Chapter Seven

Nutrition and Feeding of Sheep and Goats

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Objectives

1. To identify feed-related problems of sheep and goat production.
2. To identify alternative strategies for feed resource development.
3. To learn the structure and functions of the ruminant digestive tract and possible ways of manipulating it to improve utilization of coarse feedstuff.
4. To learn the feeding habits of sheep and goats and implications for feeding and nutrition.
5. To learn methods to improve the feeding value of roughages through chemical treatment.
6. To learn the advantages and disadvantages of urea treatment and supplementation using urea molasses blocks.
7. To identify strategies for feeding sheep and goats during drought periods.
8. To learn appropriate methods of grassland and grazing management.
9. To learn appropriate feeding practices for different classes of sheep and goats.
10. To identify the characteristics and feeding value of common feedstuff.

Expected Outputs

1. Recognition of feed-related problems of sheep and goats in different agro-ecological zones.
2. Knowledge and ability to practice alternative strategies for better feeding of sheep and goats.
3. Skills to transfer improved sheep and goat feeding methods to producers resulting in improved productivity of sheep and goats.

7.1. General Introduction

The nutrition of sheep and goats is the most important factor affecting performance. Poor nutrition results in low rates of production, often defined by growth and reproduction. It also affects the immune system and the ability of an animal to fight disease. In extreme conditions of malnutrition, death can occur. In many animal production systems, approximately two-thirds of improvements in livestock productivity can be attributed to improved nutrition. In economic terms, feed cost accounts for about 70% of the total cost of livestock production. The feasibility of livestock enterprises is, therefore, a function of the type of feed and feeding system. It is estimated that up to a five-fold increase in tropical livestock productivity can be attained if there is optimal feed resource utilization. Sheep and goat production in Ethiopia suffers from feed shortages at all levels with an estimated 40% deficit in the national feed balance. This is aggravated by seasonal availability of forage and crop residues in the highlands and by recurrent and prolonged drought in the lowlands.

Improving performance through better nutrition is determined by three interrelated considerations:

- the availability of nutrients;
- type of feeding system; and
- the level of feeding management.

7.2. Structure and Function of the Digestive Tract

Sheep and goats are ruminants. Ruminants have the ability to consume and digest coarse, fibrous feedstuffs that form the major feed base in Ethiopia. The digestive tract of ruminants is unique in structure and function, allowing them to digest the fibrous feeds they consume.

The following are some of the unique features of the ruminant digestive tract compared to monogastric animals (animals with a simple stomach such as swine, dogs, cats, humans, etc.):

- Ability to digest carbohydrate sources not digested by monogastrics.
- Ability to use sources of non-protein nitrogen (NPN) to satisfy part of their protein needs.
- Large stomach volume to accommodate and utilize bulky feeds.
- Mouth and teeth well adapted for prehension and grinding of fibrous feeds.
- Well-developed salivary glands for production of large volumes of saliva.

7.2.1. Structure of the ruminant stomach

The ruminant stomach has four compartments known as the rumen, reticulum, omasum and abomasum. Most fermentation and absorption takes place in the rumen and reticulum. The two organs are generally considered as a single organ (reticulo-rumen) due to incomplete separation.

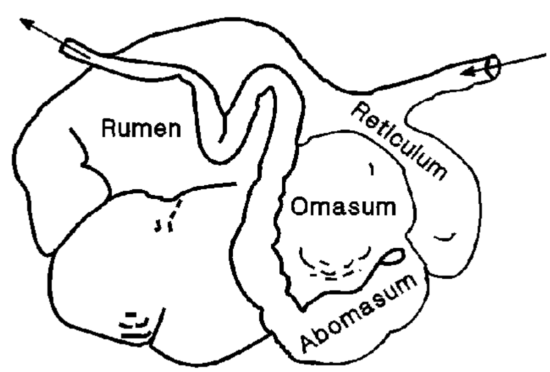


Figure 7.1. Structure of the ruminant stomach.

The reticulo-rumen is like a large fermentation vat where much of the physical and chemical breakdown of fibrous material occurs. Most of the chemical breakdown is a result of enzymatic activity of micro-organisms comprised of bacteria, protozoa and fungi. Physical breakdown is due to the strong movements of the reticulo-rumen and through rumination or chewing of the cud.

The rate at which digestion occurs is governed, to a large extent, by the number and type of micro-organisms present in the reticulo-rumen. A large and healthy population of micro-organisms results in faster digestion of feed and an added source of protein for the animal as the micro-organisms are broken down and digested later in the abomasum and small intestine. The population of micro-organisms is specific to particular diets and changes gradually in response to the type of feed eaten. The rumen can become upset when a sudden dietary change occurs because the micro-organisms cannot effectively digest the new feed. The sudden introduction of a new feed can lead to scouring, loss of condition or even death in severe cases.

7.2.2. Development of the ruminant stomach

Newborn ruminants have only a partially developed rumen and reticulum and are functionally monogastric animals. They are unable to use ordinary carbohydrates except lactose (the carbohydrate in milk) or grain-based feeds. Milk is digested in a well-developed abomasum. Milk bypasses the rumen and goes directly into the abomasum through the “esophageal groove,” a tube formed from two folds of muscular tissue in the rumen that close upon suckling action of the lamb/kid. Digestive problems will result if the newborn is weak and unable to suckle. In this situation, it must be artificially fed using a tube (see the Health chapter for procedure).

Dry feed must be consumed for the rumen to develop. The rumen becomes inoculated with micro-organisms when the lambs/kids nibble on dry feedstuff. The development of the stomach complex enables lambs/kids to benefit from the action of the micro-organisms. They then have the capacity of:

Table 7.1. Development in the relative sizes of sheep stomach compartments (% of total).

Age	Rumen	Reticulum	Omasum	Abomasum
At birth	24	8	8	60
2 months	61	11	6	22
Adult	62	11	5	22

- microbial digestion of cellulose;
- incorporation of non-protein nitrogen into microbial protein; and
- synthesis of vitamin K and the B vitamins.

Ideally, the young animal should be confined and, from 2 to 3 weeks of age, supplied with a small amount of easily digestible feed. This will promote faster rumen development. The lamb/kid will increase its feed intake as the milk supply from the dam gradually decreases. Lambs and kids are very vulnerable to malnutrition. Weaning is a critical time unless they are adapted to consuming solid feed and weaned to high-quality diet.

