

notes on goats



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FEEDING MANAGEMENT OF A MEAT GOAT HERD

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The single most significant variable cost in any livestock operation is feed cost. It averages 45% of the variable cost of an operation including labor costs or is about 64% of the variable cost of an operation excluding labor. Any management practice that can reduce feed cost will significantly improve profit. In this technical paper the major points in the nutrition of goats are discussed to help you understand the digestive system, feeds and feeding of goats.

The Digestive System of Ruminants

The goat belongs to a group of animals called ruminants that have a 4 compartment stomach (Fig. 1) and a unique ability to digest roughages containing relatively large amounts of cellulose. Cellulose is the chief part of the cell walls of plants and a potential source of energy for ruminant animals. The digestive system of ruminants contains millions of bacteria and protozoa that can digest and manufacture a variety of nutrients.

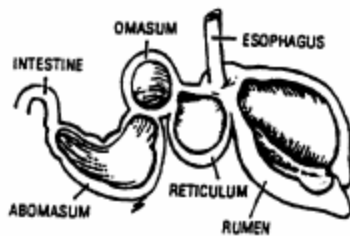


Figure 1. Goats stomach.

representing about 80% of total stomach area. It is the main site of fermentation. Bacteria and protozoa provide enzymes that can break down fiber and other parts of ingredients. Volatile fatty acids, a major source of energy to ruminants, are produced and absorbed there. Rumen microbes can also manufacture most of the vitamin B complex, vitamin C and vitamin K. Bacteria and protozoa themselves are sources of protein (microbial protein) for the animal. The **reticulum** is the “honey comb” or second stomach. It is located below the entrance of the esophagus to trap any heavy metals entering the rumen: it is also called the hardware stomach. The **omasum** is the third stomach. It has many hanging layers of tissue, which gives it the name “many plies.” The major function of the omasum is absorption of water. The **abomasum** is the true stomach. It contains acid and enzymes that break down feed material just as in single stomach animals.

Required Nutrients

Nutrients in feed are divided into six classes: protein, carbohydrates, fat, vitamins, minerals and water. Carbohydrates and fats provide energy. Protein is a source of nitrogen that is required by the body for muscle growth, milk production, disease resistance, reproduction and body maintenance. Protein is the most expensive part of the ration and usually it varies between 12-16% of ration dry matter depending on two major factors: (1) physiological stage of the

animal (pregnant, lactating, growing) and (2) forage quality. Urea and other non-protein nitrogen can be utilized by the microorganism of the rumen to produce microbial protein, which is a source of nitrogen for the host animal.

Energy requirements of ruminants mostly come from the fermentation of fibrous carbohydrates in the rumen and the rest comes from starch and fats. Energy is measured by total digestible nutrients (TDN), digestible energy (DE) and net energy (NE) system. TDN accounts only for loss of energy in feces whereas net energy accounts for energy lost in feces, urine, gases, and the work of digestion. Energy is required for maintenance, growth, production and reproduction.

Vitamins are very important nutrients in the diet. All of the vitamin B complex and vitamin K are produced in the rumen, and the body manufactures vitamin C. Therefore, only vitamins A, D and E are of concern in ruminant nutrition and should be supplemented in the ration.

Minerals of major concern are calcium, phosphorus and sodium chloride (salt). It is recommended that these minerals be mixed with the concentrate mix. The calcium to phosphorus ratio in the ration should be kept at 2:1. A good mineral mix will contain equal parts of salt and dicalcium phosphate. Trace mineralized salt may be used for trace mineral supplementation at .5% of grain mix. Certain trace minerals such as copper and selenium should be supplemented not only for their nutritional contributions to the animal, but also for enhancing the immune system in goats.

Water supply is critical for livestock, either in confinements or on pasture. Clean water should be available in each pen indoors or on each paddock or pasture outdoors. The water intake of goats may vary depending on the season of the year or ambient temperature. Goats, like other livestock, require more water during the warm season compared to other times of the year. The average daily intake varies between 1.5 to 2 gallons, and it may increase to 2 to 3 gallons in hot weather. While in the pasture, the water source should be located ideally within 700 to 900 feet walking distance for goats. Drinking water provided through surface water sources such as ponds and creeks should be free

from bacteria and pesticides (cropland runoff) that are potential hazards for goats. The water quality of wells and springs can also be a problem due to cross contamination with bacteria and nitrates from septic tanks and milk house wastewater. Good, clean water should be provided to the animals at all times.

