheat or oat hay are very low in calcium (0.15 percent and 0.24 percent dry matter basis, respectively) as opposed to alfalfa hay, and should be avoided unless the ration is balanced with other calcium sources.

Over-feeding of calcium in late gestation by feeding alfalfa without balancing with anionic salts has been associated with hypocalcaemia in cattle. Feeding an anionic ration in late gestation will also improve calcium absorption from the gut and from the bones. The ration in late gestation and early lactation should also have a calcium to phosphorus ratio of greater than 1.75:1. Prevention of pregnancy toxemia will help to prevent hypocalcaemia as well.

Pregnancy Toxemia

When a pregnant ewe or doe becomes ill, the symptoms are likely caused by pregnancy toxemia. Pregnancy toxemia goes by several other names:

- Pregnancy Disease
- Twin Lamb Disease
- Lambing Paralysis
- Ketosis
- Acetonemia

Pregnancy toxemia is characterized by the "sweet" smelling breath of affected animals, and depressed feed intake. The sweet smelling breath is a result of elevated beta-hydroxy butyrate. This substance is the result of inappropriate fatty acid metabolism (breakdown of fat) by the liver. This is caused by the liver being unable to function properly during the massive breakdown of body fat seen in prolific ewes or does attempting to support fetal growth.

Factors important in the development of the disease are:

1. Presence of two or more fetuses.
2. Undernourishment during the last one-third of pregnancy when the fetuses have the most rapid growth.
3. Addition of stress such as severe weather, sudden changes in feed, other disease or transportation upon the previous factors.

The disease usually appears in the last 30 days of pregnancy and is more common after the first pregnancy. As pregnancy progresses, there is an increasing demand is on the available blood glucose supply of the doe or ewe because of fetal development. The principal source of energy to the fetus is glucose, and utilization by the fetus occurs at the detriment of the mother.

As the glucose supply diminishes from increasing fetal demands and decreased glucose production due to undernourishment, energy requirements are furnished by other metabolic pathways, for example, from free fatty acids and amino acids. Breakdown of the free fatty acids results in increased production of ketones, acetoacetate and B-hydroxybutyrate. As hypoglycemia becomes more severe, the ketone level in the blood increases (ketonemia) and ketosis occurs.

As ketosis increases, the bicarbonate level in the blood decreases and acidosis may result. When the bicarbonate level declines sufficiently, the animal will become comatose. During the later stages of pregnancy toxemia, water consumption decreases, urine output is decreased and kidney function is impaired. The blood sugar level may increase severely (hyperglycemia) during the late stages of the disease as a result of the response of the adrenal glands to stress.

Circumstances which cause severe hypoglycemia will usually result in pregnancy toxemia. Under-nourishment of the ewe or doe may not meet the demands for glucose production. The level of nutrition should be increasing as pregnancy progresses so that the female will be able to provide fetal requirements. Ewes and does should be gaining weight during pregnancy. As previously mentioned, multiple fetuses greatly increase the glucose requirement.

A gradual onset of undernourishment, as would be seen if the feed intake were not increased during pregnancy, may be tolerated by the doe and toxemia may not develop. However, if the animal is starved for several days, pregnancy toxemia may develop readily. Sudden changes in weather or housing, as well as infections or transport may result in periods of low dry matter intake and may trigger pregnancy toxemia.

Animals carrying multiple births are also at high risk for pregnancy toxemia. Animals carrying twins require 1.9 times the dry matter intake as those with singles. Ewes or does with triplet fetuses require 230 percent more energy than ewes or does with singles. In fact, anything that affects the animal's ability to eat enough during late gestation can result in pregnancy toxemia: multiple fetuses, fat or thin animals, small animals, timid animals, grannies, dental disease, parasitism, and lack of exercise.

The symptoms of pregnancy toxemia are vague and can be similar to other diseases, especially milk fever.

Milk fever can be differentiated from pregnancy toxemia by the affected animal's response to calcium therapy. Ewes and does in early stages of pregnancy toxemia will go off feed and appear lethargic. Their heads droop and they lag behind the rest of the flock and walk aimlessly. Teeth grinding and twitching are common. Eventually, affected animals become depressed and weak and have poor muscle control. In latter stages, they lie down and are unable to rise. If they are left untreated, coma and death result.

This is a disease that needs to be prevented rather than treated. It is generally a management disease and should be initially investigated as a herd level problem rather than an individual animal problem. If one animal is clinically ill, many more in the herd are likely at risk.