7.2.3. Rumen environment and its manipulation

7.2.3.1. Rumen environment

An unhealthy and small population of rumen micro-organisms results in slow digestion and a slow passage of feed. The following conditions should be maintained in the reticulo-rumen to allow micro-organisms to grow and flourish.

- Constant temperature and pH (~6–7).
- Anaerobic environment conducive to rumen micro-organisms that are predominantly obligate anaerobes.
- Ruminal contractions to stir and mix the microbes and contents.
- Removal of the by-products of microbial digestion (volatile fatty acids, etc.).

Inadequate supply of nutrients, mainly nitrogen, sulphur and cobalt to the microbes will reduce microbial growth, and consequently reduce digestion. Supplementation of these nutrients is required in many cases. Often, the primary limitation is the concentration of ammonia (NH_3) in the rumen. Continuous availability

of NH_3 is critical for proper function.
Nitrogen metabolism in the reticulo-rumen is an example of rumen micro-organisms influencing the nutrition of sheep and goats. Most protein entering the rumen is broken into its constituents of a carbon skeleton, nitrogen (usually in ammonia form), and the side groups of amino acids. Any non-protein nitrogen entering the rumen, urea for example, is changed to ammonia. Ruminal micro-organisms use these breakdown products to manufacture microbial protein, allowing for growth and expansion of the microbial population. This microbial protein is later used by sheep and goats when the micro-organisms pass into the small intestine and are digested.

The solubility of feed protein in the reticulo-rumen varies with the source. In some feeds, such as some oilseed cakes, fish meal, feather meal, etc., a large proportion of the protein passes to the small intestine without being solubilized in the reticulo-rumen. These proteins, referred to as "bypass" protein, are digested in the small intestine. Because bypass proteins have not been altered by rumen micro-organisms, they retain their original amino acid profiles. In cases of high quality protein, this is beneficial to the animal. Forage legumes have intermediate rumen solubility. The solubility pattern of certain proteins can be changed through methods such as heating to increase the proportion of bypass protein.

7.2.3.2. Manipulation of rumen fermentation

The fermentation process in the rumen can be manipulated to improve the utilization of feed by sheep and goats by:

- Increasing the digestibility of complex carbohydrates in poor quality roughages.
- Altering the composition of microbial fermentation products (volatile fatty acids).
- Decreasing the degradation of certain nutrients in the rumen and encouraging nutrient bypass.

There are different ways of manipulating fermentation of feeds in the reticulo-rumen. Methods that have the largest effect on ruminal fermentation include chopping, heat treatment and chemical treatment.

Chopping: Results in increased digestibility largely because it increases the ease with which microbes can attack feed particles. Digestibility will be reduced if chopping is too fine. Finely chopped feeds may pass out of the rumen before microbes can adequately digest them.

Heat treatment: The effect of heat treatment depends on treatment conditions. Mild treatment can be used to increase bypass protein. High or moderate temperature treatment for a long time results in reduction of nutritive value, largely due to formation of insoluble protein complexes.

Chemical treatment: Protection of proteins (e.g., formaldehyde treatment of high quality proteins) is used to increase bypass protein for high producing animals. Digestion of structural carbohydrates can be increased by chemical treatment of poor quality hay and straws (e.g., alkali treatment, urea treatment).

7.3. Nutrients and Feedstuff

7.3.1. Nutrients

Nutrients are substances, supplied by feedstuffs, used by animals for maintenance and production.

Maintenance: All activities and body processes necessary for staying alive and maintaining an animal's bodyweight. Some specific components include:

- Energy to support essential physiological functions.
- Maintenance of body temperature.
- Repair of body tissue.

Production: Nutrients supplied above those required for maintenance allow for productive functions such as:

- Reproduction: Pregnancy and delivery make demands on the dam which should be met largely from her diet. The fetus increases in size quickly during the last third of gestation, drawing on the body reserves of the dam if she is not fed adequately.
- Growth: Any growth requires nutrients; sheep/goats require large quantities of energy and protein during the main period of growth between weaning and attaining mature body weight.
- Lactation: Milk production requires high levels of energy, protein, and water.
- Extra activity: Livestock in pastoral systems walk long distances in search of feed, particularly in the dry season. Animals may walk 10–15 km each day, which requires a great deal of energy.

There are six nutrients found in feedstuffs and animals, namely water, carbohydrates, fats (lipids), protein, minerals, and vitamins. Energy is not a nutrient but is derived from the breakdown of carbohydrates, fats, and protein. A major constituent of most feedstuffs is water. The other nutrients are said to compose the "dry matter" of a feedstuff and largely determine its feeding value. Plants contain mostly carbohydrates whereas proteins predominate in animals. Minerals and vitamins occur in relatively small quantities in both plants and animals.

Carbohydrates: Most livestock feeds are derived from plants and, thus, animal diets contain high proportions of carbohydrates. Most plant carbohydrates, due to their chemical nature, are used more effectively by ruminants such as sheep and goats than by monogastric animals. Carbohydrates are present in very small amounts in animals because they are directly used as sources of energy.

Carbohydrates can be classified as simple sugars or as complex carbohydrates such as starch and cellulose. Starch is the major component of grains and is readily available for digestion by both monogastrics and ruminants. Cellulose is often referred to as fiber and is not broken down by mammalian enzymes. Cellulose is degraded by enzymes produced by micro-organisms in the rumen. Roughages (hay, straw, browse, etc.) contain fiber and are not rich in available energy as are concentrates. The fiber in roughages can be used to provide energy through microbial fermentation in the rumen. Animals need a supply of carbohydrates in the diet at all ages. Carbohydrates consumed in excess of an animal's requirements are converted and stored as fat.

Fats: Fats are concentrated forms of energy that are generally present in small quantities in the common feeds of sheep and goats. Fats are important in the diet to increase the energy value. The fat in an animal is largely manufactured from carbohydrates. Fat deposited during periods of good feed supply may be mobilized at times of shortage as a source of energy. Sheep generally deposit more fat in the body than goats.