Feeds

A ruminant's diet consists of roughages and concentrates. Since 45% to 64% of the cost of production is feeding, good feeding management can reduce the cost of production significantly. Roughages are included in the diet, especially in small ruminants such as goats to reduce the risk of digestive disturbances (Fig. 2). Foraging preferences of goats encompass a wider spectrum of plants than for other ruminants.



Figure 2. Hay feeder designed by Mr. Bill Edwards.

Goats are inclined to forage or browse from the top downward on a plant; therefore, consider making them an effective biological herbicide for controlling many undesirable plants and/or shrubs. As selective browsers, their grazing behavior facilitates their ability to survive under more harsh semi-arid conditions than either sheep or cattle.

Goats are good browsers and can selectively utilize a wide variety of shrubs, woody plants, weeds and briers. Depending on the management system, you may use pastures, dry forage (hay), and silage or haylage. Silage and haylage in moderation and along with other roughages are very good sources of roughage for goats. Very young goats (up to 5-6 months of age) should not be fed silage.

Goats have a special interest in garden products and they can be effectively incorporated into their diet. Rape, kale or beets commonly are added to the diet of the animals. Under controlled feeding, these animals adapt well to by-products and surplus feeds including discarded produce. Some surplus or damaged produce like carrots, artichokes and turnips should be used with caution.

Cabbage contains goitrogens, which may interfere with thyroid hormones and should be limited to 30 percent of total dry matter intake. Beets are very palatable to goats and up to 1 kg DM per day can be consumed without any problems. Avoid feeding clippings from rhododendron or prunings from cherry, apricot or peach trees because when wilted, they may be toxic to goats. Sweetpotato forage and its mixture with grasses provide an inexpensive source of nitrogen in the diet of growing goats.

Pastures

Pasture is the lowest cost feed if grazing is permitted (Fig. 3). There is no need for harvesting, storage or feeding. However, pastures need to be limed, fertilized and clipped on a routine basis. Utilizing pastures as a major portion of the forage feeding program reduces the cost of meat goat production significantly.



Figure 3. Goat grazing on ryegrass pasture.

The soil and climate in most Southeastern states, California and the Midwest are favorable for growth of a wide range of productive high quality grasses and legumes suitable for grazing. Pastures can be grazed either continuously or rotationally.

Under a continuous grazing system animals are allowed to graze the pasture throughout the grazing season, and the number of animals grazing per acre (grazing intensity) is predetermined to allow sufficient re-growth. Under-stocking and overstocking may alter the output in terms of animal production. Under-stocking will result in more mature plant stands in the pasture having higher fiber content, low protein, and energy content. Under-stocking is also associated with low digestibility, thus, lower quality pastures. Also, trampling associated with under-stocked pastures results in herbage waste.

Overstocking reduces available forage per animal and may not sustain optimum animal production. In addition, parasite management is intensified under the overstocking system of grazing. Thus, the parasite burden may be increased if proper measures are not practiced for parasite management. Producers should be aware that the proper stocking rate in terms of maximum animal gain usually is not the same as maximum gain per acre. Higher stocking rates may reduce individual average daily gain (ADG) but increase maximum gain per acre, as indicated in Table 1.

Table 1. Goat performance on ryegrass pastures.

Stocking rate (n/acre)	8.0	10.4	13.6	16.4
Total weight/acre (lbs.)	430	558	730	881
ADG (lbs.)	0.31	0.20	0.22	0.18
Total gain/acre (lbs.)	370	310	446	440

Bransby et al., 2006

Rotational grazing or controlled grazing is an economical way to provide forage for goats; however, it requires careful planning, fencing, and intensive management. This system allows goats to rigorously graze a pasture and be rotated to either a rest paddock or to another similar pasture. This permits plants to re-grow on the grazed pasture. The timing of animal rotation is based on the growth characteristic of the forages in the pasture and sometimes may depend upon the parasite cycle that prevails in that environment. Perimeter fences are required to hold animals in pastures and protect them against predators; however, rotational or controlled grazing requires temporary or interior

fencing to subdivide the pasture into paddocks for rotation. For proper fencing and subdividing the pasture; please see Gay et al. (2003).