To prevent pregnancy toxemia in ewes and does:

- It is absolutely essential that ewes and does be provided adequate energy in their ration during the last four to six weeks of gestation. Good quality hay should be provided, along with grain supplementation, beginning at a quarter kilogram and increasing to one kilogram per head per day until the time of parturition. Grain and molasses are excellent sources of energy. Hay alone usually does not provide enough energy for animals carrying twins and triplets. Exercise is also deemed important in the prevention of pregnancy toxemia.
- Abrupt feed changes must also be avoided, and animals should not be stressed during late pregnancy.
- There must be adequate feeder space so that all ewes and does can fit around the feeders and get their fair share of hay and grain.
- Producers should strive to have animals in moderate body flesh (body condition score of 3+) prior to giving birth. Ewes and does should be prevented from becoming obese during early pregnancy, and thin animals should be separated and receive extra feed until they achieve the desired condition score.

Successful treatment of pregnancy toxemia requires early detection and steps taken quickly to meet the energy (glucose) needs of the affected ewe or doe:

- The most common treatment is to drench ewes with two to three ounces of propylene glycol two to three times daily.
- Yogurt mixed with water will also provide energy and bacteria to stimulate the rumen. Intravenous glucose is another possibility, but harder for producers to provide on the farm.
- Force feeding and/or injections of multiple B vitamins can help stimulate the appetite. Antibiotics can be administered to prevent pneumonia.
- In advanced cases, a caesarean section may need to be performed to remove the fetuses and save the mother's life. If the fetuses are near term, oftentimes they too can be saved.

- The nutrition of the entire flock should be suspect anytime an animal shows indications of pregnancy toxemia.
- During the later stages of the disease, acidosis and dehydration may be important factors. Intravenous administration of large volumes of electrolyte solutions with sodium bicarbonate may be important. Corticosteroids may not be effective in the later stages unless given at dosages utilized to combat endotoxic shock.

Polioencephalomalacia

Polioencephalomalacia (PEM) is a disease characterized by a disturbance of the central nervous system. The brain of infected animals becomes inflamed and swollen, and eventually the brain tissue dies.

PEM is caused by a thiamine (vitamin B1) deficiency. Thiamine is normally manufactured by bacteria in a healthy rumen. However, small ruminants on high carbohydrate diets may have an upset in normal rumen flora. A change in bacterial types may cause either a deficiency of thiamine or production of an enzyme which inhibits thiamine activity. Overdosing with amprolium (in the treatment of coccidiosis), exposure to high levels of sulphur in the diet, or grazing on mare's tail (equisetum) can also result in PEM but these causes are unusual in comparison to high carbohydrate diets.

PEM occurs suddenly. Affected animals stand or sit alone, are blind and arch their necks back and stare upwards and become "star gazers." They are disoriented, lose their appetites, and do not want to drink. Temperature and respiratory rate are usually normal but the heart rate may be depressed. Excitement may be seen but is usually replaced with dullness. Normally only a few individuals are affected. The animal may go down on its side with its head thrown back. The pupils will constrict to light but the animal will not react to a hand menace. The legs may be rigidly extended and convulsions may occur. An animal with PEM will often press its head against a wall or post. If not treated on time, most animals with PEM will die within 48 hours.

Other disorders to rule out are tetanus (the animal is not blind), pulpy kidney, lead poisoning, listeriosis, and other toxins, for example, organophosphates and organochlorines.

Sometimes the only way to make a diagnosis is through a response to treatment. Early polio cases often respond, at least partially if not completely, to thiamine administration. Often some response occurs within a few hours of initial treatment. Because thiamine is water-soluble, it is quickly eliminated from the body through the kidneys and there is therefore little risk of overdosing.

Most other neurological diseases respond slowly or not at all to indicated treatments (except specific poisonings). Because thiamine deficiency does cause brain tissue to die, however, time is important. The longer treatment is delayed, the more likely irreversible brain damage may occur. One case may not necessarily mean a herd problem, but the feeding management should be reviewed. Some problem herds do require routine thiamine supplementation but feeding management should be investigated first.

If a case of PEM is diagnosed in a flock or herd, it is advisable to inject the remaining animals with thiamine as prevention. Drinking water should be tested for sulphur contents, sources of thiamine, if any, should be removed and animals should be introduced to grain diets in steps to avoid a sudden increase in thiamine-producing bacteria in the rumen.