Proteins: Animals require a considerable amount of protein because their bodies and products (meat, milk) are composed of high levels of protein. Most common feeds are low in protein, and supplying proteins to livestock is a major challenge. Protein is costly, and the higher the percentage of protein in a feed, the greater the cost.

Minerals: Although required in small quantities, minerals are very important to the living organism. They form part of the structure of the skeletal system and play a role in most body processes. Plants obtain their minerals from the soil. The mineral composition of a feedstuff largely depends on the mineral composition of the soil. Mineral composition of plants is affected by plant species and stage of growth. Young, leafy materials generally have a good supply of all the essential minerals, particularly calcium. Cereal grains have satisfactory amounts of phosphorus and potassium but are poor sources of calcium. Roots and tubers are poor in all minerals.

Minerals are divided into two groups, macro-minerals, those required at 0.1% or more in the diet, and micro-minerals, those required at very small amounts (part per million (ppm)) levels. Macro minerals include calcium, phosphorus, sodium, potassium, chlorine, sulphur, and magnesium. Micro minerals include iron, copper, cobalt, manganese, zinc, iodine, selenium, molybdenum, and others. Mineral deficiencies can lead to decreased growth and reproduction. There are some areas of Ethiopia deficient in one or more minerals, e.g., copper in the Rift Valley region.

Vitamins: Vitamins stimulate the body's function or metabolism. Some vitamins have a general effect while others control a specific reaction or activity. In practical feeding of sheep and goats, the main vitamins of concern are A and D. Vitamin A is a general growth promoter and helps the stock resist infection while Vitamin D is important mainly for maintenance of healthy bones. The B-complex group and Vitamin K are synthesized by rumen micro-organisms, and hence there is no need to supply them through the feed. Even vitamins A and D are not a major concern in the tropics where sheep and goats generally have access to pasture or rangeland.

Energy: While not considered a nutrient, energy is vital to an animal's survival. The breakdown of nutrients, mainly carbohydrates, provides the actual physical energy an animal needs for maintenance and production. Excess energy is accumulated in the form of body fat, which is essential for production and to enable animals to survive periods of low feed intake. Energy is measured in megajoules or calories (1 calorie = 4.2 joules). Carbohydrates, followed by fats, are the primary energy sources. Excess protein can also make contributions.

7.3.2. Feedstuffs

Feeds are classified according to the amount of specific nutrients they supply. Two main classes of feedstuff are **roughages** and **concentrates**.

Roughages: These are bulky feeds containing relatively large amounts of poorly digestible material, that is, more than 18% crude fiber. They can be of two categories, namely dry and succulent based upon their moisture content.

Table 7.2. Nutrient composition of feeds used for sheep and goats.

Feedstuff class	Dry matter (%)	Crude protein (%DM)	ME (MJ/Kg DM)
Straws / stovers	88–92	3–4	5.5–7.5
Cereals	89–91	9–11	12–14
Grasses	20	10–22	9–12
Oilseed cakes	89–91	22–50	12–14
Green legumes	15–27	17–24	10–12

- Succulent feeds usually contain more than 75% moisture and include:
  - Pasture
  - Cultivated fodder crops
  - Tree leaves
  - Root crops
  - Silage
- Dry roughages contain only 10–15% moisture.
  - Hay and crop residues fall in this category

Concentrate: A feed or feed mixture which has high amounts of protein, carbohydrates and fat, contains less than 18% crude fiber and is usually low in moisture. Concentrates are rich in either energy or protein and are thus expensive. They can also be categorized on the following basis:

- Energy-rich concentrates: Feeds with high levels of energy but low in protein content. These can be of the following types:
  - Grains and seeds: best energy sources but generally expensive due to use as human food.
  - Mill by-products: cheaper and widely used (e.g. brans, shorts).
  - Root crops.

- Protein-rich concentrates:
  - ♦ Oilseed cakes: The by-products left after extraction of oil from oilseeds. The protein and energy contents of these products in Ethiopia vary widely depending upon the oil extraction method used, traditional/home extraction, expeller method or solvent-extraction method. Of these, the cake produced by the traditional method contains the highest amount of oil while the solvent-extraction method produces a product with the least amount of oil. Conversely, the protein content is highest in the solvent-extracted cakes and lowest in the traditional method.
  - ♦ Brewer's grain: These are by-products of the brewery industry. Dried brewer's grains contain about 18% crude protein and 15% crude fiber. There is substantial production of this product from home brewing.

7.4. Nutrient Requirements and Deficiencies

7.4.1. Nutrient requirements

Nutrient requirements of sheep and goats depends on their physiological state and function and contains allowances for maintenance and production. The larger the animal, the more feed it needs to maintain its body function. As production increases, so does nutrient demand and feed requirement. Nutrient requirements of sheep and goats are similar and will be presented together for the purpose of this handbook. Specific nutrient requirements for sheep and goats in Ethiopia are not available. Requirements for different animal functions derived from information on animals in the tropics are presented below.

The overall nutrient requirements of a particular sheep or goat are the sum of its maintenance requirement and other physiological functions (e.g., pregnancy, growth, lactation etc.). Maintenance requirements are presented in Table 7.3.

Table 7.3. Daily maintenance requirement estimates for energy and digestible crude protein (DCP).

Live weight (kg)	ME (MJ/kg dry matter)		DCP (g/day)	
	Confined	Extensive	Maintenance	Pregnancy
10	2.32	3.25	15	30
20	3.91	5.47	26	50
30	5.30	7.42	35	67
40	6.58	9.21	43	83
50	7.78	10.89	51	99
60	8.92	12.49	59	113

Source: Devendra (1982); NRC (1981).

Requirements for lactation depend on the level of milk production and its composition. Requirements for lactation are presented in Table 7.4.

Table 7.4. Daily nutrient requirements per kg of milk production.

Fat content of milk (%)	ME (MJ)	DCP (g)	Ca (g)	P (g)
3.5	4.5	47	0.8	0.7
4.5	5.2	59	0.9	0.7
5.5	5.7	73	1.1	0.7

Source: Devendra and McLeroy (1982).

Table 7.5. Micro-mineral requirements and toxic levels.

Mineral	Requirement	Toxic level
Copper	7–11	25
Molybdenum	0.50	10
Cobalt	0.10–0.20	10
Manganese	20–40	1000
Zinc	20–33	750

Source: NRC (1982).