Dry Forages

Dry forages added to high concentrate diets can increase rumen buffering capacity and, therefore, optimize rumen fermentation and improve animal performance. Dry forages are hays, pelleted forages and some by-products such as straws and hulls.

Grass hay usually is of a lesser quality and feeding value than legume hay. Goats tend to eat pelleted and chopped hay more than long hay. The stage of maturity of forage cut for hay can influence its feeding quality.

Legumes (alfalfa, clover) and grass (bermuda and bahia) are good sources of hay for goats; however, endophyte infected fescue should be used with caution. Feeding better quality hay allows lowering the protein content of the grain mix fed and thus the feed cost. Factors influencing quality of hay include: 1) date of the harvest; 2) leafiness; 3) lack of seed head; 4) absence of coarse stems; 5) lack of foreign material and 6) green color.

Straws, most hulls, and stovers are of lower quality (digestibility) but not necessarily of low value in mixed feed. Cottonseed hulls have higher palatability and feeding value than peanut hulls and oat hulls. Soybean hulls (an exception) in combination with hay are excellent forages for goat.

Browse

Goats prefer foliage from trees and shrubs (Fig. 4). These novel dietary ingredients are rich in nutrients, although they often contain high levels of plant toxins and anti-nutritive factors. A possible collateral benefit of browse materials containing secondary compounds is in reducing internal parasite infestations. Goats select strongly for tree foliage, shrubs, forbs, flowering parts, seeds, and nuts when they are available. Available browse can serve as a supplement in pastures with declining forage quality help and sustain grazing animal performance. Conversely, use of predominant

browse pastures can be improved by supplementation with conventional feeds (e.g., barley) to reduce secondary compound overload and provide limiting nutrients.



Figure 4. A goat browsing on mimosa.

Concentrates

In addition to the roughage, grain mixes are required in the diet of growing and nursing goats. This is the most expensive part of the diet. Concentrate mixes are made of high energy or high protein feeds. High-energy feeds are all cereal grains, some root crops, flourmill and bakery by-products, and other food manufacturing by-products such as beet pulp and citrus pulp. Vegetable oil or animal fats are also used to increase energy density of the diet; however, more than 7-8 percent fat in the diet may have a negative impact on rumen fermentation and depress fiber digestion.

When forages or browse are low in energy, 0.5-1.0 lb. shelled corn or whole cottonseed (WCS) can be used as energy concentrates. Whole cottonseed contains high levels of both protein (20 to 24 percent) and energy and requires no processing, which makes it a very desirable by-product feed. Most of the energy in WCS is from fat. Whole cottonseed also contains gossypol, a polyphenolic yellow pigment. Research has indicated that WCS could have deleterious effects on male reproduction if

consumed at higher than 15-20% of the diet (McCrary, 1998).

High protein feeds are alfalfa hay, alfalfa meal or cubes, and other high protein concentrates such as oil seed by-product meals (cottonseed, peanut, soybean, etc.) that may be more economical, especially for mixed rations. Corn gluten meal has a poor balance of amino acids, whereas fishmeal and heat-treated soybean meal provide a good and beneficial source of protein. Urea is a non-protein nitrogen that is efficiently used by microorganisms of the rumen during fermentation and protein synthesis. When used correctly in goat feeds, urea can provide an excellent cost effective source of N. Urea feeding should be limited to not more than 25 percent of required protein in the ration of nursing does. Urea does not provide energy in the ration; therefore, it should be included only with adequate soluble carbohydrates. Ratio of N (nitrogen) to S (sulfur) in the diet should be monitored and maintained at 10-12:1 when feeding urea. Its use with low quality forages is not recommended unless adequate time for adaptation and other sources of readily available energy, such as molasses, are provided. Also, it should not be included in the rations of young ruminants when the rumen is not fully functional. Ammonia toxicity can occur when a large amount of urea is introduced in the ration or the ration containing urea is improperly mixed.

According to the developing Meat Goat Quality Assurance program, protein derived from ruminants and poultry litter (potential contamination with ruminant derived protein) should not be fed to goats.

There are numerous varieties of commercial protein supplements available such as byproduct meals (most common in ration formulation), cubes or pellets, liquid supplements and blended and cooked products.

