Chapter 5
# Nutrition

The ruminant animal has the ability to digest feedstuffs, such as grain, grass, and hay, and produce consumable products (milk, meat, and fiber). The ruminant digestive system evolved so that feed such as grass could be eaten quickly and chewed later. The goat is just one example of a ruminant. Other domestic animals that are ruminants include cattle and sheep. White-tailed deer, elk, and big horned sheep are ruminants that live in the wild.

The ruminant's digestive system is composed of four compartments: rumen, reticulum, omasum, and abomasum (see figure 5.1).

## Rumen

The rumen is the first and largest compartment of the goat's digestive system, making up about 80 percent of the stomach capacity. It acts as a large fermentation vat that mixes and stirs up the food. It can hold about 6 gallons of material.

Microorganisms, such as bacteria, fungi, and protozoa, live in the rumen and break down and convert feed and nutrients to products the animal can use. The microbes also grow and multiply, and the ruminant animal digests them. The protein from the microbes may provide up to approximately two-thirds of the protein required by the animal. These "rumen bugs" are the reason that ruminants

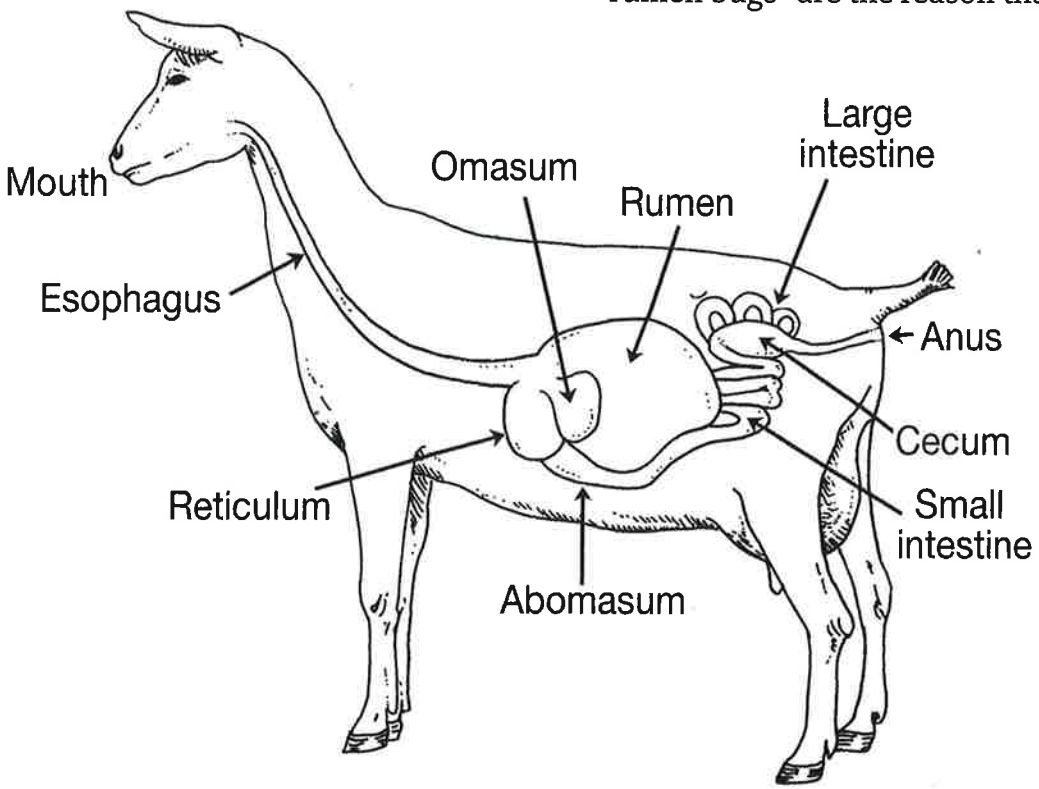


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Figure 5.1. Parts of the ruminant digestive system.

are able to digest grasses and other forages that humans can't digest. Rumen microbes have the ability to digest cellulose, a main component in forages. Humans and other nonruminants cannot digest cellulose.

The relationship between the rumen microbes and the ruminant animal is called a symbiotic relationship. Symbiosis is where each organism gains something; it is a win-win relationship. The goat's food is broken down and obtains nutrients from the microorganisms, and the microorganisms have a place to live. These microorganisms require a warm, moist, and anaerobic (no oxygen) environment. The microorganisms produce gases such as methane, carbon dioxide, and ammonia. These are either used by the animal, or the other microbes, or are let off as gases during eructation (belching).

Volatile fatty acids (VFA) are also products of fermentation, which the animal uses as an energy source. The acids of highest concentration in the rumen are acetic, propionic, and butyric. These gases and acids affect the rumen pH. The pH is a measure of how acidic or alkaline the environment in the rumen is on a scale of 1.0 (acidic) to 11.0 (alkaline). A pH of 7.0 is neutral. The healthy rumen has a pH between 6.0 and 6.5.

What the animal eats and how much it chews affects the rumen environment and pH. The goat regurgitates a bolus of food, or cud, from the rumen for rechewing in a process called rumination, or "chewing its cud." Rumination reduces particle size of the feed for further digestion by the microbes and also adds saliva to the rumen. The sodium bicarbonate in the saliva acts as a buffer to help maintain a constant rumen pH. Low fiber/high concentrate diets that do not stimulate much chewing result in the production of a lot of gas and acid from the rumen microorganisms. There is also less saliva going into the rumen since the goat is not chewing as much. Low rumen pH can cause some health problems that are discussed in Chapter 6.

## Reticulum

The reticulum is the compartment right next to the rumen. It acts together with the rumen to mix and store the food. The reticulum is also called the honeycomb because it has a honeycomb pattern (like that made by bees) on the inside. The reticulum catches large particles of feed so that they do not enter the omasum, allowing them to be further digested by rumen bacteria. Hardware, such as nails and wire, can get caught here. Although goats usually sort undesirable objects from feed, risks do exist from consumption of metal objects and their potential to irritate and infect tissue and to puncture the stomach, affecting the nearby heart.

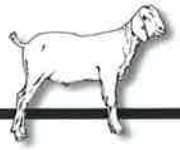
## Omasum

The omasum is the third compartment of the digestive system. It is also called "many plies," which means "many leaves," because it has many leaves or pages inside that are stacked like the pages of a book. Its main function is to squeeze and absorb water from the feed.

## Abomasum

The fourth compartment is the abomasum. It is also called the true stomach and is very similar to the human stomach. It produces and secretes digestive enzymes and acids, such as hydrochloric acid and pepsin, to break down food into nutrients that are used by the body. The abomasum helps to move food into the small intestine where the food is further digested and where many of the nutrients are absorbed. Digesta then goes





into the large intestine, where much of the water is absorbed. The remaining undigested feed and waste is then excreted out the anus of the animal.

## Nutrients

Different nutrients are required in different amounts to allow for proper animal growth, milk production, and bodily functions. There are six essential nutrients for goats: water, carbohydrates, fats, protein, minerals, and vitamins.

### Water

Water is the most important nutrient needed to survive. Each cell in the body requires water, and depending on the age and amount of body fat, the goat's body is composed of 50 to 80 percent water. Water helps with the body's digestion of food and transportation of nutrients throughout the body. It also helps to rid the body of waste material and to regulate body temperature. A goat may consume up to 4 gallons of water per day, depending on its age and productive state, the environmental temperature, and the type of feed being consumed. A goat weighing about 100 pounds and not producing milk consumes about 1 gallon of water per day. **It is especially important to provide clean, fresh water at all times. For lactating goats, remember that milk is 87 percent water.**

### Carbohydrates

Carbohydrates are a main source of energy for the goat. There are many different types of carbohydrates. All carbohydrates are made up of three elements: carbon, hydrogen, and oxygen. From these three elements, thousands of combinations are made.

In the rumen, carbohydrates are converted to volatile fatty acids (VFA). The goat absorbs these acids and uses them as the primary energy source for body functions, such as growth and milk production. Carbohydrates are separated into two groups: structural carbohydrates and nonstructural carbohydrates. Having a balance between structural and nonstructural carbohydrates is important in maintaining proper rumen health. Carbohydrates are also relatively inexpensive when it comes to the costs of feedstuffs.

Structural carbohydrates are those carbohydrates that are found in high concentrations in forages or fibrous by-products. They are the components of the plant cell walls that give "structure" to the plant. Neutral detergent fiber (NDF; includes hemicellulose, cellulose, and lignin) and acid detergent fiber (ADF; includes cellulose and lignin) are the technical references for these fiber sources. Lignin is neither digested by humans, animals, nor rumen microbes. Cellulose is a component that cannot be digested by humans and makes up a large part of the fiber in plants. Because of the rumen bacteria, goats are able to digest large amounts of cellulose. Structural carbohydrates lend to the production of more acetic acid than propionic and butyric acids. Acetic acid is a major precursor to the udder for the synthesis of milk fat. For that reason and other metabolic processes, low fiber diets may cause milk fat depression.

Nonstructural carbohydrates (NSC) are the starches and sugars found in high concentrations in grains and some by-products that are fed to goats. Nonstructural carbohydrates are more digestible than structural carbohydrates and therefore, usually provide more energy to the animal. Nonstructural carbohydrates

lend to the production of more propionic and butyric acids than acetic acid. Too many nonstructural carbohydrates can reduce rumen pH and lead to either an unhealthy rumen, sometimes causing metabolic disorders such as acidosis and laminitis, or milk fat depression.

## Fats

Fats come in the form of oils or fatty acids and supply approximately 2.25 times the amount of energy per unit than carbohydrates. Diets for kids that include large quantities of milk or milk replacer may contain 10 to 35 percent fat in the **dry matter** (DM) consumed. Fat may be added to the diets of mature animals to increase energy density of the ration and to reduce dustiness of grain diets. Diets for nonmilk-fed animals usually contain around 3 to 4 percent fat. For animals with a developed rumen, additional fat, either in the form of a natural fat source or rumen inert fats (commercially prepared) can be added, but total dietary fat should not exceed 7 to 8 percent of the DM. In the rumen, fats are not changed very much by the microorganisms except that they undergo biohydrogenation, which is the addition of hydrogen to the unsaturated fatty acids. This process causes the unsaturated fatty acids to become saturated. Too much fat can decrease feed intake, depress fat and protein content in milk, and cause scouring. This occurs because too much fat can interfere with the microorganisms in the rumen. Commonly fed natural sources of fats are whole cottonseed, whole soybeans, and tallow. Several by-products sometimes fed to goats are higher in fat concentration than forages and cereal grains, such as hominy, distillers grains, and fishmeal. Calcium salts of fatty acids and saturated tallow are the most common sources of commercially available rumen inert fats.

## Protein

Protein is needed for maintenance, growth, pregnancy, and lactation. Proteins have a complex structure and are made up of nitrogen, carbon, hydrogen, and oxygen. Some proteins also contain sulfur. Like carbohydrates, nitrogen can be combined with various chemical elements in different ways. The resulting combinations are many different structures called amino acids, which are the building blocks of protein. The goat's protein requirements are actually met by amino acids. Metabolizable protein (MP) is used to describe the actual protein that is digested in the small intestine and absorbed as amino acids. Amino acids are supplied to the goat by feeding protein that escapes microbial breakdown and also by protein made by microorganisms. Approximately 65 percent of the crude protein (CP) in a typical goat's diet may be broken down by microbial digestion to ammonia. The rumen microorganisms use this ammonia as a food source to grow and replicate. The goat then digests the microbial protein in the small intestine. If rumen ammonia concentrations are higher than what can be used by the microorganisms, the ammonia is absorbed into the bloodstream, converted to urea by the liver, and recycled or excreted as urea in the urine. All feed protein sources are not degraded in the rumen to the same extent.

Rumen degradable protein (RDP) describes protein sources that are degraded or broken down into amino acids and ammonia in the rumen. The microorganisms in the rumen use these substrates for maintenance and growth. Non-protein-nitrogen (NPN) is an example of a rumen degradable nitrogen source and is converted into ammonia in the rumen. A common NPN source is feed grade urea. Urea should only be fed to goats and not to kids. It should be gradually introduced

into the diet and not exceed 0.5 percent of the dietary DM or 1 percent of a concentrate mix, as toxicity can occur.

Rumen undegradable protein (RUP) describes protein that is not degraded or broken down in the rumen. Another name for this is "by-pass protein." Most of the RUP is digested in the abomasum and small intestines. Blood meal, fishmeal, and some processed plant by-products are examples of RUP sources. Having a balance between RDP and RUP is important when formulating rations for goats.

## Minerals

Minerals are required to help build strong bones and teeth. They are also required for chemical reactions necessary for many of life's processes. The major minerals, also called macro minerals, are so called because they are required in larger quantities and are usually denoted as a percentage of the daily diet. Micro minerals, or trace minerals, are required in lesser quantities than macro minerals, and are usually designated as parts per million (ppm). Calcium, magnesium, phosphorus, potassium, and salt are some of the important macro minerals. Copper, manganese, selenium, and zinc are just a few examples of trace minerals. See table 5.1 for a detailed list of minerals, their functions, signs of deficiency in the diet, and ways to provide the mineral in the diet.

**Table 5.1. Minerals for goats.**

| Mineral | Function | Deficiency Signs | Ways to Provide in Diet |
|---|---|---|---|
| | | | |
| Calcium (Ca) | Proper skeletal structure, muscle contraction, and milk production | Rickets in growing animals; milk fever in lactating animals | Legume forages are high in calcium, calcium carbonate (limestone), dicalcium phosphate |
| Magnesium (Mg) | Co-factor for major enzymatic reaction; normal nerve and muscle function; and bone formation | Grass tetany or Grass staggers; more commonly occurs with animals on pasture | Magnesium oxide, dolomitic limestone, magnesium chloride, magnesium carbonate, magnesium sulfate |
| Phosphorus (P) | Strong teeth and bones, energy reactions in cells, and milk production | Lack of appetite, unthrifty appearance, rickets in growing animals, signs of pica | Dicalcium phosphate, monosodium phosphate, defluorinated phosphate, nonruminant meat and bone meal, fish meal |
| Potassium (K) | Muscular activity; osmotic pressure of body fluid | Decreased feed and water intake; weight loss; reduced milk yield; pica; dull hair coat; forages are high in K, usually does not need to be supplemented except in hot weather | Potassium chloride, potassium sulfate, potassium carbonate |



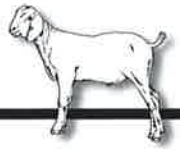


**Table 5.1 (continued).**

| Mineral | Function | Deficiency Signs | Ways to Provide in Diet |
|---|---|---|---|
| | | | |
| Salt (Sodium Chloride, NaCl) | Necessary for many bodily functions; helps to transport material across cell walls | Eating anything containing salt, signs of pica, lack of appetite, unthrifty appearance | Mix in grain, total ration, or fed free choice. |
| Sulfur (S) | Component of some essential amino acids that make up proteins; required by rumen microbes for fiber digestion | Reduced animal performance and reduced fiber digestion; excessive sulfur can interfere with copper and selenium absorption | Calcium sulfate, magnesium sulfate, ammonium sulfate, potassium sulfate |
| | | | |
| Copper (Cu) | Component of many necessary enzymes that are involved in building strong bones and connective tissues; absorption and transport of iron for hemoglobin synthesis | Loss of hair pigmentation; loss of hair, scours, and anemia; high levels of molybdenum and sulfur can affect copper absorption | Copper sulfate, copper oxide, trace mineral salt |
| Iodine (I) | Needed for synthesis of thyroid hormones that control metabolism | Enlarged neck on adults; kids born with large necks; goiter; born weak, hairless, or dead | Potassium iodide, EDDI (ethylenedaminedi-hydroiodide), trace mineral salt |
| Iron (Fe) | Needed for hemoglobin synthesis and for enzymatic reactions | Anemia; high levels of dietary iron can interfere with absorption of other minerals | Ferrous sulfate, ferrous oxide, trace mineral salt |
| Manganese (Mn) | Involved in enzyme reactions relating to the formation of cartilage and bone | Impaired growth; skeletal abnormalities; depressed reproduction; abnormalities of the newborn | Manganese sulfate, manganese oxide, trace mineral salt |
| Molybdenum (Mo) | Component in many enzymatic systems | Deficiencies are hard to produce and usually does not need to be supplemented; can be toxic due to binding of copper that results in copper deficiency | |
| Selenium (Se) | Component of enzymatic systems; important in immune functions | White muscle disease—leg weakness, flexion of hock joints, muscle tremors, and heart failure.<br>Reproductive problems—retained fetal membranes, cystic ovaries, and metritis; increase in prevalence or severity of mastitis; short-term deficiency can cause general unthriftiness. | Sodium selenite, sodium selenate, selenoyeast, trace mineral salt |
| Zinc (Zn) | Component is many enzymes that affect metabolism of carbohydrates, proteins, lipids | Reduced feed intake and growth rate; weak hoof horn and perakeratosis of the skin | Zinc sulfate, zinc oxide, zinc methionine, trace mineral salt |

## Vitamins

Vitamins are organic compounds that are needed in very small amounts and are required for growth, production of milk and fiber, and reproduction. There are two classes of vitamins: fat-soluble and water-soluble. The fat-soluble vitamins are A, D, E, and K. They are called fat-soluble because they can dissolve in fat solvents, such as ether or chloroform, and are usually stored in the fat tissues in the body. The water-soluble vitamins are B-complex vitamins and vitamin C. They are called water-soluble because they dissolve in water.