The nutrient requirement for pregnancy rises substantially during the last two months of gestation. It is particularly high if the dam is carrying twins or triplets. There is a need to increase nutrient content of the diet during this period to prevent low birth weights and/or serious loss of body condition by the dam.

Table 7.6. Water content of various feeds.

Feed	%
Succulent feeds (roots, tubers and green fodders)	80–90
Silage	75–80
Cereal grains, milling by-products, hay	12–16
Crop residues	8–12

The nutrient requirements for growth are dependent on growth rate. A supply of 0.035MJ ME/day is required per gram of growth.

Water is the most critical of all nutrients required by sheep and goats, and yet it is an often forgotten nutrient. Water is necessary for all life functions including digestion of food. The animal's body is 70% water. Water availability is one of the first limiting resources for livestock production in many parts of the country. Inadequate water supply will dramatically decrease the production of livestock. They will eat less, digest feedstuff poorly, and are more prone to digestive and metabolic problems. The animal body can lose nearly all fat and over half of its protein and still live. However, if the animal loses 20% of its body water it will die.

Animals can get their water from the following sources:

- Drinking water.
- Free water found in feed.
- Metabolic water from nutrient oxidation in the body.

Animal feeds contain variable quantities of water. The percentage variation is summarized in Table 7.6.
In the wet season, or in humid areas, sheep and goats may eat forage composed of 70–80% water and may need little or no drinking water. However, most feeds in the tropics have low moisture content and thus drinking water is essential for animals. Coarse, fibrous feeds need to be accompanied by adequate drinking water for proper digestion. The feed needs to absorb water in the rumen for it to be effectively digested by ruminal micro-organisms.

The amount of water an animal needs depends on the species, breed, climate, type of feed eaten, the type and level of production desired (milk, growth, etc.). Tropical breeds kept in arid and semi-arid areas may only need to drink once every 2–4 days in the dry season. They have better ability to reduce water loss through urine and feces than temperate breeds that may need twice as much water in the same environment.

Goats are able to extract almost all excess water from the digestive system, making very efficient use of whatever amount of water is available. This is one reason goats can survive in arid regions.

It is normally recommended that sheep and goats be supplied four times the amount of water as the amount of feed dry matter (DM) consumed, i.e., 4 kg water for 1 kg feed DM. They may need more water at higher temperatures. The situation is different with lactating animals. Milk is more than 90% water and the recommendation for lactating animals is to provide an additional 2 liters of water per liter of milk produced. The water requirement of sheep and goats is about 1.5 to 2.5 liters per day.

7.4.2. Nutrient deficiencies

Energy and protein: This is a major problem limiting production. Protein deficiency is most serious during the dry season while energy deficiency is more serious and visible during the wet season. Apart from weight loss and possible death under extreme conditions, fertility is reduced due to energy and/or protein deficiency.

Minerals: Mineral deficiencies can cause metabolic problems that bring about reductions in productivity, and in extreme cases, death. Mineral deficiencies are often difficult to detect since their only manifestation could be reduced productivity, which can also be to the result of poor nutrition or parasite infestation. However, severe deficiencies are more readily apparent and can be recognized from specific symptoms. Mineral deficiencies are best confirmed by the analysis of blood samples.

There is evidence of sodium, phosphorus, copper, cobalt, zinc and manganese deficiencies in scattered areas of the country. Copper deficiency has been identified in many parts of the Rift Valley. Areas of copper, manganese and iron toxicity have also been identified (Figure 7.2). Mineral deficiency symptoms and possible supplementation sources are summarized in Table 7.7.

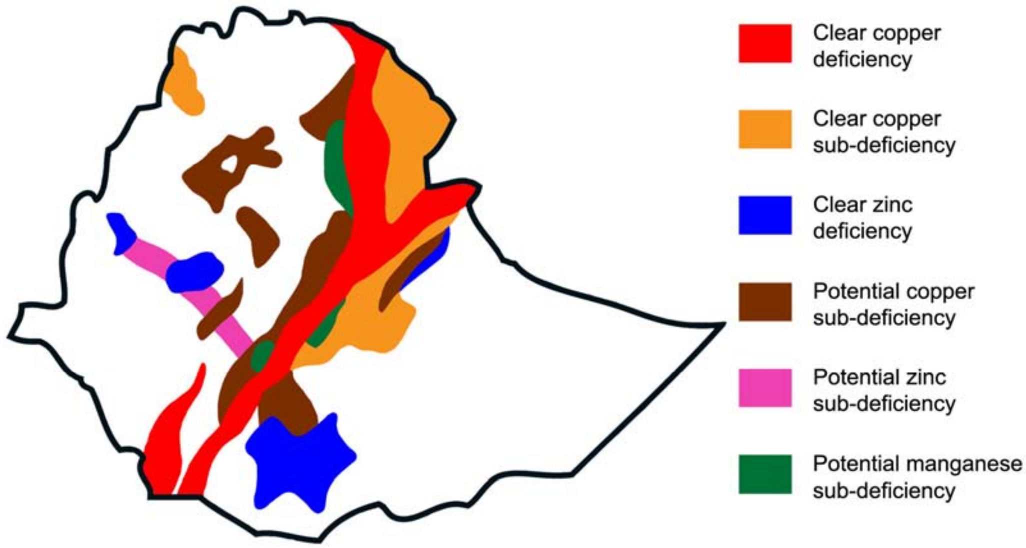


Figure 7.2. Mineral deficiency sites in Ethiopia.

Table 7.7. Mineral deficiency symptoms and possible supplementation sources.