Protein is the most expensive part of the diet; therefore, cost comparison, presence of other dietary components, palatability, feeding facilities, labor cost/convenience and uniformity of intake must be considered. Several commercial grain mixes are available for meat goat production; however, to reduce the cost of feeding, one should prepare his/her own grain mix. Formulas for different grain mixes are

available in this publication or upon request from many university Extension personnel or by contacting a goat nutritionist in your area. Grain mixes can be prepared according to the formula at different feed mills for volume production. Trace mineral supplements should be provided at all times and should be ideally formulated specifically for your area.

Feeding Practices

Herd Sires

Pre-breeding Season

Majority of meat goat breeds are year-round breeders; however, breeding season may differ according to your breeding management. A herd sire should be maintained on a balanced diet year-round for maintenance and growth. Good quality hay, ad libitum, can supply these requirements. The buck's activities during off breeding season are limited, but as the breeding season approaches, necessary measurements should be taken to prepare the buck for his active season. Depending on the condition of the animal and his prior plane of nutrition, good quality hay -- free choice -- and 1 to 2 lbs. of 14-16% protein mix will be sufficient.

Supplementation should start as early as six to seven weeks or as late as two weeks prior to the breeding season, depending on the prior nutrition of the buck. This is because production of fertile sperm is initiated 40 to 60 days before its deposition in the female reproductive tract. Grain supplements should include a sufficient amount of vitamins and minerals. Trace mineralized salt should be provided free of choice and preferably in loose form.

Breeding Season

In the breeding season (which usually starts in August and lasts through December for seasonal breeders), activities of a herd sire are increased. During the breeding season, males engage in fighting other bucks and in breeding does, and may devote little time to feeding. They draw heavily on body reserves. Sometimes they stop eating during the mating season and lose up to 17% of their body weight between August and October. Breeding males may serve does up to

20 times a day and 350 services seem to be possible in a limited breeding season.

Providing good quality hay and 2 lbs. of concentrate mix containing 14-16% protein and adequate amounts of minerals and vitamins are essential. The grain mix should contain 2000 to 3000 IU of vitamin A and 600 (IU) of vitamin D. Plenty of water and trace mineralized salt in loose form should be provided ad libitum.

Post-breeding Season

The herd sire should be removed from the herd no later than mid-January unless you are breeding year-round. You may start reducing his allowance from two to one pound of grain mix per day as early as November, depending on the animal's condition. If good quality hay is provided, the animal does not need additional supplement mix. However, if hay is of poor quality, provide one pound of grain (16% crude protein) for maintenance requirements.

Kids

The first three days after birth are the most critical days in the life of a newborn kid. You may separate the kids from the doe immediately, or you may leave the kids with mother. If you separate the kids, you should make sure that they receive colostrum for the first three days of their life. Colostrum is the very first secretion of the mammary glands. It is very nutritious and contains high levels of protein, milk solids, globulins, fats and vitamin A. Most important, it contains antibodies against the diseases to which the doe has immunity. It is critical to feed colostrum for the first three days for maximum protection against disease because the absorption of these antibodies disappears after three days.

Kids should nurse as long as possible or until weaned. If a mother rejects the kid/s, colostrum should be fed three times a day, a total of 2 to 3 pints daily. Try to find a nursing doe to adopt the kid/s as soon as possible. After three days, feed the orphan kid/s milk or milk replacer twice daily not to exceed three pints per day. When using milk replacer, follow the directions for feeding. Increase the milk replacer gradually if used. Feeding milk or milk replacer could continue up to 8-12 weeks or up to the time kids

are weaned or are able to consume .5 lb. of grain mix daily. Provide a grain mix (kid starter, Table 2) containing high levels of protein (16%) and high levels of fiber (11%) as well as good quality hay to encourage rumen development.

Table 2. Kid starter grain mix

Ingredient	% of ration
Cracked corn	29.0
Crushed oats	29.0
Wheat bran	29.0
Soybean meal	11.5
Trace mineral salt	0.5
Dicalcium phosphate	0.5
<u>Vitamins ADE</u>	<u>0.5</u>
Protein	15-16%
Fiber (minimum)	10%

Yearlings

Yearlings require nutrients for maintenance and growth if they are going to be replacement does. After weaning up to 6 months, continue feeding with kid starter .5 to 1 lb./day and plenty of good quality forage and pasture. Do not feed silage and non-protein nitrogen at this age. Fresh water should be available at all times. Macro and micro minerals should be incorporated in the grain mix or provide a loose mineral mix.