### Vitamin A

Vitamin A is available to a goat through green, leafy forages. Vitamin A keeps the eye and body cell linings healthy and working. An animal with a deficiency in vitamin A may have night blindness, be weak, and have a greater chance of infections and reproductive problems. Carotene is the natural source for vitamin A, and synthetic vitamin A is normally added to goat rations.

### Vitamin D

Vitamin D is necessary for strong bones and teeth. Animals with low concentration of vitamin D can have weak bones, swollen joints, and stiffness. They can develop a condition called "rickets" where they are weak and may drag their feet or, if they are growing, they may have crooked legs. Green, leafy, sun-cured feed and fish oils are excellent sources of Vitamin D. Animals can make their own vitamin D when the sun is shining on their skin. However, vitamin D supplementation is recommended.

### Vitamin E

Vitamin E is an anti-oxidant, reducing off-flavors in milk and preventing white muscle disease in kids. Vitamin E is very important in stimulating and maintaining a good immune system. It also helps to reduce the incidence of and severity of mastitis and to improve reproductive performance. Vitamin E is found in green, leafy forages but also should be supplemented to animals.

### Vitamin K

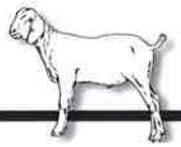
Vitamin K is necessary because it helps to clot the blood, which helps to stop bleeding. Most leafy feeds contain an adequate amount of vitamin K. It is also the only fat-soluble vitamin that is synthesized in the rumen and does not need to be supplemented.

### B Vitamins

The B vitamins are water-soluble and are synthesized by the rumen microorganisms. Animals with a deficiency in a B vitamin may become paralyzed, lose hair, become weak, or have a poor appetite. Cereal grains and rumen bacteria are good sources of B vitamins. Usually, the B vitamins do not need to be supplemented; however, in some cases, supplementation is warranted, especially for biotin, niacin, or choline. It is possible that the microorganisms cannot make enough of the B vitamins in high-producing dairy goats. The B vitamins may also need to be supplemented to animals that are stressed or sick and to very young kids.

### Vitamin C

Vitamin C, or ascorbic acid, is produced normally in the tissues of the animal, so adding it to the feed is not necessary. A deficiency of vitamin C results in loosening of teeth, brittle bones, slow growth, and a sore mouth; however, vitamin C deficiency usually does not occur in goats.



# Feedstuffs

## Classes of Feedstuffs

Feeds for goats are generally separated into two categories: forages and concentrates. The main purpose for feeding concentrates is to supply extra energy and nutrients (see table 5.2) required for growth and production above that which is obtained from forages. Feedstuffs commonly fed to goats are listed in table 5.11 at the end of this chapter, along with photographs of the most common.

**Table 5.2. Classifying feed ingredients into primary nutrient groups.**

**Carbohydrates**
- Corn
- Barley
- Beet pulp
- Forages (hay, pasture, etc.)
- Molasses
- Oats
- Rye
- Sorghum (milo)
- Soybean hulls
- Wheat
- Wheat middlings
- Whey

**Fats**
- Fish oil
- Tallow
- Rumen inert fats
- Vegetable oil
- Whole cottonseed
- Whole soybeans

**Minerals**
- Calcium carbonate (limestone)
- Dicalcium phosphate
- Trace mineral salt
- White salt

**Proteins**
- Alfalfa meal pellets
- Brewers grains
- Corn gluten feed
- Corn gluten meal
- Cottonseed meal
- Distillers grains
- Fish meal
- Soybean meal
- Urea

**Vitamins**
- Vitamin premix
- Vitamins A, D, and E

**Water**

## Forages

Forages are usually the foundation of the goat's diet. Forages are any feedstuff that contains the leafy part of the plant such as leaves, stems, flowers, etc. Fibrous feedstuffs, such as alfalfa hay and corn silage, are good examples. These feeds are high in fiber (which the goat needs to maintain proper rumen health) and may be excellent sources of protein, energy, calcium, and other minerals and vitamins. Forages, if grown, harvested, and stored correctly, can be an inexpensive source of important nutrients. Of course, forages are often grazed by goats.

Forage quality is very important. High-quality forages supply a large portion of the energy, protein, and some minerals and vitamins in a ration. Forage quality largely depends on the maturity of the forage at the time of consumption or harvest, processing, and storage. The quality of grasses or legumes can be measured based on stage of growth, with the quality of the forage decreasing as the plant matures. As these forages mature, energy, protein, mineral, and vitamin contents decrease, while fiber content increases. The higher fiber content, in turn, causes a decrease in the digestibility of the forage. It is recommended that the majority of forages be harvested in early maturity. Grasses and legumes have different standard values for fiber, protein, and minerals. They can generally be harvested either wet or dry and can be stored in the form of silage or hay, respectively. Whole plants of several grains can also be ensiled as forage sources, including corn, rye, oats, wheat, and barley.

Because the quality of forages can vary greatly by cutting, fields, and even within the same field, forages should have a nutrient analysis test done periodically so that ration adjustments can be made according to changes in the forage analysis. High quality (sufficient for rapidly growing animals or high-yielding lactating does) for a legume is 20-30-40, meaning 20% CP, 30% ADF, and 40% NDF. For high-quality grasses, the 20-30-50 rule applies. Relative Feed Value (RFV) is

used by some as an index of forage quality for legumes and grasses. The higher the RFV, the more valuable the forage. For example, an RFV of 100 relates to alfalfa that is in the full-bloom stage of maturity. An RFV of ≥ 150 is recommended for rapidly growing kids and high-yielding lactating does.

### Concentrates

Concentrates consist of cereal grain concentrates, protein concentrates, vitamin/mineral mixtures, and processed feedstuffs. Corn, oats, barley, sorghum, and wheat are examples of high-energy cereal grains that are commonly used in goat rations. Processing the grain by rolling, crimping, cracking, grinding, or steam flaking to expose the inner kernel increases the digestibility of the grain. This makes the starch more available to the rumen microbes, providing more energy to the animal. However, steam-flaked corn and finely ground dry corn are rapidly fermented in the rumen, so exercise caution in balancing the intake of these feeds with adequate forage intake.

Protein concentrates are concentrates that are high in protein. Protein is usually either from a plant or an animal source. These two sources, though they are both protein, are very different in that they are made up of different amino acids. Examples of high plant-concentrate sources are the oilseed meals, such as soybean meal, cottonseed meal, linseed meal, and canola meal. Some animal-protein concentrates are feather meal, blood meal, nonruminant meat and bone meal, and fish meal. It is usually advantageous to mix plant and animal protein sources in a ration to provide for the desired balance of amino acids.

## Feed Additives

### Buffers

Several feed additives, such as sodium bicarbonate and sodium sesquicarbonate, are added to diets to help maintain optimal rumen pH. Sodium bicarbonate is by far the most widely recognized and used rumen buffer. Some situations may necessitate adding buffers to diets:

1. Low forage/high concentrate diets
2. Diets high in fermentable carbohydrates (i.e., steam flaked corn)
3. Diets with small-particle-size forage that reduces the amount of time spent chewing
4. Diets where forage and concentrate are fed separately and at different times (i.e., feeding grain in the parlor)

### Direct-Fed Microbials

Direct-fed microbials consist of live bacteria, yeast, or extracts of fermentation products of yeast or bacteria. The exact mechanism of how they work is not exactly known. There is evidence that fiber digestibility and milk production may be increased when microbial additives are used. They also may be useful in recovery of animals that have been on antibiotic therapy.

### Ionophores

Ionophores are feed additives that are used to improve feed efficiency, control coccidiosis, and lower costs for growing animals. Ionophores work by changing the rumen bacterial environment and causing a shift in the production of the VFA to more propionate versus acetate. This provides more energy to the growing animal, causing the increase in feed efficiency. Because of the

shift in the microbial population, methane production is decreased by up to 30 percent when ionophores are fed. Ionophores also have an anti-coccidial activity and can help to reduce the incidence or severity of bloat.

An ionophore approved for the prevention of coccidiosis in goats is monensin (Rumensin®, ELANCO Animal Health, Greenfield, IN). Ionophores may be prohibited from being fed to certain animals and are toxic to horses and other nonruminant animals. Read feed tags carefully for warnings when feeding medicated feeds, and store these ingredients in a safe place away from other animals.

## Feed Tag Information

Feed tags provide important information about the nutrients and ingredients and help you choose a feed that meets your animal's needs and performance goals (see figure 5.2). Anyone selling feed commercially must supply a label or tag with each bag or bulk shipment of feed. Always read the tag to make sure you are getting what you want in the product and that you are not getting something that you do not want—such as the wrong medication or wrong feed ingredients. To provide your animals with the proper products, you must understand what is written on these tags.

Livestock feeds can be classified as either complete feeds or supplements. Complete feeds are those products containing all of the nutrients (except water and forages) required by the animals. Supplements are products that are added or mixed into other feed ingredients. They supply nutrients, such as additional protein, vitamins, minerals, or other additives, that may be lacking in the base feed. Supplements are usually added in small, specified amounts and are not to be fed as the total ration. The law requires that feed manufacturers provide the following labeling information on every bag or package of product:

### 1. Product Name and Brand Name

A product name is always present with or without a brand name. A feed tag usually contains a unique name to identify the feed (Goat Starter, Kid Grower, Lactating Doe Supplement, Goat Mineral, etc.).

### 2. Purpose of Feed

Each feed must have a purpose statement, specifying the species and animal class for which the feed is intended (Formulated for Lactating Does, Formulated for Growing Kids, Formulated for Kids, etc.).

### 3. Purpose of Medication and Active Drug Ingredients

If a drug is used in the feed, the word MEDICATED must appear below the name with a statement and claim of medication, followed by a listing of the active drug ingredients and the amount of drug in the product. For example: "For prevention of coccidiosis caused by *Eimeria crandallis, Eimeria christenseni,* and *Eimeria ninakohlyakimovae.* Monensin ..... 20 g/ton."

**GOAT STARTER MEDICATED**

Starter for Growing Kids

For the prevention of coccidiosis caused by Eimeria ovina, Eimeria crandallis, Eimeria ovinoidalis, Eimeria ninakohlyakimovae, Eimeria parva and Eimeria intricata in goats maintained in confinement.

**Active Drug Ingredient**

Lasalocid (As Lasalocid Sodium) ..... 90 G/ton

**Guaranteed Analysis**

Crude Protein ..... Min 20.00%
Crude Fat ..... Min 2.50%
Crude Fiber ..... Max 10.00%
Calcium ..... Min 0.75%
Calcium ..... Max 1.25%
Phosphorus ..... Min 0.55%
Salt ..... Min 0.40%
Salt ..... Max 0.90%
Selenium ..... Min 0.30 ppm
Vitamin A ..... Min 2,000 IU/lb

**Ingredients**

Processed Grain By-Products, Grain Products, Plant Protein Products, Forage Products, Roughage Products, Molasses Products, Ground Limestone, Salt, Lignin Sulfonate, Potassium Sulfate, Magnesium Sulfate, Magnesium Oxide, Sodium Selenite, Calcium Propionate, Vitamin E Supplement, Vitamin A Acetate, Vitamin D-3 Supplement, Zinc Sulfate, Zinc Oxide, Sodium Molybdate, Manganous Oxide, Calcium Iodate, Cobalt Carbonate, Ferrous Sulfate.

**Feeding Directions**

GOAT STARTER MEDICATED contains 45 mg of lasalocid per pound. Feed continuously as the sole ration to growing kids from 1 to 6 weeks of age at the rate of 0.33–1.55 pounds per head per day to provide not less than 15 mg and not more than 70 mg of lasalocid per head per day. Provide clean, fresh water at all times.

**Caution**

The safety of lasalocid in unapproved species has not been established; do not allow horses or other equine access to lasalocid as ingestion may be fatal; feeding undiluted or mixing errors resulting in excessive concentrations of lasalocid could be fatal to sheep.

Net Weight 50 Pounds (22.7 Kilograms)
or as shown on shipping document

Manufactured by Skillathon Feeds

Ohio State University Extension (Adapted from materials created by Dan Frobose, Agriculture and Natural Resources Educator, Wood County).

Figure 5.2. Sample feed tag.

## 4. Guaranteed Analysis

Guaranteed analysis on the product gives information on various nutrients present in the feed. Legally, the feed company is obligated to have feed nutrients listed within the range stated on the feed tag. For example: Minimum Crude Protein, Maximum ADF (Acid Detergent Fiber), and Minimum and Maximum Calcium. The type of product and/or species class that is listed determines what nutrients are listed on the feed tag.

**What does the guaranteed analysis not tell you?** The guarantees do not reflect the quality or feeding value of a feed. There is a difference between qualities of various feed sources. For example, copper from copper sulfate is 80–90% available (digestible; absorbed), whereas copper from copper oxide is only 5–10% available.

## 5. Ingredient Statement

The list of ingredients on the feed tag starts with the ingredient present in the highest concentration, then lists the other ingredients in decreasing concentration. Actual ingredients may be listed collectively, for example corn, wheat, oats, and barley may all be listed individually or collectively as "grain products." Collective terms represent a general classification of ingredients with a similar origin that perform a similar function but do not imply equal nutritional or digestibility values. The list of ingredients can be very useful or confusing. A collective term such as "Processed Grain By-Products" does not really tell you the specific sources. Therefore, it may be difficult to

determine the quality and digestibility of the product.

### 6. Feeding Instructions

Feeding instructions provide information on how the product should be fed.

### 7. Warnings and Cautions

Warnings and caution statements should be listed if medications are added to the feed. For example, any product containing monensin must carry the warning that it should not be fed to horses: "Do not allow horses or other equines access to feeds containing monensin. Ingestion of monensin by horses has been fatal."

### 8. Name and Address of Distributor

The name and mailing address of the company responsible for making or distributing the feed must be listed on the tag.

### 9. Net Weight Statement

The net weight statement serves to tell the purchaser the weight of the feed in the bag or bulk shipment. This may be listed in pounds (lb) or kilograms (kg). A kilogram is equal to 2.2 pounds. Therefore, a 50-pound bag may be listed as 22.7 kilograms.

## Feeding Systems

Pasture is a very common means of providing forage for goats, and many different legumes and grasses can be grazed. For the highest quality feed and most efficient forage growth, the land area should be fenced into different paddocks and the goats rotated among the paddocks. Goats should preferably be rotated among the paddocks every 3 to 7 days, but the frequency of the rotation depends on stoking density and forage growth. Goats also should be rotated among pasture areas as a control measure for internal parasites, allowing at least 3 weeks between rotations to break the growth cycle of the parasites. Growing kids and lactating does should be provided some concentrate mix daily to complement the forage consumed. For mature, nonlactating goats, plenty of pasture and a free-choice mineral supplement may be adequate. Plants in early stages of development and that are rapidly growing are low in magnesium (Mg) and high in potassium (high potassium intake reduces intestinal absorption of Mg), thus Mg supplementation of goats on pasture is advisable to reduce the risk of grass tetany.

Goats are more of a browser than are cattle and sheep, and goats eat grass much closer to the ground than cattle, so caution needs to be taken in avoiding damage to the established pasture with overstocking of animals. Goats have a narrow mouth, mobile upper lip, prehensile tongue, agile front legs, and extensible hind legs that aid in browsing and feed selection (Lu, 1989). Goats appear to tolerate bitterness in plants more than do other ruminant species (Lu, 1989). Goats may be less susceptible in general to toxic plants than cattle and sheep; however, their browsing nature increases the likelihood that they will consume potentially toxic plants.

Hay is the most common means of feeding stored forage to goats. For ease of handling and storage, small rectangular bales are most common, but large round or square bales can be used if properly stored and if the equipment for handling them is available. Balage (hay harvested at about 50% DM and stored in sealed plastic bags or wrapped) and silage can be used with goats, but it is difficult to feed sufficient quantity daily to

preserve feed quality, and listeriosis is a risk with inadequately preserved wet forage. Grain and hay are usually fed separately (see figure 5.3), but if the forage and grain are mixed together prior to feeding, this mixture is commonly referred to as a total mixed ration (TMR). With a TMR, the forage and concentrate are fixed. When forage and grain are fed separately, grain is limited based on the animal's needs and forage is fed free choice. Grain should never be fed free choice (unless it is in the case of creep feeding young kids) because the animal will eat too much. In a long-term situation, the animal may get too fat, but the highest risk is for acute illness (rumen acidosis) due to low rumen pH and associated health problems.

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Figure 5.3. Grain and hay are usually fed separately to goats and the concentrate mixture is a blend of cereal grains, and protein, mineral, and vitamin supplements.