Mineral	Deficiency symptoms	Types and classes of animals most affected	Feed source
		MAJOR MINERALS	
Calcium	Deformed bones, retarded growth	Young animals, newly kidded does and newly lambed ewes, finishing sheep and goats on high grain diets	Milk, green feed, ground limestone
Phosphorus	Deformed bone, retarded growth, poor fertility, soil eating	Young, growing animals	Milk, cereals
Magnesium	Falling on side with legs alternately rigidly extended and relaxed, frothing and profuse salivation, weight loss, excitability	Young and growing animals, can also occur in adults	Bran, oilseed cakes
Sodium	Chew on wood and/or lick dirt, loss of appetite, slow growth	All classes	Common salt
		MINOR MINERALS	
Copper	Swayback – young ones unable to walk on their back legs, scouring, stiff legs, dull coat	Young lambs/kids	Seeds, trace-mineralized salt containing copper sulfate at 0.5%
Manganese	Difficulty in walking, deformed forelimbs, poor fertility	Young lambs/kids, Adults	Bran
Zinc	Stiff joints, salivation, swelling of feet, poor testicular development and low libido, reduced growth rate, reduced conception rates and high incidence of abortions	Young lambs/kids, Adults	Cereal grains, corn gluten feed and meal added to trace-mineralized salt

Vitamins: All sheep and goats require dietary vitamins A, D and E. Dietary sources of the B vitamins and Vitamin K are required by lambs and kids before the rumen becomes functional. Consumption of green vegetation provides adequate carotene (Vitamin A precursor), which can be stored for up to six months and can thus be used during dry periods when animals have to depend on dry vegetation. Vitamin D deficiency is not a problem unless animals are confined for a long period of time without exposure to the sun.

7.5. The Feeding Habits of Sheep and Goats

Sheep and goats differ in their feeding habits. Selection and intake of forage depends not only on the available plant resources but also on the feeding behavior of animals. Knowledge of feeding habits that have nutritional implications is important in improving sheep and goat nutrition. A comparison of the feeding habits of sheep and goats is presented in Table 7.8 and Figure 7.3.

Goats prefer to consume a wide variety of feedstuffs. Goats are more selective and browse more, especially under extensive conditions, than sheep. The selectivity of goats is reduced under intensive management. Goats generally have better body condition compared to sheep under the same grazing conditions, mainly due to their ability to select a nutritious diet.

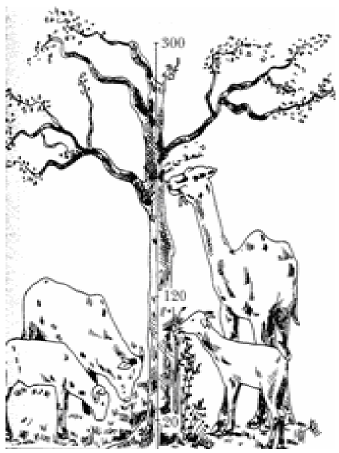
Goats prefer to eat feed at a height of 20–120 cm. They have the ability to stand on their hind legs for long periods and can even climb trees in order to reach parts of trees they prefer. They also have mobile upper lips and tongues that enable them to consume leaves between thorns.

The preference of goats for consuming browse can be used in the control of invasive species on grasslands. Keeping a mixture of browsers and grazers can maintain rangeland grazing areas rather than allowing them to become overgrown with brush. The mixed species of livestock kept by pastoralists enables simultaneous use of vegetation at different heights.

Table 7.8. Comparison between sheep and goats.

Characteristics	Goats	Sheep
Activity	Can stand on its hind legs to access browse; Can walk longer distances	Walk shorter distances
Feeding pattern	Browser; more selective	Grazer; less selective
Variety in feeds	Preference greater	Preference limited
Salivary secretion rate	Greater	Moderate
Recycling of urea in saliva	Greater	Less
Dry matter intake:		
For meat production	3% of body weight	3% of body weight
For milk production	4–6% of body weight	3% of body weight
Digestive efficiency	With coarse roughage higher	Less efficient
Retention time	Longer	Shorter
Water intake per unit dry matter	Lower	Higher
Water economy	More efficient	Less efficient
Water turnover rate	Lower	Higher
Dehydration:		
Feces	Less water loss	Higher water loss
Urine	More concentrated	Less concentrated
Fat metabolism	Increased during periods of water shortages	Less evident

Source: Devendra,C. 1986. Feeding systems and nutrition of goats and sheep in the tropics. In Adeniji, K.O., and Kategeli, J.A. Proceedings of the workshop on the improvement of small ruminants in eastern and southern Africa. 18–22 august 1986. Nairobi Kenya. pp.91–110.



a. Feeding heights (cm) above ground for different livestock species

b. Goats browsing

Figure 7.3. The feeding habits of sheep and goats.

7.6. Available Feed Resources for Sheep and Goats

Natural grazing land is the predominant feed source for sheep and goats in Ethiopia. Very little land is planted to introduced pastures or forage crops. This is especially true for the pastoral and agro-pastoral areas. Grazing areas are usually communally owned. Crop residues and agro-industrial by-products represent a large proportion of feed resources in the mixed crop–livestock system. Reliance on crop residues for animal feed is ever-increasing as more land is cropped to feed the fast-growing human population. This has decreased available grazing land and has forced livestock to graze more fragile, less productive lands not suited for high livestock numbers. Erosion and environmental degradation result in decreased soil fertility and forage productivity. This, in turn, leads to poor animal productivity. Table 7.9 presents a summarized listing of feed resources in Ethiopia by cropping system.

Table 7.9. Availability of feed resources by cropping system.

Coffee–*Enset* system	Coffee–crop system	Crop production system	Pastoral–agro-pastoral system
Natural grazing	Natural grazing	Natural grazing	Natural grazing
Hay	Hay	Hay	Standing hay
Enset by-products	Cereal crop residues	Cereal crop residues	Browse
Sugar cane tops/leaves	Oilseed cakes	Pulse crop residues	
Root crop leaves	*Enset* by-products	Oilseed cakes	
Local brewery by-products	Sugar cane tops/ leaves	Sugar cane tops/leaves	
	Root crop leaves	Local brewery by-products	
	Local brewery by-products	Molasses*	
	Molasses*	Milling by-products*	
	Milling by-products*		

*available only near sugar factories.

7.6.1. Natural pasture and browse

Natural pastures supply the bulk of sheep and goat feed. They are composed of indigenous forage species and are subject to severe overgrazing. Grazing occurs on permanent grazing areas, fallow land and on land following harvest. Both fallow land and crop stubble provide poor grazing for a very short period just after harvest. The availability and quality of native pasture varies with altitude, rainfall, soil type and cropping intensity. Average pasture yield for the highland areas is estimated to be 4 tons/ha. In many areas, natural pastures are invaded by species of low palatability. The wearing out and/or loss of teeth induced by unpalatable and tough vegetation is a problem that reduces the grazing ability of sheep and goats at an early age.