At 6 months of age up to the breeding age (9-10 months) animals may require 1-1.5 lbs. of grain mix with at least 14% protein (grower mix, Table 3), minerals, trace minerals, and vitamins A, D, and E. Do not feed more than 1/4 of protein requirement as non-protein nitrogen.

Table 3. Grower ration

Ingredient	% of ration
Corn	50.0
Alfalfa meal	15.0
Oats	17.0
Soybean meal	12.0
Molasses	3.0
Trace mineral salt	1.0
Vitamins ADE	1.0
Dicalcium phosphate	0.5
<u>Limestone</u>	<u>0.5</u>
Protein	14-15 %

When yearlings are bred, they can be placed with pregnant does.

Pregnant Does

Meat goats require a little more attention at least 4-6 weeks prior to the next kidding. A good pasture, hay or silage as well as .5 to 1 lb. of 12% protein grain mix will be sufficient. Do not use alfalfa as a sole source of forage during this period. Alfalfa contains a high calcium-to-phosphorus ratio which is not desirable for late pregnant does. Does should be kept in good flesh but not fat during this period.

Nursing Does

During the first few months of lactation, animals should consume enough to meet their needs for milk production for nursing kids. It is desirable to feed high quality legume or grass hay and a grain mix containing 16% protein and balanced for vitamins and minerals. Nursing does should be fed properly to produce maximum milk and heavier weaned kids. Good pasture, browse, and garden products including root crops can be helpful. Grain intake should be increased if needed to optimize kid growth. Grain mix should be supplemented with 6 million IU of vitamin A and 3 million IU of vitamin D per ton.

Table 4. Grain mixes for nursing or lactating does (NRC, 1981)

Ingredient %	Protein content %		
	14	16	18
Corn Grain	37	35	32
Oats grain	34	32	29
Wheat bran	16	14	15
Oil meal (soybean, linseed)	9	15	20
Molasses	2.5	2.5	2.5
Dicalcium phosphate	0.5	0.5	0.5
Trace mineral salt	0.5	0.5	0.5
Vitamins ADE	0.5	0.5	0.5

Feeding According to the Requirements

For proper feeding management, herd should

be divided into groups, such as growing kids, pregnant does, nursing does, and herd sires. Also, having an average BW of each group will help to determine their average maintenance requirements. Additional nutrients are needed for growth, pregnancy and milk production.

Growing goat kids require energy, protein, vitamins and minerals for optimum growth and profitability. Determining quantities of these nutrients needed will enable you to determine how much of grain mix and hay should be used to support maintenance and growth. Table 5 lists nutrients required for maintenance according to BW (NRC, 2007).

Table 5. Nutrient requirements for maintenance

BW (lbs.)	Energy (Mcal)	CP (g)	Ca (g)	P (g)	A (RE)	E (IU)
22	0.61	25	0.9	0.5	1000	100
33	0.82	33	1.0	0.6	1500	150
44	1.02	41	1.1	0.7	2000	200
55	1.21	49	1.2	0.8	2500	250
66	1.38	56	1.3	0.9	3000	300
77	1.55	63	1.4	1.0	3500	300
88	1.72	69	1.5	1.1	4000	400

For additional weight gain, animals also need nutrients for growth.

- Additional 0.55 Mega calories (Mcal) are needed for every 100 g gain/d. It is less (0.48 Mcal) for local breeds.
- Additional 57 g protein (CP) is needed for every 100 g gain/d. It is less (42 g) for local breeds.
- Additional 2.8 g calcium (Ca) is needed for every 100 g gain/d. It is less (2.7 g) for local breeds.
- Additional 1.3 g phosphorus (P) is needed for every 100 g gain/d. It is less (1.2 g) for local breeds.
- Additional nutrients are needed for pregnancy depending on single, twin or triplets.
- Additional nutrients are needed for nursing and milk production depending on number of kids nursing.

Pasture, hay or grain mixes used for feeding should be tested for moisture, energy, protein, and fiber content.

To determine total feed required, maintenance and growth requirements must be combined.

For example, if a group of kids have average BW of 44 lbs. and they are expected to gain 100 g per day, according to Table 5, on average, they need:

$1.02 + 0.55 = 1.57$ Mcal energy per day and
 $25 + 57 = 82$ g of protein per day.