Because of goats' ability to select feeds, grain mixtures should be pelleted or well textured, otherwise fine particles (e.g., mineral and vitamin supplements) and unpalatable ingredients are not consumed. Adding molasses to a textured feed may also help to minimize separation of the fine particles. Goats like to climb, so they often attempt to get into the feed trough, leading to fecal contamination of the feed and increased risk for disease transmission. Therefore, feed troughs, whether for hay (manger with slats or key holes) or grain, need to be constructed so that goats are not able to put their feet in contact with the feed (see figure 5.4).

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Figure 5.4. Feed troughs need to be constructed in a way that prevents goats from climbing in them.

## Feeding Kids

### Digestive System of a Kid

The digestive system of a newborn kid functions like that of a nonruminant during the first few weeks of life. When a kid is born, the rumen, the reticulum, and the omasum are very small and undeveloped. The abomasum or true stomach is the primary stomach compartment that functions in a kid. In a newborn kid, liquid feed bypasses the rumen and goes directly into the abomasum by way of the esophageal or reticular groove. The reticular groove runs from the base of the esophagus, along the edge of the reticulum, and into the abomasum. During suckling, the groove's edges contract to form a tube from the reticulum to the abomasum, allowing milk to bypass the rumen. As a young kid increases its intake of grain, the rumen and the rumen papillae (projections from the rumen wall where absorption takes place) grow. As a kid continues to mature, the digestive system

matures, and the esophageal groove ceases to close. The rumen of a kid gets larger and develops before weaning occurs. By the time a kid is weaned, the rumen is well developed.

## At Birth

The first and most important feed for a newborn kid is colostrum. Colostrum is a newborn kid's primary source of nutrients and antibodies. Colostrum is the milk that a kid's mother produces immediately after the kid is born. This milk is yellow, thick, and very nutritious. True colostrum is obtained only from the very first milking. True colostrum is higher in energy, protein, vitamins, and minerals than regular milk (table 5.3).

**Table 5.3. Composition of colostrum and normal milk from goats.**

| | Colostrum | Normal Milk |
|---|---|---|
| Total solids (percent not water) | 32% | 13.0% |
| Protein | 16% | 3.4% |
| Fat | 8% | 4.2% |
| Lactose | 3% | 4.7% |
| Ash (minerals) | 1% | 0.8% |

The most important element of colostrum is a large amount of immunoglobulins (antibodies) from the mother. Kids are born with little or no protection to disease or infection. The antibodies provide kids with some immunity and protection against diseases. The antibodies that a kid receives from its mother in the colostrum are very important for the kid's survival. This is called passive immunity because antibodies are transferred passively from the mother to the kid, versus active immunity, where the kid's immune system is working and is manufacturing its own antibodies. The types of antibodies that are in the mother's colostrum represent the diseases to which the doe has been exposed or vaccinated. For this reason, an older doe's colostrum is going to be of better quality (have a wider range of antibodies) than that of a young doe.

A kid's resistance to disease is influenced by the quality of colostrum and also by when it receives the colostrum. Kids absorb the antibodies through their gut wall. In the hours after a kid is born, the gut becomes less able to absorb the antibodies, so that by the time the kid is 24 hours old, the gut is unable to absorb the large antibodies.

Kids should receive 1 ounce of colostrum for every pound of body weight (BW) at each of three feedings during the first 24 hours after birth. The first feeding should be within the first hour and the second feeding within the next 6 to 8 hours. Kids should only be fed colostrum of high quality (ample concentration of antibodies). The quality of colostrum can be measured using an instrument called a colostrometer. Kids should continue receiving does' milk for at least the first three days after parturition. Although a kid is not able to absorb the antibodies after the first day, the milk may benefit the kid by keeping the intestinal tract healthy and because of the higher nutrient density.

## Colostrum Storage

Some high-quality colostrum should always be kept frozen in the event a doe at kidding does not have any colostrum, has poor quality colostrum, is sick, or dies during kidding. Colostrum should be thawed at room temperature or in a warm water bath. Heating colostrum in a conventional or microwave oven to thaw it can damage or destroy the antibodies. If a doe has poor quality colostrum at kidding and you don't

have any frozen colostrum at your home, contact another goat owner to determine if they have some colostrum that you can use. If this is not available, contact a goats farmer to inquire about obtaining frozen doe colostrum from their farm. It is always best to provide high-quality colostrum from does at your farm, but if such colostrum is not available, other sources are much better than not feeding colostrum at all.

## After 3 Days

After 3 days of age, you must decide if you want to continue to let a kid nurse or if you want to put it on milk replacer; of course, this decision may be based on whether you have meat or dairy goats. If you have dairy goats, excess colostrum (dilute 50% with warm water because it is more concentrated than normal milk) and waste milk (milk that cannot be used for human consumption) are the cheapest feeds for kids. If these are not available, consider whole milk from the does or milk replacer. Whole milk contains the appropriate amounts of protein, energy, vitamins, and minerals for kids. However, the cheapest option for milk feeding depends on milk prices and the price of milk replacers.

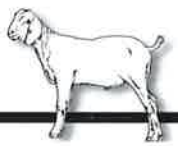
Kids should be fed milk daily at about 30% of their BW (7 lb * 0.3 = 2.1 lb or 34 oz/day of milk). It is best to feed this amount of milk over 3 to 4 feedings per day during the first 4 to 6 weeks of age, and then the stated amount of milk can be provided at 2 feedings per day. If you have meat goats, it is best to cross-foster a kid onto another doe rather than to hand-feed. Although goat milk replacer is preferred, kids can be raised on milk replacer for calves. However, the kids are susceptible to bloating from milk replacers that contain a high amount of lactose (for example, milk replacers for calves). A good milk replacer should meet recommended standards and be fed according to the label instructions. The milk replacer should contain a coccidiostat (for example, decoquniate; Deccox®, Alpharma Animal Health, Fort Lee, NJ; or an approved ionophore) to help prevent scours. The coccidiostat can be included in the grain starter, but kids do not eat enough, especially during the first couple of weeks, to provide adequate intake of the medication to prevent coccidiosis.

By the second week of life, start to offer kids a high-quality grain starter. If a grain starter specifically developed for kids is not available, a kid starter can be used. This helps with the development of the rumen and growth of the rumen microbes. It is not recommended to feed hay until after weaning. Feeding hay prior to weaning reduces starter intake, causing kids to develop a "pot-bellied" appearance. Additionally, hay is not needed for the rumen at this time. Of course, nursing kids may nibble on the pasture or hay fed to the does. Creep feeding the kids is convenient and allows the kids access to ample amounts of grain. Creep feeding also takes place before kids are weaned. By building a pen with an entrance large enough for only kids (approximately 5 inches wide X 12 inches high), you can make grain (usually at least 16% CP on an as-fed basis) available to kids at all times. Always have fresh water available for the kids. During the kid's first few weeks of life, one or two injections of selenium may be advisable to prevent against white muscle disease. Consult your veterinarian for recommendations in your area.

## Weaning

A kid can be weaned when it is consuming about 1% of its BW per day of starter (2–3





oz per day) for three consecutive days. This usually occurs when the kid is 2.5 times it birth weight and is 6 to 8 weeks old. For kids that nurse the doe, especially with meat goat breeds, weaning should occur at about 12 weeks of age. If you are purchasing milk replacer, it is more economical to wean kids as early as possible because milk and milk replacer are more expensive than dry feed. The milk should be reduced to half the full feeding rate for 1 week before removing all of the milk from the diet. Keep fresh grain starter available to kids at all times to stimulate eating, and add hay to the diet after weaning to promote rumen growth. Always make feeding changes gradually—this helps reduce digestive problems and the risk for enterotoxemia.

## After Weaning

The nutrient requirements of kids vary, especially depending on their BW and average daily gain (ADG) (see table 5.4). After weaning, kids should be fed a good starter/grower feed (commercial mix or one similar to those shown in table 5.5) and high-quality forage ad libitum (free choice). The amount of feed consumed also depends on the kid's BW and its ADG (usually between 120 and 300 g/day). Even if kids have access to all the pasture they want, some supplemental grain should be provided to complement the pasture, making sure mineral and vitamin intakes are adequate (see table 5.6). Depending on BW, growth, and forage quality, kids will generally be fed 0.5 to 1.0 lb/day of grain. The growth rate of dairy goat kids is slower than that for meat goat kids (see figure 5.5). The grain supplement should contain an approved ionophore (for example, monensin) to help reduce the risk of coccidiosis and improve feed efficiency. In general, the growth rate of kids should allow them to reach market weight at 6 to 7 months of age, and replacement does should be of breeding size (> 70 lb for most dairy and meat breeds) by 7 to 10 months of age. Overfeeding energy and underfeeding protein, especially before puberty, can result in overweight kids that lack adequate frame. As kids mature, their nutritional requirements change. Younger kids lack the rumen capacity to maintain satisfactory weight gains if they are fed only forage. Older kids, however, have sufficient rumen capacity for adequate growth if fed only high-quality forage rations, with some mineral supplementation. Abundant pasture may be adequate for older kids, but grain supplementation may be needed as pasture growth slows in the summer months. Growth and body condition (relative degree of body fat) of kids should be routinely monitored.

Typically, meat goats are not put on a finishing ration prior to harvest like some other meat animals because the consumer does not prefer "fat" goats, goats are not very efficient in converting feed into fat tissue, and this practice increases costs without adequate return. If a finishing period is used, it is usually for 30 to 60 days, and the kids are fed a ration of about 15% hay and 85% grain. The grain mixture can be a blend of shelled corn and protein concentrate pellet (for example, corn and 16% CP concentrate in a ratio of 1:1) or a grain mixture similar to the one in table 5.5 for legume hay with 15% CP.

**Table 5.4. Dry matter intake and nutrient requirements for growing kids.[1]**

| BW (lb) | ADG (lb/day) | DM Intake (lb/day) | NE (Mcal/day) | CP (g/day) | Ca (g/day) | P (g/day) |
|---|---|---|---|---|---|---|
| 20 | 0.3 | 1.5 | 0.7 | 66 | 4 | 2 |
| 20 | 0.6 | 2.6 | 0.7 | 104 | 6 | 4 |
| 40 | 0.3 | 2.0 | 1.2 | 84 | 5 | 3 |
| 40 | 0.6 | 3.1 | 1.3 | 123 | 7 | 4 |
| 60 | 0.3 | 2.4 | 1.7 | 100 | 6 | 3 |
| 60 | 0.6 | 3.5 | 1.7 | 139 | 8 | 5 |
| 80 | 0.3 | 2.8 | 2.1 | 115 | 7 | 4 |
| 80 | 0.6 | 3.9 | 2.1 | 154 | 9 | 5 |
| 100 | 0.3 | 3.3 | 2.4 | 129 | 8 | 4 |
| 100 | 0.6 | 4.3 | 2.5 | 168 | 10 | 6 |

[1]BW = body weight, ADG = average daily gain, DM = dry matter, NE = net energy, and CP = crude protein.

Source: Based in part on National Research Council's Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries. 1981.

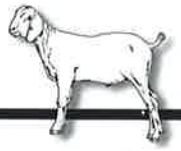
**Table 5.5. Example concentrate mix (as-fed basis) for a growing kid consuming either alfalfa or grass hay free choice.[1]**

| Grain Ingredient | Legume Hay (20% CP) | Legume Hay (15% CP) | Grass Hay (15% CP) |
|---|---|---|---|
| | % of concentrate mix | | |
| Corn, cracked or rolled | 70.0 | 55.0 | 54.0 |
| Oats, whole or crimped | 21.0 | 22.0 | 21.0 |
| Soybean meal, 48% CP | --- | 11.0 | 10.5 |
| Molasses | 8.0 | 11.0 | 10.5 |
| Dicalcium phosphate | --- | --- | 3.0 |
| Trace mineralized salt | 1.0 | 1.0 | 1.0 |

[1]CP = Crude protein.

**Table 5.6. General guidelines for dietary mineral concentrations for goats (DM basis).**





| Mineral | Lactating Does | Dry Does | Kids |
|---|---|---|---|
| Calcium, % | 0.70 | 0.42 | 0.55 |
| Phosphorus, % | 0.36 | 0.24 | 0.30 |
| Magnesium, % | 0.25 | 0.16 | 0.16 |
| Potassium, % | 1.00 | 0.65 | 0.65 |
| Sulfur, % | 0.20 | 0.20 | 0.20 |
| Iron, ppm | 50 | 50 | 50 |
| Manganese, ppm | 40 | 40 | 40 |
| Copper, ppm | 12 | 12 | 12 |
| Zinc, ppm | 50 | 50 | 50 |
| Selenium, ppm | 0.3 | 0.3 | 0.3 |
| Vitamin A, IU/lb | 1800 | 1800 | 1000 |
| Vitamin D, IU/lb | 450 | 450 | 140 |
| Vitamin E, IU/lb | 10 | 40 | 11 |

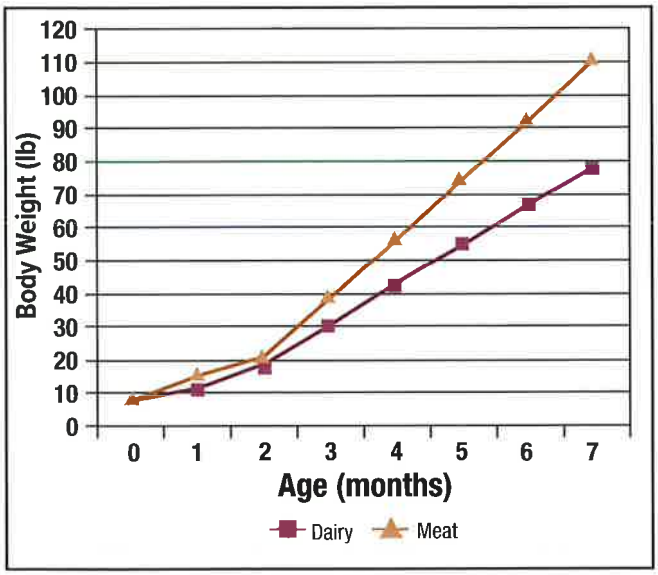



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Figure 5.5. Comparative growth chart for dairy versus meat goat kids.

## Feeding Mature Goats

### Maintenance

The nutrient requirements for goats that are not growing or lactating are relatively low. They usually eat 2.5 to 3.5% of their BW as DM, 11 to 12% of which should be CP. Be cautious about letting the animals get too fat. Except for some mineral supplementation, most of their nutritional needs can usually be met by stored forages or pasture.

### Feeding Bucks

Mature bucks can obtain most of their nutrients from forages. Bucks must be in good condition prior to the breeding season, as they will likely lose weight during the breeding season because of increased activity. To improve body condition prior to breeding, bucks can be fed 0.25 to 0.5% of their BW as grain. To reduce the risk of

urinary calculi, calcium intake by bucks should be limited; therefore, legume forage consumption by bucks should be limited. Whole cottonseed or cottonseed products should not be fed to breeding bucks because cottonseed can contain gossypol that may decrease male fertility.

## Feeding Does Prior to Breeding

Does should not be overconditioned going into the breeding season, so their energy intake needs to be constantly managed. Overconditioned does are at higher risk for health problems at kidding, especially for pregnancy toxemia and dystocia. About 2 weeks prior to breeding, it may be advantageous to increase the energy intake of does—this is called "flushing." This management practice may increase the number of ovulations, thus potentially increasing the number of multiple births. Flushing is usually accomplished by feeding about 0.5 lb/day of shelled or cracked corn. If the does have been on low-quality forage, turning them to lush pasture may have the same effect.

## Feeding Does Prior to Parturition

Feeding the dry does separately from the lactating does is very important in making a smooth transition from the dry to lactating states. During the later 2 to 3 weeks of gestation, the grain feeding to the dry doe should be increased to meet the increased requirements for fetal development, to allow the rumen and its microorganisms to adjust to more dietary starch, and to accommodate for some of the drop in DM intake during the last few days before parturition. About 1% of BW as grain should be fed daily during this time. The increased energy intake also is important to reducing the risk of pregnancy toxemia (acetonemia; ketosis); does with multiple fetuses are especially at risk. Intake of calcium should be limited (for example, limit feeding of legume hay) to reduce the risk of parturient paresis (milk fever) after kidding. To prevent white muscle disease in the kids after birth, it may be advisable to inject the does with selenium at 2 to 3 weeks prior to kidding. Consult your veterinarian for advice.