Grazing and browsing comprise the feed supply in pastoral areas. The higher rainfall areas of the pastoral zone are characterized by dense thorn bush of low carrying capacity.

When compared with tropical grasses, browse is richer in protein and minerals in the dry season. The crude fiber content of browse also tends to be lower than that of grasses and usually ranges between 20 and 40% and is even lower in shoots and leaves. The low content of crude fiber suggests that the energy content of browse is higher than that of dry grass. Browse could, therefore, supplement the low protein content of grass forage during dry periods.

7.6.2. Crop residues and fallow grazing

Crop residues are fibrous materials that are by-products of crop cultivation. Crop residues have low crude protein content in the range of 3–13% of the dry matter. This is a basic limitation in residues such as straw and bagasse with crude protein contents around the border-line level of 6–7% required to create an appropriate rumen environment to promote dry matter digestibility and intake. Most residues are deficient in fermentable energy and minerals. Crop residues have low palatability and digestibility that leads to poor intake, particularly when fed as the sole roughage.

The availability of crop residues is closely related to the farming system, the type of crop produced and the intensity of cultivation. Teff, wheat and barley straws are the major residues available in the highlands. Pulse crop residues like chickpeas, haricot beans and lentils are also important. Residues of maize and sorghum form the bulk in the lowlands. The common practice in utilizing crop residues is feeding in the long dry form.

a. Wheat straw

b. *Enset* residue

c. Sweet potato vines

d.Corn stover and cobs

Figure 7.4. Crop residues.

Crop residues are often left in the field or accumulated in places where the crop is threshed. Transportation of crop residues, even over short distances, can become difficult and costly because of their bulk. The production of crop residues is also seasonal, available in very large quantities right after harvest and less available thereafter.

7.6.3. Agro-industrial by-products

Agro-industrial by-products result from the processing of agricultural produce such as oilseeds, sugarcane and citrus, and from slaughterhouses during the slaughter and processing of livestock. In comparison to crop residues, these products are very good in their composition of useful nutrients and digestibility. The feeding value of such by-products varies considerably.

Most of the oilseed produced in Ethiopia is exported whole without processing. This represents a loss of by-product oilseed meal that could be fed to livestock. The case of molasses is similar in that it is exported rather than kept and used in-country.

Figure 7.5. Sheep feeding on local brewing by-product and sweet potato tubers.

7.6.4. Thinnings and leaf strips from maize and sorghum

Thinning and leaf stripping from cereals such as maize and sorghum are widely practiced in eastern Ethiopia, serving as important sources of feed. This is a useful practice that should be expanded to other parts of the country.

Thinning: Farmers use high seeding rates initially. The extra seedlings are eventually thinned out as necessary and fed to livestock.

Leaf stripping: Farmers start stripping maize leaves about 90 days after planting or as soon as the cob can be seen, with removal of one leaf per plant per week starting with the bottom leaves. If properly implemented for an extended period of time, this could supply 800 kg/ha of valuable fodder with an average crude protein content of 13% and digestibility of 64%.

7.7. Voluntary Feed Intake and Its Improvement

The amount of feed an animal eats will affect its health and productivity. Generally, the more feed an animal eats, the better. Feed consumption is a voluntary activity and it is difficult to force an animal to eat. Understanding the factors that affect feed consumption and how these factors can be manipulated is important.

The factors that determine the quantity and quality of feed consumed can be categorized as those related to the animal, the feed and the presentation of the feed. This applies whether in situations where an animal is stall-fed as well as where it is free-grazing.

- **Feed-related factors:** These include factors such as taste, smell and physical ease with which the animal can eat the feed.
  - ♦ If the feed is contaminated with urine and feces, smells bad, or tastes bad, the animal will reduce its intake.
  - ♦ Long, coarse grasses or crop residues like maize stover are difficult for sheep and goats to consume. They should be chopped to facilitate intake.
  - ♦ If coarse feeds are used, the animal will need access to plenty of water as such feeds with high dry

matter content need to soak up water to be digested. Highly digestible feeds are rapidly degraded and absorbed, passing quickly through the digestive tract. This stimulates appetite because the animal soon feels empty.

- **Presentation factors:** Animals are very selective in what they consume. If excess feed is offered, the total amount eaten by an animal will be more than if it had only a small amount from which to select. In very hot climates, the heat can reduce the amount that the animals eat. Animals may stop eating during the hottest part of the day because they have difficulty regulating body temperature rather than because they are full. In hot environments, allowing animals to graze early in the morning and late in the evening can significantly increase the amount eaten.
- **Animal factors:** These include the effects of the physiological state of the animal (e.g., pregnancy, growth, etc.)

Supplementation is one method used to improve feed intake. Supplementing a deficient nutrient in a diet will improve intake. Supplementation of available nitrogen (protein and/or non-protein nitrogen sources) to diets with poor fermentable nitrogen will improve digestion, and consequently intake, by promoting multiplication of micro-organisms in the reticulo-rumen. Supplementation of sulphur will also promote digestion and intake.

7.8. Feed-Related Constraints of Sheep and Goat Production in Ethiopia

Constraints of sheep and goat production related to nutrition and feeding can be summarized as follows:

- Inadequate feed supply mainly due to small land-size and overstocking brought about by the shrinking amount of land reserved for grazing.
- Low feeding value of available feed resources resulting in low efficiency of utilization.
  - Much of the feed consumed is utilized to fulfill maintenance requirements with little surplus for production.
  - Fibrous feeds with poor digestibility and low intake result in low levels of overall production.
  - Poor quality of feeds for lambs/kids at weaning, causing a sharp drop in weight and possible death.
  - Poor nutrition of lactating dams, resulting in low milk yields and poor rates of growth and survival among lambs and kids.
  - Deficiencies of protein and energy, which are the main nutritional factors limiting productivity of sheep and goats. Mineral deficiencies, such as a lack of sodium in feeds with high moisture content or in a specific area are also of concern.
  - Poor presentation methods of feed to confined sheep and goats.
  - Uncertain availability and high cost of supplements (e.g., oilseed cakes) and other alternative feeds.
- Inability to make maximum use of the limited total feed resources.
  - Crop residues and agro-industrial by-products that could be fed to animals are largely wasted or inefficiently used because infrastructure for transporting, processing and marketing feedstuff is underdeveloped. One example is the large amount of bagasse from sugar factories.
  - Efficient use of the rangelands by pastoralists is hampered by the lack of information on where adequate grazing conditions exist. Institutionalized information in pastoral communities as to where to move herds to find grazing exists based upon previous experience. Such information may be of little value when drought occurs.
  - Shortage of grazing resources as a result of bush encroachment caused by overgrazing, cultivation of marginal areas and inadequate water supply.
- Marked seasonal variation in the quantity and quality of feed supply.
  - Dry season:
    - Acute shortage of feed during the dry season. Available feeds during this period are of