You may feed hay up to 2% of BW:
 $44 \text{ lbs. BW} \times 0.02 = .88$ lbs. of hay

If hay contains 0.5 Mcal/lb. energy and 12% crude protein, it can provide:
 $0.88 \text{ lbs.} \times 0.5 = 0.44$ Mcal energy and
 $0.88 \text{ lbs.} \times 0.12 = 0.106$ lbs. or 48 g protein.

Animals will need additional:
 $1.57 - 0.44 = 1.13$ Mcal energy and
 $82 - 48 = 34$ g of protein.

Corn grain contains about 0.85 Mcal/lb. energy and about 9% crude protein. Therefore:

$1.13/0.85 = 1.3$ lbs. of corn grain will satisfy energy and will provide needed protein:
 $1.3 \times .09 = 0.117$ lbs. or 53 g protein.

The higher the quality of hay, the less grain mix is needed. If animals are expected to gain more than 100 g/day, intake is limited, therefore, higher concentrated energy and protein diets maybe needed.

Practical Notes on Feeding Goats

- Goats usually consume 3-4% of their body weight in dry matter.
- Younger growing goats as well as lactating does may require higher levels of nutrients in the diet and may consume higher amounts. Mature and maintaining animals may require less nutrients in the diet and consume lower amounts.
- Overfeeding grain mixes is expensive and not healthy for goats.
- Corn can replace oat or wheat.
- Wheat should not exceed 25% of the grain.
- Wheat bran can be replaced by soy hulls or cottonseed hulls.
- Soybean meal can be replaced by other oil meals.

- To increase the protein in the ration, increase oil meal and reduce corn, wheat, or oats.
- Grain mixes should be fed with good quality roughages such as pasture, hay, browse or silages (with caution).
- With lower quality roughages, animals should be fed higher protein in the grain mix.
- In all rations make sure each animal receives:
 - Vitamin A, 2000-4000 RE/day
 - Vitamin D, 330-500 IU/day
 - Vitamin E, 200-300 IU/day
- Make sure that animals receive at least 15 ppm copper in their diet.
- Provide mineral mixes at all times. Check the latest publication on Nutrient Requirements of Goats (NRC, 2007) for adequacy of other minerals and trace minerals.

Other Factors Considered in Feeding Goats

Goats can consume large amounts of forages by grazing; however, intake may be higher at the trough with cut and carry feeding systems. Chopping green forage increases the ease of handling but may reduce intake. On heterogeneous resources (browse and graze), goats are more selective and choose a diet of higher quality than that offered in the trough. Goats have more preference for legumes than grasses; for alfalfa than red clover; for Italian ryegrass, corn, and sorghum than orchardgrass and fescue hay. The voluntary intake can vary depending on the stage of plant growth; maximum consumption is generally observed 1-2 weeks before ear production with grasses and 1 week before budding with legumes. In the case of garden produce, when dry matter is less than 10-12 percent, forage wetness may limit intake.

Refusal allowance is another factor to be considered in feeding forages to goats. Goats will eat more forage (depending on the type of forage) with more refusal allowance having selection opportunity. Mixed green forages or green forages along with dry forages may be preferred over single forage giving them a chance for selection.

Silages are partially fermented grain/grass or legume forages and should be produced free of molds. Feeding silage to goats has been associated with metabolic and other problems

and should be gradually introduced in the goat's diet. Goats tend to eat less silage when compared to green or pelleted forages. Supplying hay with silage is advisable to reduce digestive and metabolic problems and improve intake.

Many factors can influence supplement consumption by individual animals including supplement type and delivery methods such as trough space, supplement allowance, supplement form, and formulation. Trough space allowance per animal can influence competitiveness and variation in supplemental feeding. A feeding space of 10 to 12 linear inches/kid and 15 to 20 inches/adult goats will be adequate for proper feeding. Providing space less than that will increase aggressiveness and dominance/submissive behavior. However, as in some cases with cattle, when excessive space was provided, dominant animals tended to exhibit more aggressive behavior such as fighting and chasing other cows. Most importantly, infrequent feeding and changes in feeding times along with limited space can cause more dominant animals to overeat possibly resulting in grain engorgement (enterotoxaemia) and weaker animals not eating at all.

More supplemental allowance encourages selectivity and more consumption; however, it may induce more wastage. Animal related factors are exposure time, previous experiences, and social interactions. With more frequent feeding, goats will consume more. They will readily consume familiar materials. Dominant animals will consume first. Forage consumption will depend on its availability.