# Feeding the Lactating Doe

Nutrient requirements for lactating does are higher than for most any other life stage for goats; therefore, they need to eat a lot of feed. Nutrient requirements (see table 5.6) and DM intake (see table 5.7) will vary primarily by BW, age, milk yield, and milk composition. The yield of milk and milk composition vary by breed of dairy goats (see table 5.8). You can split the lactation period into different stages: early lactation, mid-lactation, and late lactation. It is important to feed does appropriately for each stage. Overfeeding can result in lost income and overconditioned or fat does. Underfeeding can result in animals not reaching their genetic potential and lost growth in does during their first lactation. Energy is usually the nutrient that is most limiting in diets for lactating does. This can be a challenge with high-producing does and does in early lactation. For dairy does, your goal should be to feed the does for maximum milk production, while maintaining good health. For nondairy breeds of goats, the goal is to feed the does for adequate milk for the kids that are nursing and to maintain good health of the doe. Commercial grain mixtures for goats are often available. If such concentrate mixtures are not available in your area, grain mixtures for goats can be used (grain mixtures for sheep are not advised because the copper requirement

for goats is higher than for sheep). You can also prepare your own grain mixture. Some example concentrate mixtures for lactating does are provided in table 5.9, and suggested feeding rates are provided in table 5.10 based on milk yield, milk composition, and quality of forage.

The majority of dairy rations have forage to concentrate ratios of 40:60, 50:50, and 60:40. This is to try to maintain enough forage in the diet for good rumen health and to maintain enough energy for maximum milk production. Forage quality influences what that ratio should be depending on the nutrient requirements for a group of animals.

The decline in milk production after peak milk is known as "persistency." The downward slope on the lactation curve is a measure of persistency. The gentler the slope, the more persistent the animal. First lactation does generally have lower peak milk but are more persistent than older does, which have higher peak milk. This makes the lactation curves of the young does much flatter. After peak milk yield, milk production should be approximately 90 to 95 percent of the previous month's milk yield, meaning that milk production for the current month should be 90 to 95 percent of the milk production achieved in the previous month. The length of lactation varies, but for most dairy breeds, the length of lactation is about 10 percent shorter than for goats.

Examining your animal's lactation curve can be helpful in locating feed and management problems in the herd. High-producing does require a high peak and good persistency. Does that are not peaking well may indicate problems in the transition feeding from the dry period to the lactation ration (change may be too abrupt), and does lacking persistency may indicate a nutrient or energy deficiency in the ration.

## Early Lactation

Following kidding, the doe's body is going through many changes, with the main event being the onset of lactation. Making milk requires large amounts of energy. Does lose BW during early lactation because milk production peaks earlier than DM intake. In other words, the doe cannot eat enough feed to keep up with the nutrient needs for maintenance and milk production. This puts her in a state of negative energy balance. She compensates some by using her own body fat reserves. This is why does always lose weight after kidding and why it is important for them to have high-quality feed and adequate body reserves (body condition). A goal is to minimize the length of time and the extent that the negative energy balance occurs by using good feeding practices.

The main challenge for early lactation does is providing a diet that has enough energy density, but also enough fiber to maintain a healthy rumen. This makes it very important to feed high-quality forages that provide a minimum of 26 to 28% of NDF in the dietary DM. To avoid digestive upsets, feedstuffs should not be ground too fine or chopped too small. Feed and fresh water should be available at all times.

## Mid-lactation

Does at this stage are doing many things that require their bodies to be healthy. They are producing milk, getting pregnant, maintaining pregnancy, and regaining body condition lost in early lactation. Energy is still the most limiting nutrient, and good quality forages are very important.

## Late Lactation

Does in late lactation are still an important group to be managed nutritionally. At this

point, milk production is decreasing and body reserves are being replenished. It is important in this time period to avoid letting does become too fat. Nutritionally, energy and protein requirements are less during this stage than for does in early and mid-lactation. Balancing rations for late lactation does can prevent overfeeding, which can lead to fat does, lost income from feed costs that are higher than necessary, and health problems at the next parturition.

**Table 5.7. Dry matter intake (% of body weight) for lactating dairy goats.**

| FCM[1] (lb/ day) | Body weight (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 |
| 2 | 4.1 | 3.5 | 3.2 | 3.0 | 2.8 | 2.7 | 2.6 | 2.5 |
| 4 | 5.5 | 4.4 | 3.8 | 3.5 | 3.3 | 3.1 | 3.0 | 2.8 |
| 6 | | 5.3 | 4.5 | 4.0 | 3.7 | 3.5 | 3.3 | 3.1 |
| 8 | | | 5.2 | 4.6 | 4.2 | 3.9 | 3.6 | 3.4 |
| 10 | | | | 5.1 | 4.6 | 4.2 | 4.0 | 3.7 |
| 12 | | | | | 5.1 | 4.6 | 4.3 | 4.0 |
| 14 | | | | | | 5.0 | 4.6 | 4.3 |
| 16 | | | | | | | 5.0 | 4.6 |

[1]4% Fat-corrected milk (FCM) = (0.4 * lb milk) + (15 * lb fat)

**Table 5.8. Milk yield and composition for some of the most common goat breeds based on individual doe lactations during 2005 (ADGA, 2005).**

| Breed | Number of does | Age at Start of Lactation | Milk Yield (lb/ lactation)[1] | Milk Fat (%) | Milk Protein (%) |
|---|---|---|---|---|---|
| Alpine | 493 | 3 yr, 6 mo | 2334 | 3.3 | 2.9 |
| Lamancha | 234 | 2 yr, 6 mo | 2050 | 3.9 | 3.1 |
| Nubian | 457 | 2 yr, 6 mo | 1754 | 4.8 | 3.7 |
| Oberhasli | 63 | 2 yr, 6 mo | 2137 | 3.4 | 2.8 |
| Saanen | 381 | 2 yr, 6 mo | 2537 | 3.3 | 2.9 |
| Toggenburg | 192 | 3 yr, 6 mo | 2101 | 3.3 | 2.8 |

American Dairy Goat Association, 2005.

[1]Based on Dairy Herd Improvement Registry. Individual doe records not corrected for age.

**Table 5.9. Example concentrate mix for lactating does consuming either alfalfa or grass hay free choice.[1]**

| Grain Ingredient | Legume Hay (20% CP) | Legume Hay (15% CP) | Grass Hay (15% CP) |
|---|---|---|---|
| | % of concentrate mix | | |
| Corn, cracked or rolled | 61.7 | 69.0 | 68.3 |
| Oats, whole or crimped | 32.2 | 14.1 | 13.7 |
| Soybean meal, 48% CP | 4.0 | 15.5 | 15.0 |
| Limestone | 0.8 | — | 1.6 |
| Dicalcium phosphate | 0.5 | 0.6 | 0.6 |
| Trace mineralized salt | 0.8 | 0.8 | 0.8 |

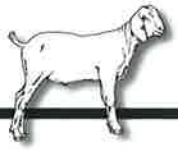
[1]CP = Crude protein.

**Table 5.10. Suggestions for amount of grain (lb/day; as-fed basis) to feed to lactating does based on milk yield, milk fat concentration, and quality of forage.[1]**

| Milk yield (lb/day) | 3.5% Milk fat | | 4.5% Milk fat | |
|---|---|---|---|---|
| | 15% CP Forage | 20% CP Forage | 15% CP Forage | 20% CP Forage |
| 2 | 1.0 | 1.0 | 1.0 | 1.0 |
| 4 | 2.0 | 1.5 | 2.5 | 2.0 |
| 6 | 2.5 | 2.0 | 3.0 | 2.5 |
| 8 | 3.0 | 2.5 | 3.5 | 3.0 |
| 10 | 3.5 | 3.0 | 4.0 | 3.5 |
| 12 | 4.0 | 3.5 | 4.5 | 4.0 |

[1]CP = Crude protein.





## Balancing Rations

A balanced ration is one that provides all the necessary nutrients that the animal needs during one day. To balance a ration, you need to list the animal's requirements and determine which feeds and the amounts of those feeds that are necessary to meet those requirements and keep the animal healthy.

## As-Fed Versus Dry Matter

Some feeds commonly fed to goats contain large amounts of water (for example, high moisture corn, corn silage, and molasses) and all feeds have some variability in water content, so rations are formulated on a dry matter (DM) basis. How do you convert the nutrient content to a DM basis? Let's examine alfalfa hay that is 88% DM and 12% water (as-fed). This means that for every 100 lbs of hay, as-fed, 12 lb is water and 88 lb is actual hay.

To convert the amount of feed from an as-fed to a DM basis, you need to know either the percentage DM or the percentage of water in the feed. This can be determined by a nutrient analysis from a lab. There are also several simple on-farm methods for determining DM. Use the equation below to convert the amount of feed from as-fed to DM basis.

$$\text{Pounds of Feed (DM basis)} = \frac{\text{Pounds of Feed As-Fed} \times \%\text{ DM}}{100}$$

**Example:** You have 5 lb of hay at 88% DM that you are feeding your doe each day. How many lbs of hay DM is she eating per day?

$X = 5 \times (88/100)$, where x = lb of DM

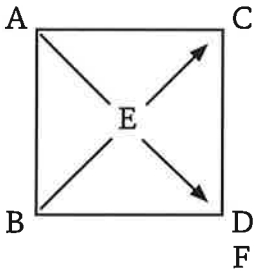
= 4.4 lb of DM

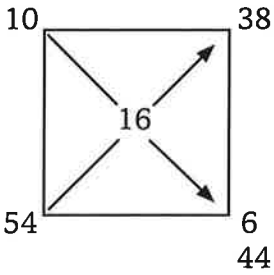
There aren't very many computer programs designed to formulate and/or evaluate rations for goats, but spreadsheets can be designed to be quite helpful with some of these calculations. However, if forage DM changes or a protein value changes, it is helpful to know how to change your ration easily, especially if the computer is not available.

Some simple guidelines for formulating rations are as follows:

- Always formulate rations on a DM basis.
- The percentage of a nutrient in a feed on a DM basis is always higher than it is on an as-fed basis.
- The amount of DM consumed or required is always less than the feed consumed on an as-fed basis. Remember: DM is the amount fed minus water, and as-fed is with water.

Once DM is known, there is an easy way to make mixtures with a desired concentration of a nutrient. It is called a Pearson's Square.




**Example:** You would like to mix corn and soybean meal to make a 16% crude protein mixture on a DM basis.

1. Draw a square.
2. Place an E for the concentration of the mixture that you would like in the middle of the square.
3. Place at A and B the concentration of the nutrient in the feeds (DM basis) you are using.

Corn – 10% CP and Soybean Meal – 54% CP

4. Subtract diagonally: A – E = D and B – E = C and put the results on the right side of the square and disregard the sign of the result.
5. The C is the number of parts of feed A, and D is the number of parts of feed B. Do not get confused because that is not how the numbers were determined.
6. Add C + D together to determine F, divide C by F and multiply by 100 to get the percentage of C:

   (C ÷ F) × 100 = % C

   (38 ÷ 44) × 100 = 86%

   and now do the same for D.

You can check your answer by:

86% corn × 0.10 (proportion of protein) = 8.6%

14% soybean meal × 0.54 = 7.6%

8.6% + 7.6% = 16.2% (does not exactly equal 16% because of rounding)

This can be done for any nutrient as long as you know the composition of your feed ingredients. Also, the exercise can be done on an as-fed basis. Use the desired concentration of the nutrient on an as-fed basis and the nutrient concentration in feeds on an as-fed basis (A and B). Then C and D will be the proportion of feeds to use on an as-fed basis.

Another item that is important is determining DM of forages, especially if a lot of wet forage, such as silage, is used in the ration. If your silage DM changes from 35% to 45%, how does the amount of silage in the ration need to change?

For this, you need to know how DM is determined. For example, there is 80 lb of corn silage in your mix on a DM basis. That is 228.6 lb as-fed with the corn silage at 35% DM.

Here is the equation:

DM (lb) = As-fed (lb) × (% DM ÷ 100)
= 80 lb = X × 0.35
(80 ÷ 0.35) = X (as-fed) = 228.6 lb as-fed

So, if the DM changes suddenly for the corn silage from 35% to 45%, how much corn silage should be in your mix on an as-fed basis to maintain the 80 lb DM of corn silage?

80 = X × 0.45
80 ÷ 0.45 = X = 177.8 lb as-fed

So the amount of corn silage changed from 228.5 to 177.8 lb in the ration. This is something that you can easily check on the farm and change without having to consult your nutritionist or feed salesperson for a new ration.

Example diets for different stages of production are found earlier in the chapter. Examine the chart below for examples of feedstuffs fed to goats.



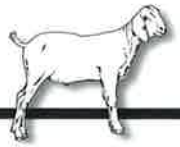


**Table 5.11. Feedstuffs fed to goats. These feedstuffs are used throughout the livestock industries.**

| Name of Feed | Color | Texture | Other Characteristics |
|---|---|---|---|
| Alfalfa meal pellets, dehydrated | Green | Smooth | Tubular shaped particles that may be of varying lengths because of breakage of the pellets. |
| Barley, steam-rolled | Brown | Flaky | Whole barley that has been steamed and rolled; look for creases in the kernel caused by the roller; darker color and shorter in length than rolled oats. |
| Barley, whole-grain | Brown | Slightly rough with irregular edges | Particles are shorter than for oats. |
| Brewers grain | Brown | Flaky | By-product from making beer from grains; particles more oblong than for soybean hulls. |
| Buckwheat | Brown to light black | Smooth with sharp edges | Grain grown in limited quantities. |
| Complete pelleted feed | Light brown with yellow spots | Smooth | Tubular shaped particles that may be of varying length because of breakage of the pellets. |
| Corn, cracked | Yellow/White | Rough | Whole corn kernels that have been broken; starch may stick to fingers. |
| Corn gluten feed | Light brown | Flaky | By-product from removing starch, oil, germ, and gluten from corn. |
| Corn gluten meal | Yellow | Granular to powdery | By-products from removing starch, oil, and germ from corn. |
| Corn, ground | Yellow | Powdery | Whole corn ground very fine. |
| Corn, whole kernel | Yellow | Smooth | Most common cereal grain in Ohio. |
| Cottonseed meal | Brown | Granular to powdery | By-product from removing oil from cottonseeds. |
| Cottonseed, whole | White | Fuzzy | By-product from removing cotton lint from seeds. |
| Dicalcium phosphate | Gray | Granular | Looks like small rocks of uniform sizes. |
| Distillers grains | Brown | Flaky to powdery | Sweet smell; by-product from making alcohol for liquor or fuel. |
| Fish meal | Brown | Powdery | Smells like fish; look for tiny bone chips; by-product from fisheries or removal of oil from fish. |
| Hay cube | Green | Rough | Large cube with noticeable hay particles pressed together. |
| Limestone, ground | Light gray | Granular | Looks like small rocks of various sizes. |
| Linseed meal | Varies from light to dark brown | Granular | By-product from removing oil from flax-seed; not commonly used in most areas of the United States. |
| Milo (whole-grain sorghum) | Reddish-brown | Smooth | Round, bead-like grain. |
| Molasses, dry | Dark brown | Flaky and/or Granular | Sweet smell; high in sugar; made from sugar beets (most common source) or sugar cane. |



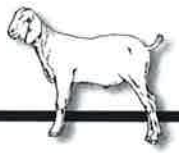


**Table 5.11 (continued).**

| Name of Feed | Color | Texture | Other Characteristics |
|---|---|---|---|
| Oats, steam-rolled | Light brown | Flaky | Whole oats that have been steamed and rolled; look for creases in the kernel caused by the roller |
| Oats, whole-grain | Brown | Slightly rough with irregular edges | Common cereal grain fed for its fiber. |
| Rye, whole-grain | Brownish-gray | Smooth with round edges | Particles are longer than for wheat. |
| Salt, trace mineral | Bronze | Granular, grainy | Looks like tiny, uniform crystals. |
| Salt, white | White | Granular | Looks like tiny, uniform grainy crystals. |
| Soybean hulls | Light brown | Flaky | Look for dark specks from the outer coat of soybeans; by-products of removing oil from soybeans. |
| Soybean meal | Light brown | Granular to flaky | By-product after removing oil from oil-seeds; 44% crude protein (CP) soybean meal = soybean meal plus soybean hulls; 48% CP = soybean meal without hulls. |
| Sugar beet pulp, dried | Grayish-brown | Rough | Looks like a dried root; by-product from removing sugar from beets. |
| Urea | White | Granular | Small bead-like particles; used as a source of nonprotein nitrogen for ruminant animals. |
| Wheat middlings | Brown with white spots | Flaky | By-product from removing starch from wheat; looks like crumbled bran cereal. |
| Wheat, whole-grain | Brown | Smooth with round edges | Look for crease along the middle of one side. |
| Whey, dried | Light brown | Powdery | Smells sweet like milk replacer; by-product from making cheese. |

Prepared by Dr. Maurice L. Eastridge, Department of Animal Sciences, The Ohio State University.

## Feedstuffs

Department of Animal Sciences, The Ohio State University.

Whole-Grain Oats

Department of Animal Sciences, The Ohio State University.

Dry Molasses

Department of Animal Sciences, The Ohio State University.

Cracked Corn

Department of Animal Sciences, The Ohio State University.

Whole-Kernel Corn

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Complete Pelleted Feed

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Steam-Rolled Oats

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Trace Mineral Salt

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Steam-Rolled Barley

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Ground Limestone

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Hay Cube

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Dried Sugar Beet Pulp

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Wheat Middlings

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White Salt

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Dicalcium Phosphate

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Fish Meal

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Urea

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Dehydrated Alfalfa Pellets

Department of Animal Sciences, The Ohio State University.