Urinary Calculi

Urinary calculi or “water belly” is a common metabolic disease of male sheep and goats. The disease occurs when calculi (stones lodge in the urinary tract and prevent urination. The most common type of stones are calcium phosphate and struvite magnesium phosphate from high grain diets.

Normally, phosphorus is recycled through saliva and excreted via feces in ruminants. High grain, low roughage diets decrease the formation of saliva and therefore increase the amount of phosphorus excreted in the urine.

The primary cause of urinary calculi is feeding concentrate diets which are excessive in phosphorus and magnesium and/or have an imbalance of calcium and phosphorus. Lack of water, and water sources that are high in minerals, are also contributing factors.

While urinary calculi can occur in intact males, wethers are at greatest risk because castration of young males removes the hormonal influence (testosterone) necessary for the penis and urethra to reach full size. Lambs castrated within the first month of life are most vulnerable. For this reason, some veterinarians advocate delaying castration until after puberty. If castration is performed after puberty, it should be done under anesthesia by a veterinarian. It should be pointed out that this recommendation is for wethers to be kept after puberty as pets, for pack animals, etc. However, early castration of terminal (meat) animals does not usually pose a problem.

In females, calculi are formed, but excreted due to anatomic differences in the male and female urinary tracts.

The blocked animal will be uncomfortable and will strain and act depressed. Often the presenting complaint is constipation. With careful observation, the producer may notice frequent dribbling of small amounts of urine which may be blood tinged. If you are not sure if the goat or ram is urinating, place him in an unbedded, cement pen by himself for several hours. Pre-pucial hairs may have dried crystals on the end. If the blockage is not noticed and is total, the bladder ruptures in 24 to 36 hours. After bladder rupture, the abdomen swells with urine and the animal appears more depressed. He may live another few days before succumbing to the toxins in his system. Occasionally the urethra ruptures and the urine pools under the skin. This condition is called "water belly."

In rams or bucks, the penis can be exposed and the urethral process examined. Sand or stones, discolouration and swelling may be evident. A normal appearing process may mean the blockage is higher. In wethers, often the prepuce is adherent to the penis and it is difficult to expose the end.

As with most disease conditions, it is better to prevent urinary calculi than to treat it. The disorder can be prevented by feeding rations which contain a calcium-to-phosphorus ratio of at least 2:1. The ratio of Ca:P should never be allowed to go below 1:1.

High calcium diets are effective at reducing the absorption of phosphorus from the GI tract. Neither magnesium nor phosphorus should be added to concentrate diets. In addition diets high in potassium should be avoided. All rations should contain adequate amounts of vitamin A.

Extra calcium is well tolerated by sheep, so where rations are unbalanced, they can be counterbalanced by adding ground limestone (not dicalcium phosphate!). Legume hays (for example, alfalfa) are good sources of calcium. In addition, roughage will increase salivation and rumination which will increase the amount of phosphate excreted in the urine. Cereal grains (corn, barley, etc.), on the other hand, have an abnormally low calcium-to-phosphorus ratio: 1:4 to 1:6. Therefore, rations containing cereal grains need to be balanced with other feeds or mineral sources to form a complete ration that has the proper ratio of calcium and phosphorus.

Adequate water intake is also necessary to prevent urinary calculi, plenty of fresh, palatable water should always be available. Inadequate water intake causes the urine to be more concentrated, which makes the formation of stones more likely.

The use of ammonium chloride at a level of 0.5 percent of the total diet will help to acidify the urine and prevent the formation of calculi. Most commercial lamb and meat goat diets contain ammonium chloride, as well as the proper ratio of Ca:P.

Vaginal Prolapse and Uterine Prolapse

Vaginal prolapses (protrusion of the vagina) are most commonly observed during the last month of pregnancy or shortly after lambing or kidding.

Vaginal Prolapse

Many factors have been implicated in the cause of vaginal prolapse:

- Hormonal/metabolic imbalances
- Over-fat or over-thin body condition
- Bulky feeds
- Lack of exercise
- Dystocia in previous pregnancies
- Increased abdominal pressure and fetal burden
- Milk Fever
- Ketosis
- Poor pregnant ewe or doe nutrition and management

Prolapses often recur in subsequent pregnancies.

The exposed vagina of affected ewes or does should be washed with soapy disinfectant solution and forced back into the animal. A bearing retainer or "spoon" can be inserted and secured in the ewe to prevent further prolapses.