To improve fertility, flushing is a practice of feeding supplemental protein or energy to breeding does 30 days prior to and after the introduction of the herd sire (buck), especially for dairy goats. This may not be necessary for meat-producing animals if the quality and quantity of available forage is ample.

Creep feeding is not a common practice in meat goat production but may become profitable with changes in goat marketing strategies that promote premium prices for larger, more highly finished kids. Lightweight goats that are in poor condition or have had a long stressful haul, may be reconditioned through a controlled grazing scheme and with no or limited grain feeding.

Generally, most of the male kids and those female kids that are not used for replacement herds are either sold as weaned kids or are fed for meat production. On most farms all male kids are castrated as soon as possible for easy handling and docility of the animal. However, if kids are fed for the meat market, castration will stunt their growth, reduce the average daily gain, and increase the length of time needed for goats to reach their market age. Research has indicated that intact buck kids gained on average 0.3 lbs. per day whereas castrated wether kids gained on average only 0.15 lbs. (Solaiman et al., 2006a). With this practice you lose almost 50% of the potential gain. It is recommended for commercial meat production, if bucks could be kept separate from does, eliminate the cost of castration and let intact bucks gain weight as fast as they can; however, it will depend on your management practices (Fig.6).

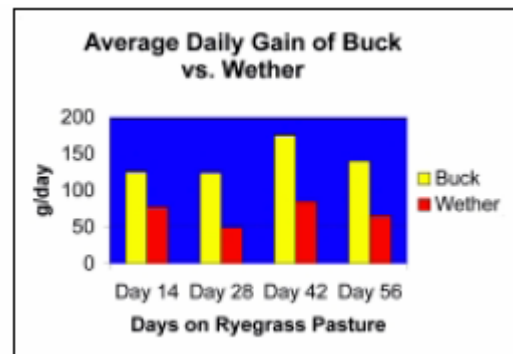


Figure 6. Comparing buck vs. wether average daily gains on ryegrass pastures.

A Note on Copper and Selenium Requirements of Goats

Soils in many areas of the U.S. are deficient in copper, resulting in copper deficient feeds produced in these areas. However, adding a mineral supplement to the diet that has an adequate amount of copper can eliminate most symptoms of deficiency. In fact, copper deficiency is sporadic throughout the country. All coastal areas on the west (including California) and east coasts, the Southeast and major parts of the Midwest are deficient in copper. Generally, animals raised in Western

states had lower serum copper than those raised in Southeastern and Midwestern states.

In some states copper levels in soil may be sufficient; however, other minerals such as molybdenum or sulfur may reduce its availability. Also soil copper levels may vary from location to location within a state.

Therefore it is recommended to check your soil mineral level for copper, molybdenum and sulfur.

Copper deficiency symptoms vary depending on the severity of the condition. Symptoms may be exhibited as frequent staph lesions on the body, a thin and faded hair coat, bald tail tips, twisting and bending of the front legs, spinal cord injuries or even anemia. Generally, the immune system breaks down due to hypocupric conditions and animals become vulnerable to diseases and parasites. Although most symptoms of copper deficiency may be reversible by feeding adequate copper, other symptoms in young kids such as swayback (caused by deficient pregnant does), and spinal cord injuries are not reversible. Research on feeding high levels of copper to goats has indicated that goats are much more tolerant to high levels of copper than sheep or cattle (Solaiman et al., 2001). Feeding levels as high as 100 mg copper per day actually improved daily weight gain and immune functions in goats (Table 5, Solaiman et al., 2004), and these findings confirm previous recommendations of other producers and goat experts.

Table 5. Effect of Cu (mg) supplementation on growth performance of goat kids.

Days	0 Cu	100 Cu	200 Cu	P-value
Average Daily Gain, g				
28	156.6	144.5	167.7	0.61
42	147.6	156.6	134.1	0.39
56	137.4	149.6	129.9	0.19
70	134.9	153.1	119.2	0.02
84	131.7	147.6	116.6	0.01
981	29.2	147.3	122.5	0.04

Pat Coleby (2001) in her book *Natural Goat Care* repeatedly has recommended feeding copper as copper sulfate at the level of 1

teaspoon per week per animal for continuous supplementation in feed or water to goats. In addition, copper has been shown to improve herd health and production. Internal parasites can also contribute to copper deficiency and in turn parasites can be more prevalent in copper deficient animals. Thus, parasite infestation can be appropriately managed when animals are kept at high copper status. Ms. Coleby recommends a higher copper sulfate dosage of 1/2 teaspoon per animal per day when they have parasite infestation. Feeding high levels of sulfur (> 0.35% of diet dry matter), molybdenum (> 2 ppm molybdenum in feed or ratios of copper: molybdenum < 5:1), iron (more than 250 ppm), calcium, zinc, manganese and cobalt can reduce copper absorption and deplete liver copper. Soils heavily limed or high in pH may cause copper to be unavailable.