Whole-Grain Wheat

Department of Animal Sciences, The Ohio State University.

Cottonseed Meal

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Whole-Grain Barley

Department of Animal Sciences, The Ohio State University.

Soybean Meal

Chapter 7

# Dairy Goats

Dairy goats are a common project for 4-H youth because they are easy to handle and require minimal space. They also provide milk that can be consumed by the family, possibly sold (limited market potential), or used to make other products such as cheese. However, the milking procedure requires more time and daily commitment than the care and management of other types of goats. Some dairy goat breeds produce more milk, others produce milk with higher concentrations of fat and protein, and others are desirable because of their smaller size. You should select a dairy goat based on your preferences and project goals.

This chapter describes the anatomy and health of the mammary gland, composition of milk, and the procedures and equipment used for harvesting the milk from goats.

## The Mammary Gland

Mammals are warm-blooded animals that give birth to live young and produce milk in mammary glands to feed their young. Goats are mammals and have a mammary gland or udder. The goat's udder has two sections or halves, each being a separate gland. The definition of a gland is "a cell, group of cells, or organ of endothelial origin that selectively removes material from the blood, concentrates or alters them, and secretes them for further use in the body or elimination from the body."

The mammary gland is very unique and has several roles:

1. It has the ability to remove nutrients from the bloodstream that originate from digestion and absorption from feedstuffs.
2. It can process and synthesize nutrients obtained from the bloodstream into milk components and secrete them into a gland.
3. It has the ability to secrete or remove milk from the gland.

The goat's udder has two separate halves, with separate glands in each half. The udder is attached to the body by a very strong support system. The main support, which also divides the udder into halves, is the medial suspensory ligament. This elastic ligament stretches and allows the udder to fill with milk. The other supporting structures are the lateral suspensory ligaments, which are fibrous connective tissue that supports the sides of the udder and comes down the sides of the udder to join with the medial suspensory ligament.

These ligaments help keep the udder closely attached to the body. If these support structures start to break down or are not very tight initially, the udder will be pendulous. Pendulous udders are easily injured because they are closer to the ground and also because they swing easily, sometimes hitting hard surfaces. Pendulous udders also cause problems with milking. These factors can decrease the length of time the animal spends in the herd.

Illustrations of goat mammary structure are on the following pages.

## Anatomy of the Mammary Gland

Let's start with the smallest unit in the udder and look at the pathway milk follows as it moves out (see figure 7.1). The smallest unit in the udder is called an alveolus (plural is alveoli). This is where the milk is actually made. Surrounding each alveolus are myoepithelial cells, or muscle cells, and very small blood vessels called capillaries. The alveoli are in groups, like grapes. These groups form alveolar lobes. The lobes empty into small milk ducts, which empty into large milk ducts. The large milk ducts empty into the gland cistern. A majority of the milk is stored and held in the gland cistern. This is different from cattle, because cattle store most of their milk in the alveoli with very little storage in the gland cistern.

The teat cistern is the next area; milk empties out of the teat cistern through the streak canal. The streak canal or teat canal is lined with a sticky, waxy substance called keratin. Keratin helps keep bacteria out of the mammary gland and prevent mastitis. Circular muscles called the sphincter muscles surround the streak canal. Sphincter muscles can be loose or tight, affecting how fast the milk is released. Does that milk out easily or that start to leak before you get to milk them may have loose sphincter muscles. Hard-milking does may have tight sphincter muscles.

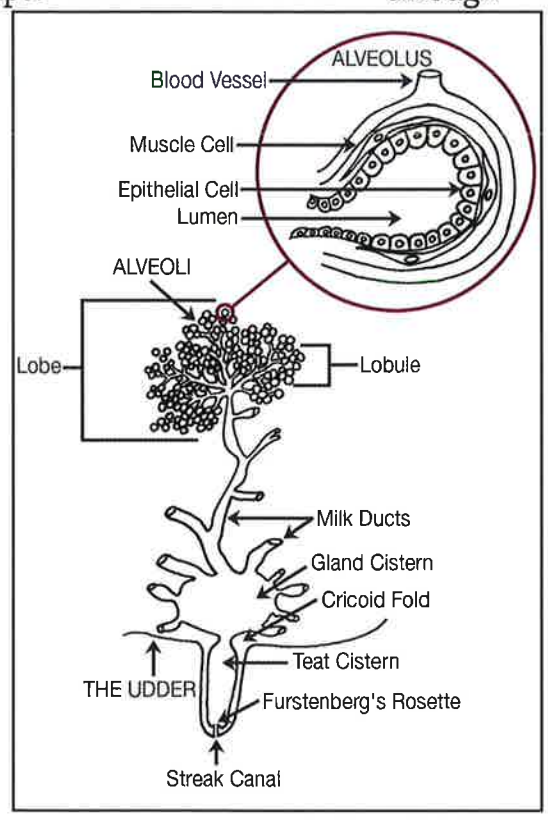


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Figure 7.1. Anatomy of the mammary gland.

## Milk Synthesis and Letdown

Blood comes into the udder where the udder meets the body wall. Blood leaves the udder through the milk vein. The milk vein is the large blood vessel that runs along the abdomen of the animal. Approximately 300 to 500 pounds of blood pass through the udder for each pound of milk produced. The alveolus is made up of a single layer of epithelial or milk-producing cells that make a small pouch. The inside of the alveolus is a hollow area or lumen. Milk-producing cells pull nutrients from the blood and synthesize the milk components, such as casein, lactose, milk fat, vitamins, and minerals. The milk components are secreted into the lumen of the alveolus. When the alveoli are full, milk is secreted into the milk ducts and into the gland cistern, the main storage area of milk.

Female goats, as with all mammals, start lactating after giving birth to their young. To get the most milk out of your does, they need to be healthy, comfortable, in familiar surroundings, and familiar with the individuals doing the milking. Several hormones are involved with mammary development and milk production. The most important hormone in the milking process is oxytocin (see figure 7.2). Oxytocin

is responsible for milk letdown and is stored in the posterior pituitary gland at the base of the brain. Udder preparation for milking stimulates oxytocin release, similar to the kid nuzzling the udder to nurse. Oxytocin travels from the brain through the bloodstream to the udder, where it causes the myoepithelial cells surrounding the alveoli to contract and squeeze milk from the alveoli. The milk ducts fill with milk and mammary pressure increases, making the doe easier to milk. Other familiar repetitive actions can also stimulate milk letdown, such as seeing the milker, entering the milk room or parlor, or hearing and seeing other animals being milked.

Once oxytocin is stimulated, it takes 20 to 60 seconds for the full milk letdown response. This response lasts only 5 to 6 minutes because the liver and kidneys do a very good job of removing oxytocin from the bloodstream. This is why it is extremely important to milk does quickly once the milking process has started.

A hormone that works opposite of oxytocin is epinephrine (also called adrenaline). Epinephrine is the "fight or flight" hormone. It is released when the goat is scared, startled, or disturbed in some way. It acts opposite of oxytocin in that it causes constriction of the capillaries and blood vessels and inhibits the myoepithelial cells from contracting. Does that are in new places, have new milkers, or are upset and stressed do not produce as much because ephinephrine prevents proper milk letdown.

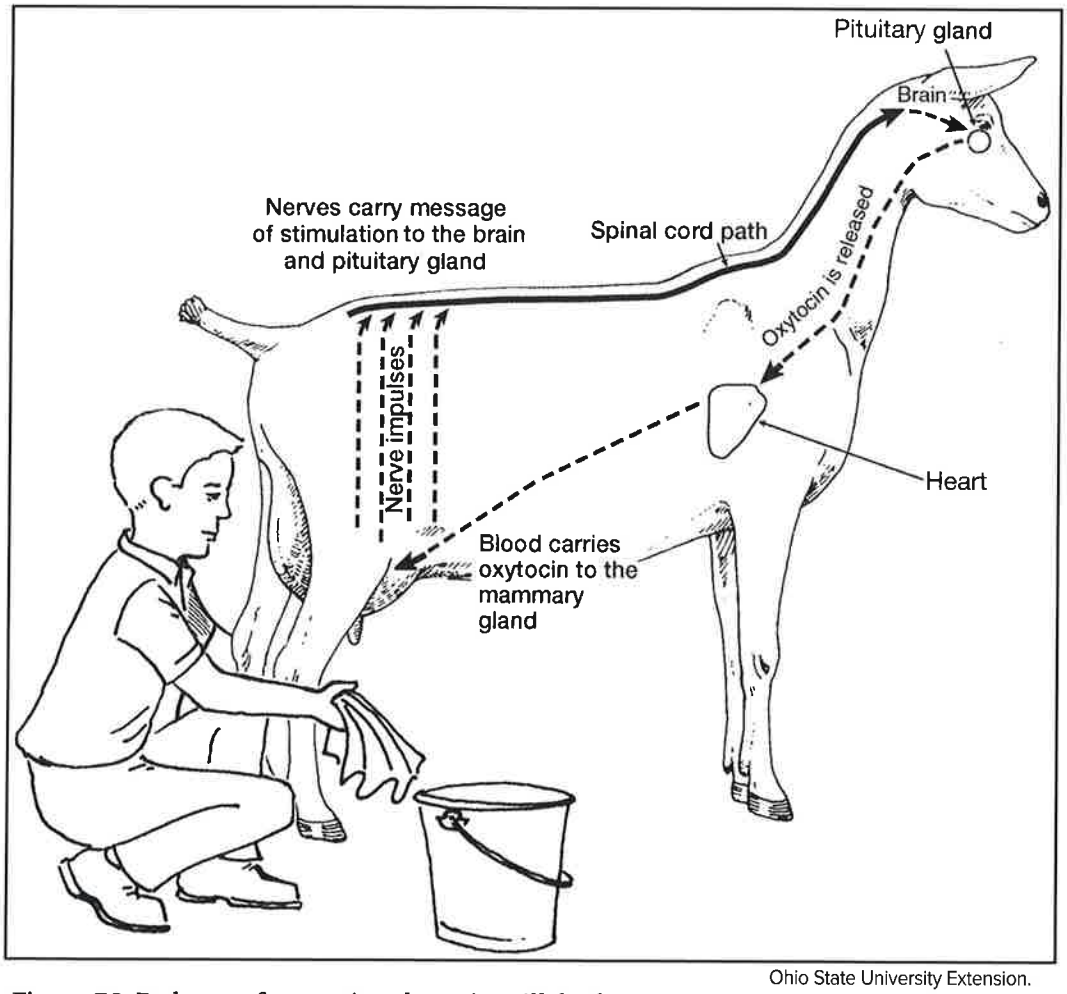


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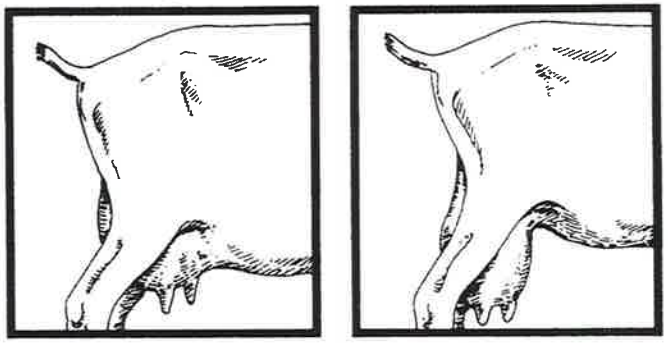
Figure 7.2. Pathway of oxytocin release in milk letdown.

# Goat Mammary Structure (Attachments)

## Fore Udder Attachments

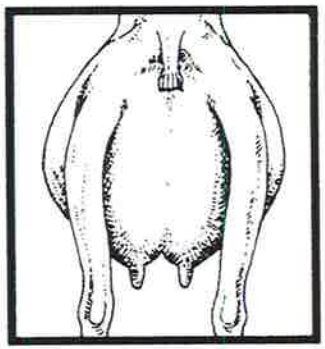


Ideal



Broken

## Rear Udder Attachments



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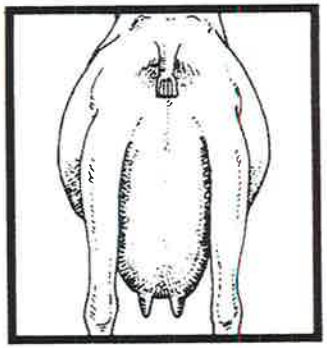
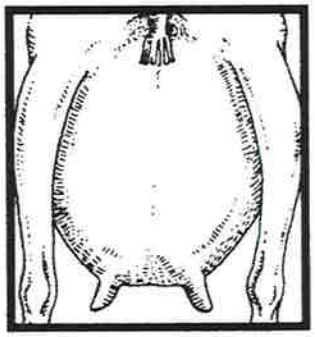


Broken

## Medial Suspensory Ligaments



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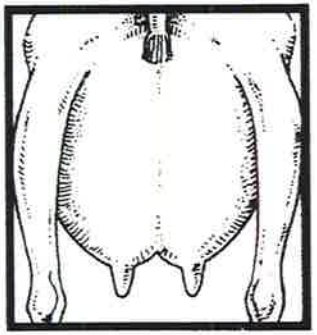

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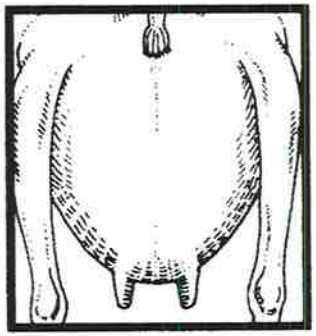


Weakened

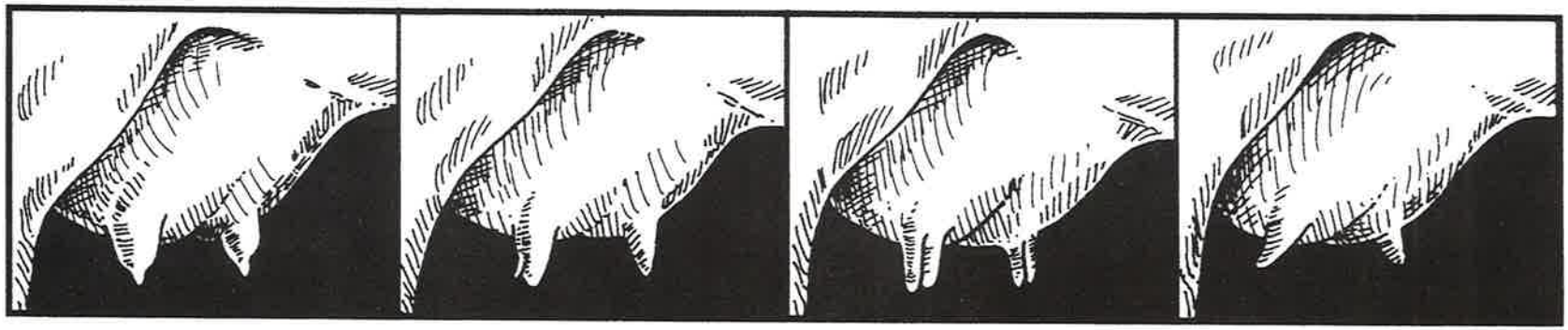
**GOAT LEARNING LABORATORY KIT**

**Exploratory Learning: Educational Program**

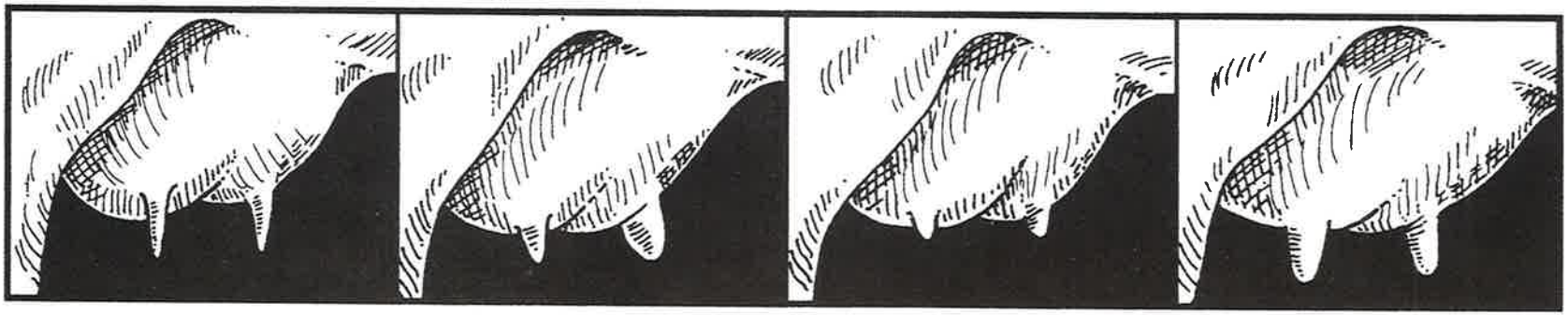
This component adapted from materials of the American Dairy Goat Association

Product distribution through the Curriculum Materials Service

# Goat Mammary Structure (Teats)



Bottle-Shaped Teats | Spur Teat | Double Teats | Teats that Point Sideways



Pencil-Shaped Teats | Uneven Teats | Extremely Small Teats | Ideal Teats

**GOAT LEARNING LABORATORY KIT**

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## Mammary Health and Mastitis

The goat's mammary gland can be susceptible to mastitis. **Mastitis** is an infection or inflammation of the mammary gland and is caused by pathogens, like bacteria. Bacteria usually enter the udder through the streak canal and cause an infection. Occasionally, mastitis can be caused by a systemic infection in the animal, but it is not common. Infection can be spread from animal to animal during the milking process. When bacteria enter the mammary gland, the immune system releases white blood cells, or somatic cells, to fight off infection. Somatic cells destroy bacteria and are helpful in repairing damage to glandular tissue. Somatic cells are always present, even in normal milk, but concentrations greatly increase during mastitis.