In an animal that has given birth, sutures are used to secure the prolapse.

Uterine Prolapse

A uterine prolapse occurs when the womb is turned inside out and pushed through the birth canal by the abdominal straining of the ewe or doe. It occurs immediately after parturition and is a life-threatening situation.

A prolapsed uterus must be manually forced back into the animal. The uterus should be cleaned with a warm, soapy, disinfectant solution prior to replacement and should be replaced before the tissues become dry or chilled. Deep sutures are necessary to keep the uterus in place.

Affected animals should be removed from the flock. Older ewes and does are more commonly affected than younger ones, probably due to their pre-disposition to milk fever, ketosis, etc.

White Muscle Disease

White muscle disease (WMD) is a degenerative muscle disease found in all large animals. It is caused by a deficiency of selenium and/or vitamin E. Selenium (Se) deficiency is associated with selenium deficient soils and the inadequate uptake of selenium by forages grown on these soils.

Most of Canada is very deficient in selenium. Deficiency causes acute muscle necrosis known as white muscle disease. Usually young, fast growing animals are affected, at any time from birth to full grown. The young animals are in acute pain; they are reluctant to move but may still eat. Sometimes the disorder manifests itself as sudden death because the heart muscle is affected. Selenium deficiency has also been identified as a cause of ill thrift in growing lambs. Cattle supplemented with selenium (when deficient) have fewer problems.

Vitamin E deficiency is independent of soil type and more closely reflects forage quality. Grazing animals usually consume adequate amounts of vitamin E. This is because fresh legumes and pasture are good sources of vitamin E, whereas silage, oil seeds, root crops, cereal grains, and dry hays tend to be poor sources of vitamin E. Prolonged storage of feedstuffs results in a degradation of Vitamin E activity, as much as fifty percent per month.

In addition to WMD, selenium and vitamin E deficiencies can produce symptoms of ill thrift and reproductive losses: lower conception rates, fetal re-absorption, dystocia, retained placenta, reduced milk production, and reduced semen quality. They can cause poor rate of growth or ill thrift in young lambs and kids throughout the growing period. Sheep and goats consuming selenium-deficient diets produce low wool yields and have increased incidence of periodontal disease. Selenium and vitamin E also play key roles in the animal's normal immune response.

All breeds of sheep and goats are susceptible to WMD, and the condition may develop under extensive or intensive management systems. WMD is most commonly found in newborns or fast growing animals. Kids are believed to be more susceptible than lambs, possibly because they have a higher requirement for selenium. The disease can affect both the skeletal and cardiac muscles.

Symptoms

When the skeletal muscles are affected, symptoms vary from mild stiffness to obvious pain upon walking, to an inability to stand. Lambs/kids may tremble in pain when held in a standing position. A stiff gait and hunched appearance are common. Affected lambs/kids may remain bright and have normal appetites, but eventually they become too weak to nurse. When the problem occurs in newborns, they are born weak and unable to rise. Sudden exercise may trigger the condition in older lambs and kids.

When the disease affects the heart, the animal shows signs similar to pneumonia, including difficult breathing, a frothy nasal discharge (which may be blood stained), and fever. The heart and respiratory rates are elevated and often irregular.

Treatment

Injection of lambs and kids at birth with a quarter cc of a commercial Vitamin E-Selenium preparation is common practice (read the label to confirm dosage as there are several different formulations). It is advisable to inject with a sterile 22 gauge (blue) needle under the skin (instead of into the muscle). Does and ewes can be injected two to four weeks prior to kidding as well. Kids and lambs should be re-injected at one month of age if no feed supplementation is fed.

High concentrations of other minerals (for example, calcium, sulphur, copper and zinc) and feed contaminants (for example, nitrate, unsaturated fats, sulphates) may decrease absorption of selenium in the small intestine.

Prevention

WMD can be prevented by supplementing the diet of susceptible animals with selenium and vitamin E. Since it occurs mostly in lambs and kids whose mothers were fed a selenium-deficient diet, supplementation of pregnant animals helps reduce disease in newborns. This is because selenium is transferred from dam to fetus across the placenta, and also is present in the colostrum. While not much vitamin E is transmitted across the placenta, colostrum levels of vitamin E increase with ewe/doe supplementation.

It is important to note that selenium in feed is governed by the CFIA.