The level of copper in the liver can accurately determine copper status; however, liver biopsy samples are needed. Safe procedures are in place for cattle for liver biopsies; however, similar procedures in goats are questionable. The secondary measurement that can determine copper status of goats is plasma or serum copper; however, liver can be dramatically depleted before plasma or serum copper drops.

Copper can be supplemented through mineral mixes that are high in copper. Do not feed mineral mixes that are labeled for both “sheep and goats” to goats. Sheep are more sensitive to high copper levels; therefore, mineral mixes appropriate for sheep will not have adequate copper for goats or may have high levels of molybdenum. I recommend copper levels to be as high as 20-30 ppm in the diet (Solaiman et al., 2006b). The lower level is advised when copper is not deficient in the area. Many producers follow Coleby’s recommendation of 1 teaspoon of copper sulfate per goat per week on a regular basis. Copper also can be supplemented through slow release copper wire needles as copper boluses (0.625 to 1.35 grams) given early to kids (2-4 weeks of age) or 1 gram copper oxide in bolus form per 22 pounds of weight every 5-6 months in copper deficient areas. These needles are deposited in goat’s stomachs and release copper slowly. Some feeds such as alfalfa, wheat, barley, and oats are low in copper and

some, like alfalfa, are also high in molybdenum. Applying 1.5 to 3 pounds of copper per acre as organic compounds such as copper EDTA, copper lignisulfonates, or copper polyflavonoids can increase soil copper levels for a long time.

Selenium also can be deficient depending on the region of the country. The Dakotas are rich in selenium and selenium toxicity may occur; however, most other places including California and Southeast may be Se deficient. Selenium injections are used for pregnant does toward the end of the pregnancy and young kids at birth. For dosage and directions, I recommend consulting with your veterinarian. Selenium or copper can be toxic if overdosed.

References

Bransby, D., S. Solaiman, C. Shoemaker and S. Sladden. 2006. Goat production from annual ryegrass in Alabama. In: Proceedings, Annual Forage and Grassland Congress meeting.

Coleby, P. 2001. Natural Goat Care. Acres USA, Austin, Texas.

Gay, S.W., S. R. Smith and G. E. Groover. 2003. Planning fencing systems for controlled grazing. Virginia Cooperative Extension, Publication 442- 130.

McCrary, Q. 1998. Effect of feeding whole cottonseed on reproductive performance in goats. M.S. Thesis. Tuskegee University, Tuskegee, AL.

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NRC. 2007. Nutrient Requirements of Sheep, Goats, Cervids and Camelids. National Academy Press. Washington D.C.

Solaiman, S. G., M. A. Maloney, M. A. Qureshi, G. Davis, and G. D'Andrea. 2001. Effects of high copper supplements on performance, health, plasma copper and enzymes in goats. *Small Ruminant Res.* 41:127-139.

Solaiman, S. G., T. Craig Jr., G. Reddy, C. E. Shoemaker, and G. F.W. Haenlein. 2004. Effects of supra-nutritional Cu levels on growth, rumen fermentation and immune responses of goat kids. Pp. 136-144 in Proceedings of 22nd Workshop on Macro and Trace Elements. First volume, M. Anke, G. Flachowsky, K. Kisters, U. Schafer, H. Schenkel, M. Seifert and M. Stoeppler, eds. Friedrich Schiller Univ., Jena, Germany.

Solaiman, S. G., D. Bransby, C. Kerth, B. Blagburn, R. Noble and C. Shoemaker. 2006a. A sustainable year- round forage system for goat production in the Southern U.S. Final Report, Project # LS02-141, Southern SARE.

Solaiman, S. G., C. E. Shoemaker, W. R. Jones and C. R. Kerth. 2006b. The effect of high level of Cu on serum lipid profile and carcass characteristics in goat kids. *J. Anim. Sci.* 84:171-177.



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