Goats produce milk differently than does do. When milk is produced in the udder, more somatic cells and other cellular material are shed into the milk than with cattle. This leads to goats having naturally occurring higher somatic cells counts (SCC) than cattle, while not necessarily having an intramammary infection. Currently, the legal limit on Grade A goat milk is 1 million cells/ml of milk, compared to 750,000 cells/ml of milk for does. Somatic cell counts also vary due to stage of lactation. They are higher at the beginning and the end of lactation, so this variation must be taken into account when managing the goat herd.

Mastitis can cause a considerable amount of economic loss to a dairy goat producer. Much of the loss is due to decreased milk production potential, discarded milk, lost production, drug and veterinary costs, increased labor costs, and increased replacement cost for the animal if culled.

Milk quality also affects processing of milk products. Decreased cheese production, decreased shelf life of a product, and less acceptance by the consumer of the product are all consequences of poor milk quality. Although not many 4-H projects are milking animals for commercial use, mastitic milk still can have a negative effect. Milk with high SCC should not be used for human consumption and should be pasteurized if fed to kids.

Prevention of mastitis can be as simple as having does kid in clean dry areas, having the housing areas clean and dry, and using proper milking procedures.

### Types of Mastitis

The two types of mastitis are clinical and subclinical.

Clinical mastitis is characterized as mastitis showing visible signs of infection. Visible signs include abnormal milk, hot udder, hard spots in the udder, fever, swelling, and sensitivity to the udder. There are two types of clinical mastitis—acute and chronic. Acute mastitis occurs when animals exhibit all the signs of mastitis. Chronic mastitis is when the infection remains at low levels, but flares up with mild or severe occurrences. Clinical mastitis is observed in less than 5 percent of animals in a well-managed herd.

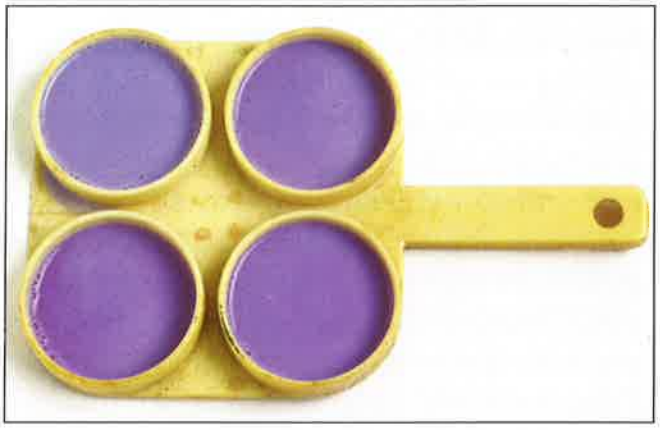
Subclinical mastitis occurs when there are no visible signs of mastitis or infection, but when somatic cell counts are above normal. As mentioned earlier, somatic cells fight infections. An above-normal somatic cell count indicates the animal is fighting an infection. Up to and above 50 percent of animals in a herd can have subclinical mastitis at any given time.

## Mastitis Testing

Several tests can be used to detect subclinical mastitis. These tests were originally developed for goats and are good management tools to use in the goat herd even though goats have a naturally higher milk SCC. Milk SCC in goats is not necessarily a reliable indicator of a mastitis infection, as normal SCC per milliliter of milk in a healthy goat can vary between 50,000 and more than 1 million cells/ml. If SCC exceeds 1 million cells/ml, further testing is needed to determine if the high numbers are due to mastitis or biological variation in the doe.

The Dairy Herd Improvement Association (DHIA) has a milk-testing program and can monitor SCC for animals on test. The electronic somatic cell count program uses an electronic counting device to count the number of somatic cells. A report is sent to the producer with the doe's SCC.

On the farm, producers can use the California Mastitis Test (CMT), shown in figure 7.3. This test was originally developed for cattle but can also be used in goats. By mixing a sample of milk and the CMT reagent, a score of 0 to 5 is assigned. Scores of 1 or higher indicate the milk contains more than 1 million cells/ml.



Department of Animal Sciences, The Ohio State University.
Figure 7.3. California Mastitis Test (CMT).

The Wisconsin Mastitis Test is much like the CMT, but it is performed on the bulk milk samples instead of on individual doe samples. Milk processors usually do this test before accepting a bulk tank of milk from a producer. This test takes more time than the CMT but is more objective.

The official SCC test for goat's milk is the Direct Microscopic Somatic Cell Count (DMSCC), which uses Pyronia Y-Methyl Green stain. This process stains the somatic cell nucleus and the cells are then counted under a microscope. Only white blood cells (leukocytes) have a nucleus. If the increase in cell count is due to leukocytes in the milk, then there may be an intramammary infection. Currently, there is no method to distinguish whether high SCC milk from goats is caused by mastitis or by some other physiological cause. This is why the high legal limit of 1 million cells/ml of milk remains. If any of the above tests have over 1 million cells/ml of milk, the DMSCC test is done for verification.

## Organisms that Cause Mastitis

Mastitis in dairy goats is most commonly caused by Staphylococci species, such as *Staphylococcus epidermitis* and *Staphylococcus aureus. Staph. epidermitis* is commonly found on the skin of human hands and on the udders of goats. *Staph. aureus* is the most common bacteria isolated from mastitis cases in dairy goats. A very small percentage of mastitis is caused by other organisms, such as the Streptococci species, including *Streptococcus uberis, Streptococcus dysgalactiae,* and *Streptococcus agalactiae.* While Mycoplasma is troublesome in some dairy doe herds, it is rare in dairy goat operations and is most commonly associated with pneumonia.

## Teat Disinfection

The use of teat dips is recommended by the National Mastitis Council to decrease the incidence of mastitis. Teat dipping does not totally prevent the incidence of mastitis, but it certainly helps.

Pre-dipping of the teats before milking is recommended if the udder is fairly clean. Pre-dip is applied, left on for 30 seconds and then wiped off with paper towels. Do not share towels between animals, as this passes mastitis-causing organisms between animals.

After milking, a post-milk teat dip should be used. Approximately one-half to two-thirds of the teat needs to be dipped, and the dip is left on. Give the goats feed after milking to keep them on their feet for at least 30 minutes, because it takes approximately that long for the teat ends to close up after milking. If animals lie down before the 30 minutes is up, then the teat ends can be contaminated. If the temperature is 10°F or below, blot the teat dip to remove any droplets and prevent frost damage to the teat. Teat disinfection does not cure or affect current cases of mastitis. Treatment is necessary for current cases.

## Caring for the Mammary Gland

Taking good care of the mammary gland of your animal is crucial whether you are milking your dairy animal or feeding your kids on a doe. Examine the udder prior to freshening to make sure there are no cuts, scrapes, bruises, or signs of infection that could affect the milking or feeding process. Keep the area free of hardware, such as nails, boards, or screws, that could cause damage to the udder. It is helpful to trim the hair from the udder before kidding. This lessens the amount of dirt and bacteria that can enter the mammary gland.

Mastitis is a disease that not only affects the dairy operation but also the meat goat operation. Does that have mastitis have decreased milk production and may not let kids nurse because of a painful udder, resulting in decreased growth rates and possible loss of the kids.

# Milking Procedures

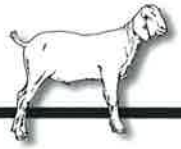
Whether animals are being hand milked or machine milked, there is not much difference in milking procedures. The purpose of milking is to harvest milk. Milk and milk products are one of the most nutritious foods available because they provide vitamins, minerals, and protein. To further promote the growing dairy goat industry, you need to produce a wholesome, good tasting product and to be aware of what the consumer would think of your farm and milking procedures.

Providing proper milking procedures, good management, and clean facilities ensures that high-quality milk is produced for the consumers of the milk and milk products. They also provide the doe with a familiar milking routine for maximum milk production.

## Pre-Milking Procedures

The milking equipment and the milker's hands should be clean and dry before milking occurs to minimize bacterial contact and reduce the chance of mastitis. Physically examine the udder and teats for any signs of injury, frostbite, chafing, or if a half is hard, hot, or sensitive to the touch. Also, strip a few streams of milk from each teat (fore-strip) to check for abnormal milk. Abnormal milk is any milk that is "stringy, pink-tinged, clumpy, flaky, or watery." Strip from each half into a strip cup or onto the milking parlor floor.





These first few streams of milk are usually high in bacteria and somatic cells and help to flush out the teat canal. Do not fore-strip into your hands because this may spread mastitis-causing organisms to another doe. Fore-stripping also helps with the oxytocin release and milk letdown.

After examining for signs of mastitis or injury, and fore-stripping, the next step is to disinfect and stimulate the teats. A sanitizer or an approved pre-dip should be applied to the teats. The pre-dip should remain on the teats for at least 30 seconds to be effective. When pre-dipping, use a clean dip cup with fresh pre-dip. Teats should be fairly clean before teat disinfection. If washing is practiced, use individual towels for each doe. It is then very important to dry the teats thoroughly using either paper towels or cloth towels. Not drying thoroughly can leave mastitis-causing organisms on the teats, and hand milking wet teats can cause mastitis-causing organisms to go back into the gland through the teat canal. If machine milking, wet teats increase the chances of slips and squawks, which increases the chance of mastitis. To dry the teats, use only **one** towel per doe and **never** share towels between does. Cloths used on more than one doe can transfer mastitis-causing organisms to other does. If cloth towels are used, launder them in hot water with soap and bleach between uses.

## Milking

The milking process should be started within 1 minute of starting the pre-milking procedures to take advantage of milk letdown.

If hand milking, milk with clean, dry hands into a stainless steel hooded bucket. Before milking the next doe, wash and dry hands thoroughly. Be gentle while milking and avoid rough, vigorous milking, as teat damage may occur.

If machine milking, attach the unit carefully to not let air enter into the system. Most goats milk out in 2 to 6 minutes. Avoid stripping with the machine (pulling down on the claw or a teat cup to remove the last small amount of milk in the udder) as this can increase liner slips and the chance of the doe getting mastitis.

Remove the milking unit as soon as the last half is milked out. Many modern milking units are equipped with automatic take-offs; these should be checked to make sure that they are adjusted correctly. If the parlor does not have automatic take-offs, the vacuum should be shut off at the claw, and then the teat cups removed. Removing the teat cups while the vacuum is still on can cause liner slips, possible new infections, and harm the teat end.

## Post-Milking Procedures

Teats should be dipped with an approved germicidal post-milking teat disinfectant immediately after milking. Teat dip cups should be cleaned routinely and fresh disinfectant should be used for each milking. If using teat sprayers or a spray bottle, be sure to cover all sides of the teat. A common mistake with spraying teats is spraying only one side. The goal is to cover the entire bottom one-half to two-thirds of the teat with disinfectant. Dipping is preferred over spraying because of better teat coverage. Also, less dip is used when dipping. Teats can continue to be disinfected in cold weather; however, if it is below 10°F or the wind chill is very low, remove excess teat dip after 30 seconds to prevent frostbite and chapping.

A good teat disinfectant kills mastitis-causing organisms on the teat and prevent bacteria from getting into the teat canal. Many commercial teat disinfectants have been shown to reduce the rate of new infections by approximately 50 percent. If mixing disinfectants from concentrates, follow these guidelines: (1) mix small batches more often, (2) never mix old disinfectant with newly mixed disinfectant, and (3) use only clean, potable water to mix. Check with the manufacturer to be sure that your water meets the correct pH and hardness standards as these can alter effectiveness. Contact your local Extension office or veterinarian if you would like to obtain research results on teat disinfectant effectiveness.

### Hair Removal

It is recommended that hair be removed from the doe's udder and flanks to reduce the amount of dirt and bacteria near the teat. This makes udder preparation easier and reduces the risk of milk contamination. Hair is most easily removed by clipping. Hair should be removed about every 3 months, maybe more often in cold weather.

## Milking Facilities

Milk is a highly perishable food product. Care must be taken when handling milk to preserve quality. Several management techniques have a large impact on milk quality. Improper feeding, poor handling of animals, and improper milk handling before and after milking all negatively impact milk quality.

Many people say that they do not like goat milk because it tastes "goaty," with a flavor very different from doe milk. If handled properly, goat milk should not have a "goaty" flavor. Compared to doe milk, goat milk is higher in the medium chain fatty acids, which include caproic, caprylic, and capric acids. These fatty acids are enclosed in the milk fat globule, which is more fragile than the fat globule of doe milk and is easily broken during handling and cooling. Insufficient cooling of the milk causes the milk fat globule to break, resulting in a "goaty" flavor and a less desirable product.

The milking facility is one of the main areas to control milk quality. On most farms, the kitchen serves as the main area for processing milk. On larger dairy farms, the size and extent of facilities depend on the number of animals being milked and on the goals of the producer. Milk processing is discussed in Chapter 13.

Regardless of the size of the dairy or number of animals, the milk room should be separate from the animal housing area and should have a solid floor, such as concrete or tile, with a drain for easy cleaning.

If possible, facilities should have hot and cold running water along with separate sinks for washing equipment and another for washing hands between animals. If you want to set up a Grade A or manufacturing-grade dairy farm for selling milk and milk products, such as cheese and/or yogurt, the dairy needs to meet certain guidelines in the Pasteurized Milk Ordinance and to pass inspection by the state. State milk inspectors can also help with the planning and set-up of a Grade A or manufacturing-grade milking facility. In Ohio, contact the Ohio Department of Agriculture, Dairy Division.

### Hand-Milking Facilities

A basic facility with individuals who milk a small number of goats is a milk room with a milking stand and no running water. Care

must be made to properly disinfect and clean the udder before milking, and milk should be milked into a seamless, stainless steel hooded bucket. This type of bucket allows less odors to be absorbed by the milk and minimizes bacterial contamination. Plastic buckets tend to get pitted and grooved and can hold bacteria, even after disinfecting. After milking, post-milk teat dipping is recommended. See Chapter 13 on processing of milk after milking.

## Automated Milking Facilities

Automated milking of goats occurs one of two ways: (1) bucket milking or (2) a pipeline system.

### Bucket Milking

A bucket-milking unit has a bucket, pulsator, and claw and is hooked up to a vacuum system. You can have buckets that milk just one animal, or buckets that milk two animals at once. Milk travels from the udder into a bucket and is then usually carried to a cooling and storage system before further processing.

### Pipeline System

In a pipeline system, milk is transported directly from the udder to a refrigerated bulk tank for cooling and storage. A pipeline system commonly uses one of three types of parlors—parallel, herringbone, or rotary. There are advantages and disadvantages of each system, depending mainly on how many does are to be milked and on operator preference.

In the parallel parlor, the does are situated next to each other at a 90-degree angle to the milker and are milked between the back legs (see figure 7.4). The big advantage of parallel parlors over herringbone parlors is less space between each doe. This reduces prep time and travel time between does. The size of the milking center building can also be reduced because the parallel parlors take up less space.

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Figure 7.4. Parallel milking parlor.

In the herringbone parlor, the does are stationed at an angle to the milk alley and are milked from the side (see figure 7.5). An advantage of the herringbone over the parallel is cleanliness; when a doe urinates or defecates, it does not occur on the milker or by the milking unit.


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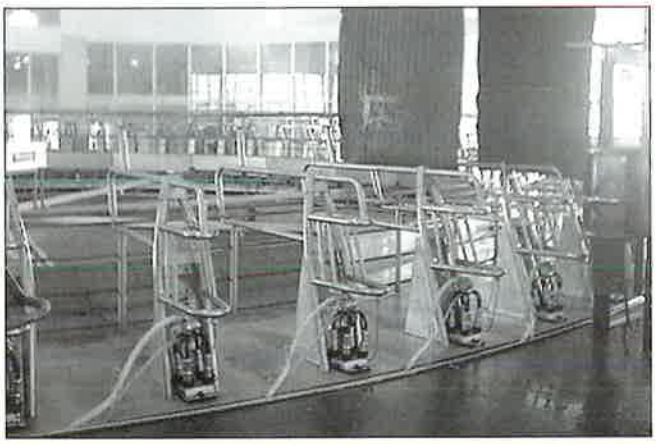
Figure 7.5. Herringbone milking parlor.