very poor quality (low in protein and high in fiber).
- Low digestibility and low voluntary intake of available feeds.
  - Adequate rumen function is necessary to digest and utilize nutrients in feeds. A crude protein content of below 7% is inadequate for proper rumen function. This occurs when the protein content of pasture forage falls below this level and/or when animals are fed only on crop residues.
  - Limited intake of feeds with poor digestibility: Poorly digested feed leaves the digestive tract slowly, thus occupying digestive tract space and limiting intake of additional feed.
  - Poor availability and access to water.

- Rainy season:
  - Low dry matter intake from grazed forages due to high moisture content of vegetation.
  - Reduction of grazing area due to cropping of most of the land in crop–livestock production systems.
  - Wastage and/or deterioration of valuable grazing resources that animals can't utilize at this time of year.

7.9. Improved Feeding Strategies of Sheep and Goats

Strategies for ensuring appropriate nutrition of sheep and goats include:

- Matching sheep and goat production systems to available feed resources;
- More efficient use of agricultural and industrial by-products as sources of feed; and
- Encouraging increased intake.

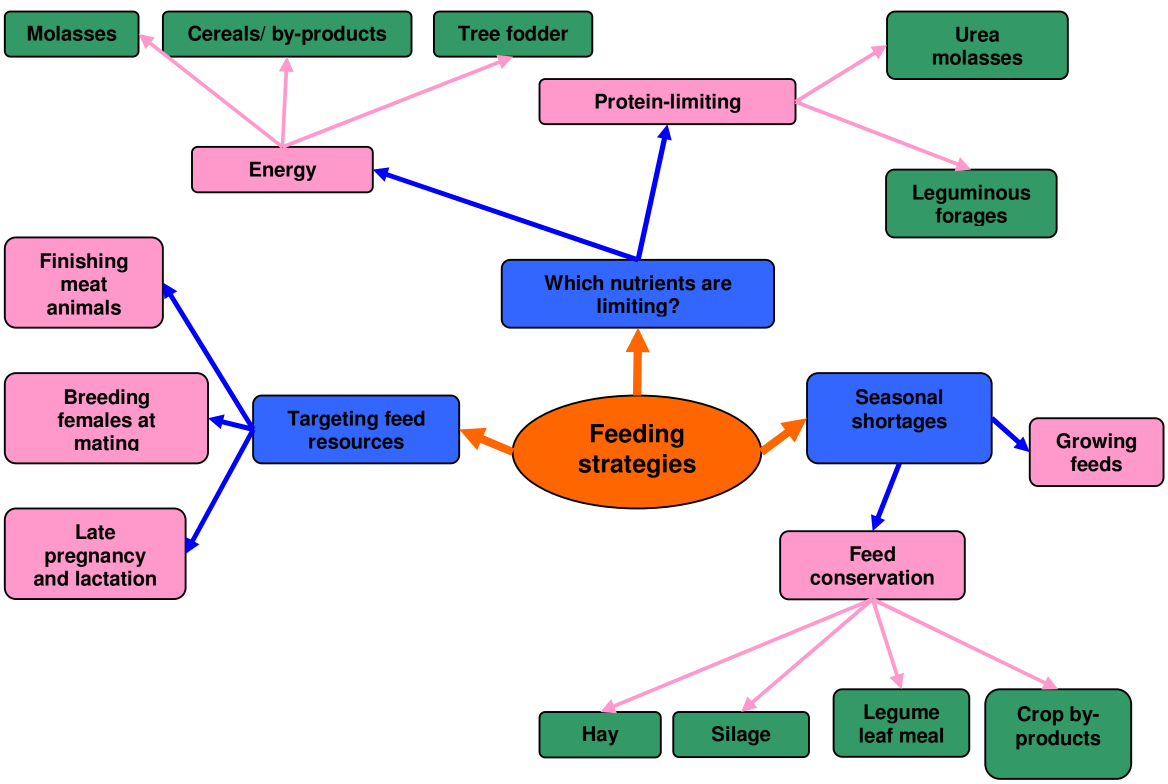


Figure 7.6. Feeding Strategy Considerations.

Adapted from: http://www.smallstock.info/info/feed/feed-strat.htm

7.9.1. Matching sheep and goat numbers to available feed resources

One of the strategies of increasing feed availability is through increasing offtake of animals through sale (destocking). This will increase the amount of feed available to the remaining animals. Feed efficiency can also be increased if older, mature animals are sold leaving younger, growing animals that utilize feed nutrients more efficiently.

The scope for increasing offtake can be attained by taking the following steps. (Improvement of marketing is presented in more detail in the Marketing section of this handbook.)

- Organizing producers into marketing cooperatives.
- Improving the infrastructure of livestock marketing.
- Providing market information through the mass media (i.e., prices and volume of livestock traded in various markets).
- Regulating the standards of products and services and negotiating favorable trade agreements in export markets.

7.9.2. More efficient use of feed resources

There are various means of improving the efficiency of utilization of available feed resources. The following are some of the possibilities.

7.9.2.1. Supplementation

Ruminant diets are generally based on fibrous feeds that have low digestibility and are deficient in protein, minerals and vitamins. These characteristics keep intake and productivity low. Provision of appropriate supplementary feedstuff during critical periods of the year is important to enhance productivity or at least avoid body-weight loss. This is especially true for livestock consuming poor-quality pasture and crop residue-based diets.

A supplement is a semi-concentrated source of one or more nutrients used to improve the nutritional value of a basal feed, e.g., protein supplement, mineral supplement. Supplementation may be at various levels and for different reasons. It may be done to assure survival, to assure maintenance or to assure production and reproduction. Supplementation can be done by providing a complete feed or by giving specific nutrients. Supplementation can enable animals to consume more forage, to digest the same quantity of forage more efficiently or to overcome a nutrient deficiency that critically limits performance.