Injectable selenium compounds are available to prevent WMD in at risk-animals; however, injections are a poor alternative compared to routinely providing adequate selenium and vitamin E in the diet. Ideally, the total diet for sheep and/or goats should contain 0.10 to 0.30 ppm of selenium.

10. Addendum

Macro and Micro Minerals			
Macro		**Micro**	
Ca	Calcium	Al	Aluminium
Cl	Chlorine	As	Arsenic
Mg	Magnesium	B	Boron
P	Phosphorus	Cd	Cadium
K	Potassium	Cr	Chromium
Na	Sodium	Cu	Copper
S	Sulphur	Co	Cobalt
		F	Fluoride
		I	Iodine
		Fe	Iron
		Pb	Lead
		Mn	Manganese
		Hg	Mercury
		Mo	Molybdenum
		Se	Selenium
		Zn	Zinc

General Nutrition Terms	
BW	Body Weight
BCS	Body Condition Score
CFIA	Canadian Food Inspection Agency
DMI	Dry Matter Intake
Forbs	Weeds, Flowers etc.
GI	Gastro-intestinal
TLC	Theoretical Length of Cut
VFA	Volatile Fatty Acids

Forage Testing Terms	
DM	Dry Matter
CP	Crude Protein
SP (SIP)	Soluble Protein
DIP	Degradable Intake Protein
UIP	Undegradable Intake Protein
ADF-CP (ADF-N, ADICP, ADIN)	Acid Detergent Insoluble Nitrogen
NDICP	Neutral Detergent Insoluble Crude Protein
ADF	Acid Detergent Fibre
NDF	Neutral Detergent Fibre
NSC	Non-structural Carbohydrates
NE_G	Net Energy (growth)
NE_M	Net Energy (maintenance)
NE_L	Net Energy (lactation)
TDN	Total Digestible Nutrients
NIR	Near Infrared Reflectance Analysis
RFV	Relative Feed Value

11. Literature Citations

1. Introduction: General comments on the nutritional considerations of sheep and goats

1. Peischel, A. Current. Sheep and Goat Nutrition. Power Point Presentation Tennessee State University.

2. The Digestive System of Sheep and Goats

1. Bowen, R. 2004. Fundamental Physiology and Anatomy of the Digestive System. Hypertext . Colorado State University.
2. Bowen, R. 2003. Digestive Anatomy of Ruminants. Hypertext. Colorado State University.
3. Bowen, R. 1998. Fermentation Microbiology and Ecology. Hypertext. Colorado State University.
4. Bowen, R. 1996. Basic Fermentation Chemistry. Hypertext. Colorado State University.
5. Bowen, R. 1996. Rumen Physiology and Rumination. Hypertext. Colorado State University.

3. Nutrient Requirements: What are they and where are they digested

1. Landefeld, M. and J. Bettinger. 2002. Water Effects on Livestock Performance. Ohio State University Fact Sheet.
2. Pfost, D., Fulhage, C., and S. Castel. 2001. Water Quality for Livestock Drinking. University of Missouri Extension Sheet.
3. The Water Source as a Factor Affecting Livestock Production by Walter Williams and others, Agriculture and Agri-Food Canada, PO Box 3000, Lethbridge, AB, T1J 4B1, Canada
4. Agricultural Waste Management Field Handbook, Part 651, page 1 t0 16, National Engineering Handbook. Washington, D.C.: Natural Resources Conservation Department, U.S. Department of Agriculture, 1992.
5. Kleinschmidt, J. D. Current. Power Point Presentation. Carbohydrate Nutrition (in Ruminants). Personal communication.
6. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted form "Feeding Fat to Dairy Cows". Personal communication.

7. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted from "Protein (in ruminant nutrition)". Personal communication.

8. Machen, R. Current. Minerals: Small Ruminant Series. The Texas A&M University System, Extension Service.

4. Feedstuffs for Sheep and Goats

1. Lacefield, G., Henning, J. C., Collins, M. and L. Swetnam. Current. Quality Hay Production. University of Kentucky, Cooperative Extension Services.

2. Schroeder, J. W. 2004. Haylage and Other Fermented Forages. North Dakota State University and the USDA.

3. O'Brian, A. 1997. Baled Haylage for Sheep. Ontario Ministry of Agriculture, Food & Rural Affairs.

4. Bell, B. 1997. Feeding Sheep Corn Silage. Ontario Ministry of Agriculture, Food & Rural Affairs.

5. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted from "Forages for Dairy Cows". Personal communication.