Does in a rotary parlor are set up on a platform with the stalls in a circle, with their heads facing the center (see figure 7.6). The number of stalls or units depends on the number of animals being milked. The parlor rotates while the milker stays in position. The rotary parlor is advantageous when milking a very large herd. Rotary parlors are typically more expensive than herringbone or parallel parlors.



Department of Animal Sciences, The Ohio State University.
Figure 7.6. Rotary milking parlor.

## Milking Equipment and Maintenance

The main goal of milking is to produce a safe, high-quality product. Milk needs to be free of pathogenic bacteria, high somatic cell counts, antibiotics, insecticides, and herbicides. It also needs to taste good. Many dairy goat owners milk their goats by hand. Even so, producing high-quality milk and other products for consumer use is possible. Proper milking equipment and care of that equipment is necessary.

To be a Grade A (fluid milk) or manufacturing-grade dairy farm requires a license and inspection by the state dairy inspector. Proper milking and milk handling procedures are regulated by the state. If you want to sell milk or milk food products, contact the Dairy Regulation Department in your state. Goat dairy farms must follow the same rules as dairy doe farms for producing and selling milk and milk products.

### Hand Milking

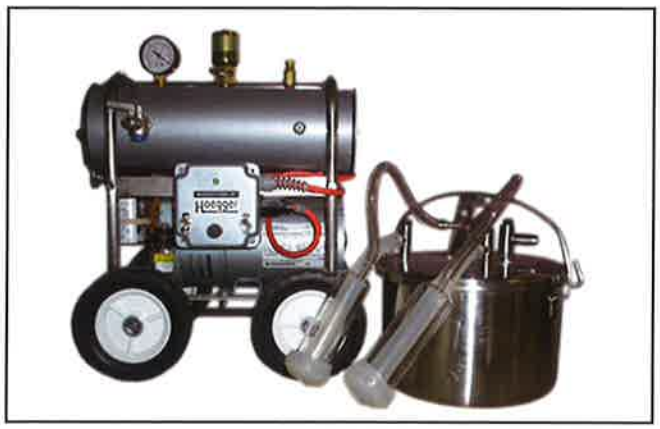
For home use, the only equipment that is necessary is a milking stand, a seamless, stainless steel hooded pail, and a clean milking area. Do not use plastic equipment, as it is porous and is very hard to sterilize and keep free of bacteria. A metal milking stand is more sanitary than a stand made of wood because metal is easier to disinfect.

### Automated Milking

When milking with a machine, the equipment needs to function correctly or milk quality decreases. Improper milking equipment can cause teat or udder injury, increase cases of mastitis, or decrease milk production by leaving milk in the udder. (These same problems can occur with hand milking if proper milking procedures are not followed.)

A milking machine (see figure 7.7) mimics how a kid nurses on the teat; milk is sucked out, not squeezed out as in hand milking. There are three basic functions of the milking equipment: (1) to create a controlled vacuum or low air pressure at the teat end to open the teat orifice and to allow milk to flow efficiently, (2) to massage the teat intermittently to provide stimulation and minimize blood and lymph congestion at the teat end, and (3) to move and handle the milk in a way conducive to maximizing milk quality, quantity, and flavor.

The four essential parts of the automated milking system are (1) the vacuum supply system, (2) the pulsation system, (3) the milk line system, and (4) the milking unit.



Courtesy of Hoegger Supply Company.
Figure 7.7. Milking machine.

The vacuum supply system consists of the vacuum pump and the regulator. It creates a vacuum that moves and regulates air through the system. Air must be removed from the system to create low air pressure or a vacuum. Vacuum pressure must be regulated (by letting atmospheric air in) to provide a controlled, stable vacuum or consistent low pressure at the teat end. This allows the teat end to open and milk to flow from a high-pressure area (the udder) to a low-pressure area (the milking unit). To maximize milk flow, there needs to be a large pressure difference between the doe and the machine. However, the pressure cannot be too high, or the doe's teats will be injured and mastitis can result. Always set vacuum levels according to the requirements of your milking system, as these are different for bucket systems versus milk line systems.

## Vacuum Pump

The vacuum pump is a mechanical device that extracts and exhausts air from the system to create a vacuum. Pumps are rated by the amount of air they can move, measured in cubic feet per minute (CFM). The amount of CFM needed in a system depends on the number of milking units. A series of pipes or lines are needed to distribute the vacuum to the milking and pulsation systems. Vacuum lines should be properly sized according to the amount of air or CFM being moved through them. The vacuum pump should be located in a clean, dry room near the milking center. If it is located too far away, a larger pump than necessary may be needed. The room should be large enough to do any maintenance necessary. The pump should not be kept very close to the milking parlor because of the loud noise and because of the risk of contamination of milk from the oil in the pump. The vacuum pump should have a vacuum gauge and a test port on the main line. The vacuum gauge should be checked during milking to make sure a stable vacuum is occurring. If fluctuations are noted, the test port can be used to check the vacuum pump and make sure it is working correctly. There should be a cut-off valve after the test port so that pressure can be accurately measured at the port. This measures airflow from the pump, not exhaust. It is crucial to test the vacuum during milking with all units on to evaluate the system correctly. If bucket milking, the vacuum pump may be portable. For proper vacuum, use a bucket milker that is made for goats, not cattle.

## Regulator

Vacuum pump regulators maintain a stable vacuum pressure in the line. Sensors control valves that allow air to enter when necessary so the system does not exceed the set limit for vacuum. The regulator senses all air going in and out of the system and continually adjusts for the difference. It is extremely important to have a sensitive regulator and to install it in the proper place. Because regulators are a very important part of the milking system equipment, they must be routinely cleaned and checked for proper functioning.

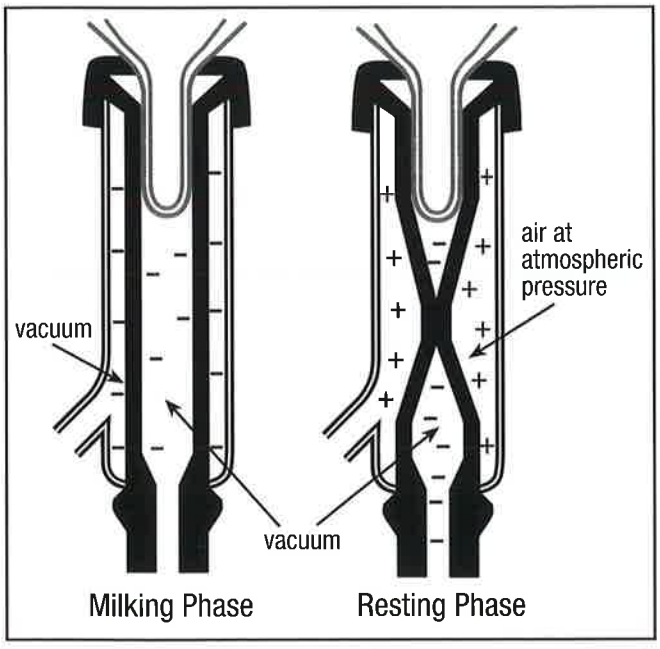
## Pulsator

The pulsator is an automatic air-vacuum valve that directs atmospheric air into the hoses and chamber between the teat cup liner or inflation and the shell. This alternates the vacuum and atmospheric air between the shell and the liner and is responsible for the actual milking action. The pulsator removes the air by opening a port into the vacuum system, causing the liner to inflate and be in the milk or open phase. When the pulsator lets air in between the shell and the liner, the liner collapses and massages or rests the teat.

Pulsators have many small working parts and should be cleaned and maintained regularly. They should be evaluated and checked by a certified equipment service person with the proper equipment. Air hoses should be checked regularly for cracks and splits and should be changed once a year.

## Pulsation Rate and Ratio

Pulsation rate is the number of times that the teat goes through the rest and milk phase (see figure 7.8). The two phases make up one cycle. This is how fast the doe is going to be milked. You do not want this to be too slow or too fast. Common rates are 60 to 90 cycles per minute. A lower number of cycles per minute results in a slower milking speed.




Ohio State University Extension.

Figure 7.8. Pulsator action.

Pulsation ratio describes the proportion of the cycle that is in the rest phase versus the milk phase. Generally, pulsation ratios are 50:50 or 60:40. For example, if the pulsation ratio is 60:40, this means that 60 percent of the cycle is in the milking phase (liner open) and 40 percent of the cycle is in the rest phase (liner closed).

## Milking Unit

The milking unit is the part of the machine that is suspended from the doe, performs the milking operation, and receives the milk. It includes the teat cup assembly (shell and inflations or liners), claw, and connecting milk hoses. Components should be sized to maximize milk flow from the teat. Hoses should be as short and straight as possible to minimize air and milk flow restrictions. Inflations are the only piece of the milking unit to touch the doe. The inflations change shape during every pulsation. It is very important to replace inflations at the recommended time. Not doing so increases the risk of mastitis due to poor milk-out and increased liner slips or squawks that allow an unexpected rush of air in the system. There is also an increased chance for bacteria to harbor in the cracks.

Air bleed holes in the inflations or claw (there should be only one, either in the claw or in the inflation) allow a precise quantity of air in to increase air pressure (lower vacuum) slightly so that milk can be moved efficiently. Routine listening to air bleed in this hole at milking, as well as other air admission places, is important. Keep bleed holes open

or milk flow will slow down, causing a large vacuum drop. Do not make the holes too big, as excess air causes milk agitation, slowed milk-out, and increased risk of mastitis.

## Cleaning and Sanitizing

Keeping your milk system clean is one of the most important tasks on the farm. Dirty milk lines cause an increase in milk bacterial counts and reduce milk quality.

Two types of cleaning systems are normally used on the farm. One is a manual system, where the milk-line system or milk buckets are cleaned by hand. The other is a Clean in Place (CIP) system, which is automated. Whichever way you clean your system, it should be done immediately after milking to prevent the build-up of milk solids in the lines and on the buckets. You should always follow cleaning recommendations and directions from the milking equipment manufacturers.

Proper and routine maintenance is essential to keep milking systems functioning properly. Pulsators, bleed holes, and regulators (air inlets) should be cleaned routinely when inflations are changed or at least every six months. Inflations or liners should be changed routinely according to the material and brand used. All hoses should be replaced annually and a certified service person or veterinarian should evaluate the milking system at least once a year to evaluate pump, regulator, and vacuum system performance, pulsators, and milking time performance. Milk lines should be cleaned daily. The buckets, cans, or bulk tanks should be cleaned each time they are emptied, and vacuum lines should be cleaned at least twice a year.

For specific information on automated goat milking systems, see "Guidelines for the design, installation, and cleaning of small ruminant milking systems," Dairy Practices Council #70 (**dairypc.org**).

Modifying equipment made for goats can be done but is not always the best option as small ruminants have needs for different pulsation rates and vacuum levels. Contact your local equipment dealer and see what your options are for setting up a system that will work best for you.

# Dairy Goat Products

Although cow milk is the major fluid dairy product consumed in the United States, goat milk is more highly consumed in the rest of the world. In many developing countries, goat milk is cheaper to produce than cow milk, and goat milk production is possible in places where the landscape and terrain prohibit the grazing of larger animals. Cost of production, land availability, and efficiency are not the only reasons people choose goat milk production. The composition of goat milk also may make it more digestible.

## Composition of Milk

Goat milk has a similar composition as cow milk. The average composition of milk from goats, cows, and humans is provided in table 7.1. Notice the similarities between the composition of milk from goats and cows (American Dairy Goat Association; **adga.org**). Despite having similar compositions, goat milk and cow milk are still very different. The fat in goat milk contains more shorter-chained fatty acids than cow milk, and the fat globules are smaller than the globules in cow milk. Goat milk is sometimes called "naturally homogenized" because the fat does not separate as it does in cow milk. Fat globules separate in cow milk because

they are larger and because of a protein that causes them to group together and separate from the liquid. These proteins, called agglutenating euglobulins, are not present in goat milk, giving the appearance of natural homogenization.

**Table 7.1. Comparison of the composition of goat, cow, and human milk.**

| | Goat | Cow | Human |
|---|---|---|---|
| Protein, % | 3.0 | 3.0 | 1.1 |
| Fat, % | 3.8 | 3.6 | 4.0 |
| Lactose, % | 5.1 | 4.9 | 7.0 |
| Calories/100 ml | 70 | 69 | 68 |
| Cholesterol (mg/100 ml) | 12 | 15 | 20 |
| Calcium, % | 0.19 | 0.18 | 0.04 |
| Phosphorus, % | 0.27 | 0.23 | 0.06 |
| Iron, % | 0.07 | 0.06 | 0.2 |
| Vitamin A (i.u./g fat) | 39 | 21 | 32 |
| Vitamin B1/ thiamin (µg/100 ml) | 68 | 45 | 17 |
| Riboflavin (µg/100 ml) | 210 | 159 | 26 |
| Vitamin C (mg ascorbic acid/100 ml) | 2 | 2 | 3 |
| Vitamin D (i.u./g fat) | 0.7 | 0.7 | 0.3 |

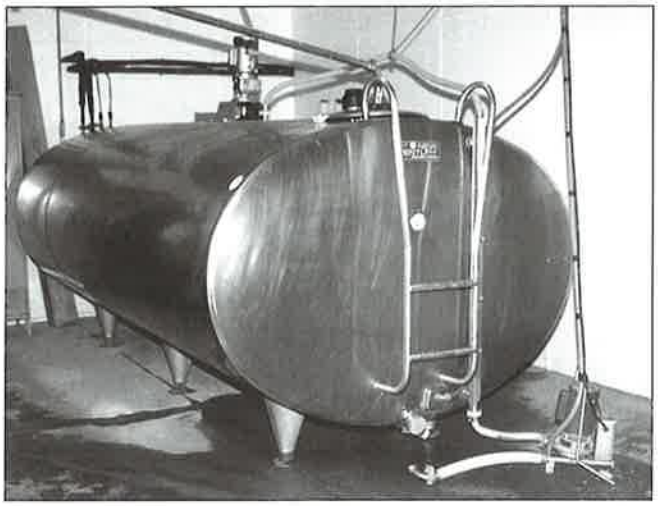
## Milk Processing

Though the composition of goat and cow milk differs slightly, the handling and processing of the milk from both species is similar, especially on large dairy goat operations. However, as we will learn later, many dairy goat producers process and develop their own products, which changes the way the milk is handled from farm to refrigerator. Size of operation and method of milking (hand versus milking machines) definitely influence the type of processing the milk undergoes.

Because milk spoils easily, the dairy industry is highly regulated by the Federal Food and Drug Administration (FDA). Each state is responsible for enforcing the rules and processing regulations. Dairy farms and milk processing plants are routinely inspected to make sure the facilities are clean and that milk is handled properly and safely. This is to make sure that all milk and all milk products arrive safely to the consumer. Commercial dairy goat milk processors make their products under the Pasteurized Milk Ordinance (PMO). In addition to the PMO, goat milk undergoes inspection, sampling, and laboratory testing to ensure that it conforms to quality standards and that it is pure and wholesome for human consumption.

When milk is on the farm, it is kept in a large tank called the bulk tank (see figure 7.9). This is a refrigerated tank that keeps the milk cool (less than 40°F, but above freezing) and prevents bacteria from growing. Milk is picked up in a refrigerated tank truck (see figure 7.10) that carries the milk to the processing plant. Number of goats in the herd and the size of the bulk tank determine how often the milk truck comes. The milk on a truck is usually be from several different farms.

When the milk hauler picks up the milk at the farm, employees take a sample of milk from each individual bulk tank. This sample is then tested for antibiotic residues, milk fat, milk protein, bacteria, and SCC.



Department of Animal Sciences, The Ohio State University.
Figure 7.9. Bulk tank.

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Figure 7.10. Tank truck.

Today's milk processing plants are almost fully automated. They are full of stainless steel tanks, pipes, and machines that handle the milk from the time it enters the plant to the time it is packaged for the consumer. Every day, all of the equipment is cleaned and sanitized to make sure that the milk stays safe to drink.

Look at the processes described below and in figure 7.11—a lot goes into taking milk from the farm to the grocery:

The processing of fluid milk starts with clarification, which is the removal of sediment, such as dirt, epithelial cells, leukocytes, and bacteria, by filtration and centrifugation. The milk is then pasteurized, or heated, to kill any disease-causing organisms. There are several methods of pasteurization. One is batch pasteurization, which heats up the milk to 145°F (63°C) for 30 minutes. Another is flash pasteurization, which heats the milk up to 160°F (71°C) for 15 seconds followed by a rapid cool down.

Flash pasteurization is also called high-temperature short-time pasteurization (HTST). The equipment used for this type of pasteurization is different than for batch pasteurization. Milk during HTST is run through many very small tubes to heat and route the milk to where it needs to go. The majority of modern processors use HTST for several different reasons:

1. The equipment takes up much less space than the equipment for batch pasteurization.
2. The process is a more efficient use of labor; it requires less people.
3. The equipment is easier to clean and sanitize.
4. The equipment is cheaper and can easily be expanded.

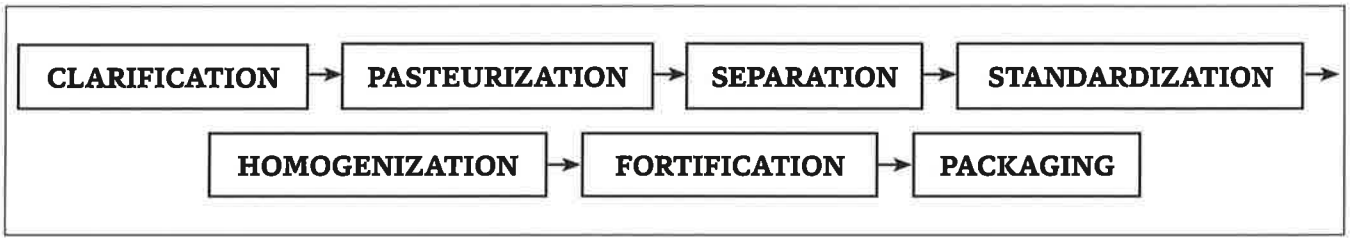



Figure 7.11. Milk production processes.

Recent technology has developed a new pasteurization process called Ultra High Temperature (UHT) pasteurization, which heats the milk up to 250°F (under pressure) for 1 to 2 seconds. The UHT process is mainly used for coffee creamers and juice. However, Europeans commonly pasteurize milk this way. The UHT products do not require refrigeration until after they have been opened because the UHT process sterilizes the milk. These products often have a slightly "cooked" flavor.

After pasteurization, the milk is immediately cooled to 40°F. For the rest of the processing, the milk is kept at this constant cool temperature. Now the fat is separated from the milk in a process called separation, with the result being cream (fat) and skim milk.

Standardization is the next step in getting the milk to your grocers' shelves. Standardization brings all of the milk from different farms to the same milk fat percentage. Goat milk composition can vary widely from goat to goat and farm to farm, so standardization becomes very important in meeting federal and state requirements for goat milk product processing.

Milk is then homogenized. This is the process of breaking up the fat particles into smaller pieces so that they stay mixed in the milk. While goat milk is naturally homogenized, some of the pasteurization steps may cause the milk fat to separate, especially when using HTST pasteurization. Large-scale pasteurization operations often homogenize goat milk. However, smaller operations or those with batch-size processing may find homogenization unnecessary. After homogenization, milk is fortified with either vitamin A or D, or both. Finally, milk is put into plastic jugs or bags, cartons, or boxes and delivered to grocery stores and restaurants, ready to be served. Milk that is not packaged for you to drink is made into other dairy products. Ice cream, cheese, and yogurt are just a few.

## Small Scale Processors

While some fluid milk is marketed by large scale processors, other dairy goat producers prefer to process, package, and market their own dairy goat milk products. Some people have interest in raw goat milk (milk that has not been pasteurized). Remember, pasteurization kills disease-causing organisms, so drinking raw milk poses some serious health risks. Besides health risks, selling raw milk is against the law in Ohio and consumption is highly discouraged by the United States Department of Agriculture.

Many small-scale dairy goat producers own their own milk processing equipment and supplies. Pasteurizers can easily be purchased and used on the farm. Farm direct products are growing in popularity in the dairy industry, both for dairy doe and goat producers.

## Cheese and Other Products

Besides fluid milk, goat milk can also be used for producing a variety of value-added products, like cheese or powdered milk. Many on-farm processors market their goat milk through value-added products. Perhaps the most popular use of goat milk is for making cheese. In the United States, goat cheese consumption has been on the rise. Actually, the United States needs to import goat cheese from other countries to meet the consumer demand. The majority of goat cheeses come from France, but Italy and Norway also produce goat cheese.

Making cheese from goat milk requires four main steps.
**Step 1.** Preparation of the cheese milk
**Step 2.** Coagulation of the milk protein (casein)
**Step 3.** Separating the curd from the whey
**Step 4.** Aging

## Preparation of Milk for Cheese

In commercial cheese production, the first and most important step is standardization of the milk. As discussed earlier, standardization adjusts the milk fat and protein contents to a set level. Commercial cheese processors have to produce cheese that is of uniform quality and of legal composition. There are federal and state laws that specify fat and protein composition of dairy products. Goat producers making cheese for their own consumption probably are not concerned with the composition of their product, but if the cheese is to be sold commercially, it must meet the established standards.

Milk destined for cheese production also needs to be low in bacteria counts. Some of the later steps in cheese making use special, beneficial bacteria, so if there are a lot of undesirable bacteria in the milk itself, this interferes with steps in the cheese-making process.

## Coagulation of the Milk Protein

Coagulation of the milk protein or casein is necessary to separate the curd from the whey. Depending on the cheese variety, coagulation may involve culturing with special bacteria, enzymes (rennet), or a combination of the two. Cheeses that are consumed fresh are usually made by culturing the milk with bacteria, while cheeses that are aged are usually made using enzymes.

## Separating the Curd from the Whey

Cheese variety influences when the coagulated protein, or curd, is separated from the whey. Commercial cheese makers separate the curd by using metal frames and mesh-like wire that fits directly into their cheese vat. The wire is moved across the vat, and the curd is cut into cubes. After the curd is cut, the cubes are left undisturbed to increase firmness. Once the cubes have reached the desired firmness, the excess whey is drained from the vat.

## Aging

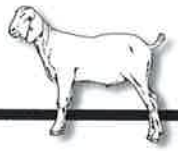
While all of the processes discussed above influence the flavor, texture, and quality of cheese, the aging process has the most influence on the final cheese variety. The purpose of aging is to develop a specific flavor, body, and texture. Microorganisms and enzymes that are active in the coagulation step also influence the ripening of the cheese. Salt is a very common ingredient added to cheese to enhance flavor.

## Varieties of Cheese

Today, cheese is available in hundreds of varieties, types, and flavors. Variation in the steps of the cheese-making process determine the final type of cheese produced. When talking about variety, goat cheese can be classified either as ripened or unripened (fresh). Ripening is a classification of how long a cheese has been aged. Typically "younger" cheeses, or unripened cheeses, are whiter in color than ripened cheeses, which are a creamier color.

In addition to age classification, cheese can be further separated by moisture content and classified as soft, semisoft, firm, or hard. Generally, a drier, or harder, cheese has a stronger flavor than a more moist variety.





## Other Value-Added Products

While cheese production is a very important use of goat milk, the milk can also be used for a number of other uses, including yogurt, dried powder, and fudge. Besides food products, goat milk is commonly used to make cosmetic and hygiene products, such as soap, bath soaks, and lotion. These products are commonly seen at farmers' markets, craft sales, and even some up-scale department stores.

# Appendices

## Glossary

**antibiotics**. Substances made by organisms that kill bacteria. They are used to fight diseases and infections caused by bacteria.

**artificial insemination**. Depositing of sperm into the reproductive tract of a female other than by natural mating.

**bloat**. Abnormal condition in ruminants due to the accumulation of gases in the rumen.

**breed**. Group of goats with similar traits, such as coat color, head shape, or body conformation, that are passed from generation to generation.

**buck**. An intact male of the caprine species.

**cabrito**. Term used often by Hispanic and Latino populations to describe meat from goats, usually referring to a goat carcass that weighs 15 to 30 pounds.

**caprine**. Of, relating to, or being goat.

**carbohydrates**. Nutrient group that includes sugars, starch, hemicellulose, cellulose, and lignin and is made of up carbon, hydrogen, and oxygen (sometimes abbreviated CHO).

**carcass**. The muscle, bone, and fat associated with the harvest of an animal; left after removal of the head, hide, and internal organs.

**castrate**. To remove the testes from a buck so that it cannot reproduce.

**cervix**. The entrance into the uterus. Protects the uterus from infection.

**Chevon**. Term used to describe meat from goats.

**chromosome**. Contains genetic material. Goats have 60 chromosomes or 30 pairs of chromosomes.

**clip**. All the hair from one goat in one year, or all the hair from one herd in one shearing.

**closed herd book**. A breed association's policy to restrict registration to offspring of animals already registered.

**colostrum**. It is the mother's first milk that she produces after kidding. Colostrum is high in antibodies and nutrients for the newborn kid.

**complete feed**. A feed ingredient that provides all of the required nutrients to the animal except for those from the forage, usually in the form of a meal or a pellet.

**concentrates**. Feed ingredients that are mixed with other ingredients to form a diet for the animal, for example, protein concentrates or grain concentrates.

**conception**. When the sperm from the male fertilizes the egg from the female.

**conformation**. The general shape and structure of an animal. Animal placing classes are judged on conformation.

**crossbred**. Goats with parents and/or close ancestors of different breeds.

**cud**. The bolus or ball of feed that is regurgitated from the rumen and chewed to break down particle size of feed for further digestion.

**dam**. The mother of a kid.

**dehorn**. To remove the horns.

**diet**. A nutritionally balanced mixture of feed ingredients.

**doe**. A female goat.

**dominant gene**. One gene of the gene pair that determines a characteristic of an animal, such as hair color. Gene pairs can be homozygous or heterozygous.

**embryo**. A term for the fertilized egg during the early part of the pregnancy.

**embryo transfer**. When an embryo is removed from the original doe and given to another doe (recipient doe) to develop.

**estimated transmitting ability (ETA)**. An index that predicts the genetic potential of offspring based on the PTI of the sire and dam (or dam's sire); the higher the ETA, the more genetic potential.

**estrogen**. A hormone that is responsible for the development of female characteristics and bringing a female into estrus.

**estrous cycle**. The reproductive cycle of the female that is approximately 21 days in length in cattle. It is characterized by the development of a follicle, ovulation, and the onset on estrus.

**estrous synchronization**. The use of hormones to bring a group of females into heat at the same time to be able to breed them within a short period.

**estrus**. Also called *heat*. The part of the estrous cycle where the female is exhibiting signs that she is ready to be bred. It occurs before ovulation.

**F1**. The first generation that results from the mating of two individuals.

**fertility**. The description of how productive a breeding animal will be in terms of reproductive abilities.

**fertilization**. The joining of the egg and the sperm to form an embryo.

**fleece.** All the hair from one goat.

**flight zone**. The animal's safety zone. The size of the zone varies depending on its degree of tameness.

**forages**. Plants used as feed for livestock.

**fresh doe**. A doe that is 0 to 14 days post kidding.

**freshen**. To begin lactating; to begin producing milk.

**gene**. The unit of genetic material that controls a trait. Genes are transmitted singly (one of the genes at random of each parent) from each parent to their offspring. Genes occur in pairs to control traits.

**genetics**. A branch of biology that deals with inherited characteristics and how they vary.

**genotype**. The gene pair that results in a specific physical trait or phenotype.

**gestation**. Also called *pregnancy*. The time period between conception and birth.

**grade goats**. Goats that are not registered in any breed association herd book but that are often purebreds with the characteristics of a given breed. Grade goats also include crossbred animals. Grade animals are usually ineligible for registration in an association herd book because their parents are not registered.

**Halal**. In the Islamic religion, that which is permitted or lawful.

**Haram**. In the Islamic religion, that which is forbidden or unlawful.

**hay**. A forage source that has been dried and stored.

**herd book**. The official ancestry record of registered animals of a breed kept by the breed association.

**heredity**. The passing of genetic material from parents to offspring.

**heritability**. A statistic used to describe the amount of variation within a population and that is used to evaluate animals and to predict response. The higher the heritability of a trait, the more likely it is to be passed on to the offspring.

**heterosis**. Also called *hybrid vigor*. Occurs in crossbreeding where the offspring perform above the average of the parents.

**heterozygous**. Individuals that have two different genes (one dominant and one recessive) in a gene pair, for example, Pp (P being dominant and p being recessive).

**homozygous**. Individuals that have the same genes (either two dominant or two recessive) in a gene pair, for example, pp for horns.

**hormone**. A substance secreted by a gland into the bloodstream that may control other bodily functions.

**immunity**. The protection from or resistance to a disease that a body has.

**inbreeding**. Production of offspring from parents more closely related than the average of a population. Inbreeding increases the proportion of homozygous genes.

**kemp**. Straight, coarse, hollow, and brittle chalky-white hair fibers in the fleece (primary hair) that does not accept dye and that lowers the value of the fleece; fleeces with less that 1% kemp are tolerated.

**kid**. A young goat less than six months of age.

**kidding ease**. Refers to a lack of difficulty in giving birth.

**kosher**. In the Jewish religion, food that is selected and prepared according to certain criteria.

**legume**. A nongrass plant that produces nitrogen with its roots. Legumes are usually higher in protein than grasses because of this. Some examples of legumes are alfalfa and soybeans.

**line breeding**. A form of inbreeding in which an attempt is made to concentrate the inheritance of an outstanding ancestor of a herd.

**lock**. Group of fibers that cling together.

**luster**. The ability of fibers to reflect light; brightness.

**mastitis**. An infection or inflammation of the mammary gland.

**nutrients**. Nutrients provide a living organism with the substances to live. The six nutrients are carbohydrates, fat, protein, vitamins, minerals, and water.

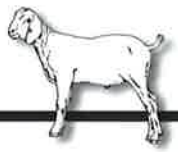
**open doe or yearling**. A doe or yearling that is not pregnant.

**open herd book**. A breed association's policy to allow offspring from nonregistered parents (grade purebred) to be registered. There may be a multi-step process in which registered sires must be used for several generations before offspring receive full or provisional status.

**ovary**. The female organ that produces eggs for reproduction. There are two ovaries in goats.

**ovulation**. The process of releasing an egg from a follicle for fertilization. In goats, ovulation occurs 12 to 14 hours after standing heat.





**oxytocin**. The hormone responsible for milk letdown and for stimulating uterine contractions during calving.

**parasite**. An organism that requires another organism in order to live. Examples of parasites are lice, worms, and ticks.

**parturition**. The process of giving birth.

**pedigree**. A summary of the ancestors of an animal.

**phenotype**. The physical result or expression of a gene pair or genotype.

**pica**. An abnormal desire to eat substances that are not normally eaten, such as dirt, wood, and ashes. When seen in goats, it is usually due to a mineral deficiency.

**placenta**. Also called *afterbirth*. The membrane in which the kid develops and through which it receives nourishment. After kidding, the placenta is expelled by the doe.

**polled**. Having no horns.

**predicted transmitting ability (PTA)**. A measure of either yield or type evaluations for selecting the best animals for breeding programs. The higher the number, the more likely improvements will take place using those genetics.

**progeny**. The offspring of an animal.

**progesterone**. A hormone that maintains pregnancy in the female.

**prostaglandin.** A hormone-like substance that is naturally produced by the reproductive tract of a doe. A synthetic version is also produced and used to synchronize estrus in goats.

**purebred**. Usually refers to registered animals; however, nonregistered or grade animals that have characteristics of a breed and several generations of ancestors of that breed may be considered purebreds.

**ration**. The amount of food that is nutritionally balanced for a one-day period.

**recessive gene**. A gene that is not dominant for a characteristic. For the characteristic to be expressed, an offspring must have two recessive genes (be homozygous), one from each parent. The opposite is a dominant gene.

**registered animals**. Animals that are officially recorded in a breed association herd book.

**replacement yearling**. A kid that is being kept to enter the herd.

**residue**. A residue is the amount of a substance that remains in an animal's body tissue after exposure to a substance. The substance can enter the animal's body when it is used as a feed or water additive, by an injectable or external application, or by accident.

**roughages**. High fiber feeds that are necessary to ruminant animals to keep the rumen functioning properly. Examples are hay, corn silage, and pasture.

**ruminant**. Any animal that has four stomach compartments: the rumen, reticulum, omasum, and abomasum.

**semen**. The ejaculate fluid that consists of sperm and the fluids from the accessory glands.

**silage**. Forages that have gone through the anaerobic process of fermentation in a silo. Examples are corn silage and haylage.

**sire**. The father of a kid.

**skirting the fleece**. Refers to removing stained fibers, matted clumps, short fibers (less than 2½ inches long), portions

with kemp, vegetable matter, and coarse areas from the fleece. These portions that are removed should be kept separate or discarded as they are of low or no value.

**soundness *(in reference to fiber)***. Free from "breaks" in the fiber or thin spots in the fleece.

**standing heat**. The window of time during estrus when a female is receptive to mating.

**staple**. One fiber.

**style**. The degree of crimp inherent to a single fiber.

**total mixed ration (TMR)**. The process of mixing all feed ingredients into one complete diet that satisfies all nutritional requirements for the day.

**uterus**. The female reproductive organ where the embryo develops into a kid during pregnancy.

**vulva**. The external opening to the female's reproductive system.

**wean**. To start a kid on solid food versus liquid food. Dairy kids are typically weaned at 6 to 8 weeks of age.

**wether**. A castrated male kid.

**withdrawal time**. The period of time that must pass before a product can be harvested after treatment with a medication.

**zoonotic disease**. Disease that can be transmitted from animals to humans.

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