6. Luginbuhl, J-M., Green, J. T., Mueller, J. P. and M. H. Poore. 1998. Forage Needs for Meat Goats and Sheep. In: "Production and Utilization of Pastures and Forages" - Technical Bulletin 305 North Carolina Agricultural Research Service, North Carolina State University, Raleigh

7. Putnam, D. Current. Recommended Principles for Proper Hay Sampling. University of California, Davis. (National Forage Testing Association Web Site).

8. Zhang, H., Redfearn D. and J. Caddel. Current. Collecting Forage Samples for Analysis. Oklahoma Cooperative Extension Service.

9. National Forage Testing Association Web Site. http://www.foragetesting.or

10. Murphy J. 2003. Nutrient Testing. Ontario Ministry of Agriculture, Food & Rural Affairs.

11. Agri-Foods Laboratories, Guelph, Ontario. http://www.agtest.com/contact.cfm

12. Schoenian, S. 2007. The Truth About Grains: Feeding Grain to Small Ruminants. Small Ruminant Info Sheet Series. Maryland Cooperative Extension.

13. Stock, R.A. and B.A. Britton. 1993. Acidosis in feedlot cattle. In: Scientific update on Rumensin/Tylan for the professional feedlot consultant. Elanco Animal Health, Indianapolis, IN.

14. Crickenberger, R. and R. E Carawan. 1996. Using Food Processing By-Products for Animal Feed. North Carolina Cooperative Extension Service.

15. Lardy, G. and V. Anderson. 2003. Alternative feeds for Ruminants. North Dakota State University Extension Service.

16. Hutjens M. F. 2007 "Feed Additives–the Good, the Bad, and the Useless". WCDS Advances in Dairy Technology (2007) Volume 19: 87-101.

5. Management Tools for Nutrition

1. Parker, G. and R. Coffey. "Body Condition Scoring In Farm Animals". Current. Power Point Presentation. University of Kentucky.

6. Working with the Feed Industry

1. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted from "Working with the Feed Industry". Personal communication.

2. Canadian Food Inspection Agency. Livestock Feeds Web Site. http://www.inspection.gc.ca/english/anima/feebet/feebete.shtml

7. Feed Cost of Production

1. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted from "Feed Cost of Production". Personal communication.

8. Bunk Management

1. Kleinschmidt, J. D. Current. Power Point Presentations. Personal communication.

9. Nutritional/Metabolic Diseases in Sheep and Goats

1. Schoenian, S. 2007. Sheep 201: A Beginner's Guide to Raising Sheep.

2. Fleming, D. Bloat . Adapted from: http://www.boergoats.com/clean/articleads.php?art=346

3. Neary, M. 2002. Copper Toxicity in Sheep. Purdue University Extension.

4. Nix, J. 2004. Choosing the Right Mineral Supplement (for sheep). Adapted from: http://www.sweetlix.com/media/documents/articles/Sheep_001.pdf

5. Gasparotto, S.W. Current. Copper Toxicity and Deficiency in Goats. Adapted from: http://www.tennesseemeatgoats.com First Published in Goat Ranger Magazine.

6. Schoenian, S. 1998. Enterotoxemia in Lambs. Maryland Cooperative Extension.

7. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted from "Feeding for Fertility". Personal communication.

8. Markus, S. 2003. Grass Tetany. Ag-Info Centre, Alberta Agriculture and Rural Development.

9. Kleinschmidt, J. D. Current. Power Point Presentation. Adapted from "Summer Time in the Barn". Personal communication.

10. Pennsylvania State University. 2002. Adapted from "Discussion of Listeriosis": http://www.goatconnection.com/articles/publish/article_40.shtml

11. Adapted from Goat World Hand Book, USDA: http://www.goat-world.com/articles/nutrition/metabolicnutritional.shtml

12. Adapted from Goat World Hand Book, USDA: http://www.goat-world.com/articles/nutrition/metabolicnutritional.shtml

13. Adapted from Purdue University: http://ag.ansc.purdue.edu/sheep/ansc442/Semprojs/2002/neurological/polio.htm

14. Schoenian, S. 2005. Urinary Calculi in Sheep and Goats. Maryland Cooperative Extension.

15. Schoenian, S. 2007. White Muscle Disease in Sheep and Goats. Maryland Cooperative Extension