Grazing stock may sometimes be supplemented with hay or straw to provide bulk for prevention of nutritional disorders. This is when the pasture is very lush with high moisture or protein content or where there is a danger of bloat in legume-rich swards.

Bypass nutrients, with the exception of those from legume leaves, come generally from rather expensive feeds which are either in demand for human nutrition (cereals) or exported for foreign exchange (oil seeds). However, because recent research has shown that inclusion at a low rate in the diets is beneficial, these supplementary feeds should be economical in many situations.

Most supplements are expensive and their use in ruminant nutrition competes with monogastric animal and/or human nutrition. Moreover, they are generally not easily available. Optimum utilization of these scarce resources is, therefore, essential. This targeted use of supplements is referred to as “strategic supplementation” and is designed to have maximum effect and optimum economic benefits. This can be achieved by identifying and providing critically deficient nutrients based on the following considerations:

- Supply rumen microbes with the necessary rumen-degradable nitrogen and other essential nutrients to enhance their capacity to degrade poor-quality roughages in the rumen. This is a first priority.

- Supply small amounts of bypass nutrient sources to increase utilization of absorbed nutrients and animal performance.
- Supplement during times of most critical deficiency of a nutrient, giving priority to supplementation of the most critically deficient nutrient.
- Make better use of supplements by giving priority to the physiologically most vulnerable groups of sheep and goats, e.g., pregnant animals during the last third of gestation, lactating females, young growing lambs, etc.

The main objective of supplementation is to catalyze the more efficient utilization of poor-quality roughages. For this reason the term "catalytic" supplement has also been used to describe these effects. The role of a supplement ceases to be "catalytic" when it exceeds about 30% of the diet dry matter, at which point it assumes a major role and substitutes the basal roughage source.

Steps in the provision of supplementary feed

Three levels of supplementation are recommended for effective utilization of roughage resources and improving animal productivity. The first creates an appropriate environment in the reticulo-rumen for effective fermentation of poor-quality roughages. The second step is to further improve fermentation through additional supplementation with a small quantity of highly digestible forage. The third stage is supplementing a source of protein that can bypass rumen fermentation and be utilized in the small intestine for high productivity. The level of the forage and the bypass protein source can be increased as much as possible to support further productivity. These steps are presented below in more detail:

Step 1. Fermentable nitrogen sources: The first supplement to be considered should be a source of fermentable nitrogen (usually urea) to ensure a crude protein level of at least 7% of the total diet for effective fermentation of roughages. As a general rule, if a deficiency is suspected, urea should be added at the rate of about 1–2% of the organic matter in the diet. Feeding molasses/urea blocks or high-urea (10%) liquid mixtures with molasses is a convenient way of ensuring a continuous supply of ammonia-nitrogen in the rumen, as is treating poor quality roughages with urea. Urea treatment of roughages has the added advantage of improving the feeding value of the roughage.

Step 2. Highly digestible forage: The second supplement should be a source of highly digestible forage, preferably legume, given at about 10–20% of the diet. This helps to ensure a more efficient rumen environment for the digestion of fiber.

Step 3. Bypass protein source: The third supplement should be a source of bypass protein such as an oilseed meal, cereal bran, etc., that should be given in amounts not to exceed 30% of the total diet dry matter. The 30% limit is to prevent depression/substitution of the intake of the basal poor-quality roughage diet. Lower amounts may be more economical. The optimum economic level and the degree of response to the supplement will depend upon the fermentability of the basal diet. Providing bypass protein to sheep and goats owned by small farmers is often difficult, and at times, too expensive. Oilseed cakes and other protein sources that have been heat-treated have considerably higher proportion of bypass protein.

Types of supplements

Concentrate supplementation

Supplementary concentrates such as oilseed cakes, cereals and cereal by-products provide readily fermentable carbohydrates, nitrogen and other essential nutrients. Problems associated with concentrate supplementation and justifications for its use are outlined below.

- Problems of concentrate supplementation:
  - Concentrates are expensive and may not be readily available.
    - Availability and prices of agro-industrial by-products are generally lower in and around

urban areas. Prices in rural areas are higher because of the high cost of transportation in Ethiopia.

- ♦ Many smallholder farmers scattered in the rural areas have limited market access for sale of animals. This reduces the economic incentive to supplement concentrate feeds to increase sheep and goat productivity.

Despite these problems, the following points justify concentrate supplementation:

- Scarcity of nutrients from other cheaper sources for high production.
- Restriction in energy uptake imposed by roughages.
- Beneficial economic return, i.e., increased sale price of produce higher than the cost of concentrate required for production.

Supplementation with forage legumes

Dietary protein, rather than energy, is the main limiting factor in many situations. A realistic alternative approach to supplying protein through oilseed cakes or other purchased feedstuff is the use of good quality leguminous forages as sources of supplementary protein. Forage legumes may be in the form of herbaceous, shrubby or tree legumes. Forage legumes have the following advantages:

- Are rich in protein and other nutrients such as minerals and vitamins.
- Can enhance the utilization of poor-quality roughages in smallholder mixed farming systems.
- Have the added advantage of improving soil fertility by fixing nitrogen, and thereby enhancing crop yield and maintaining soil fertility.
- Wilting or drying improves the feeding value of the foliage from fodder trees possibly due to:
  - ♦ Increases in proportion of bypass protein reaching the intestine due to decreased solubility in the rumen.
  - ♦ Reduction in anti-nutritional factors in the legumes.

The legume used should have high protein content and supply both fermentable and bypass protein. Legume forages rich in tannins are superior as bypass protein sources since tannins link with proteins during mastication and reduce their degradation in the rumen. The ideal concentration of condensed tannins is 20–40 g/kg diet dry matter; higher levels are detrimental. Sheep can adapt to high tannin levels. Condensed tannin-containing forage in the diet is beneficial provided that it is only used as a supplement (e.g., less than 25% of the diet dry matter). Tropical legumes are generally richer in tannins than temperate legumes and therefore function better as sources of bypass protein. Examples of tropical legumes known to contain tannins are leucaena, glyricidia and sesbania. The presence of toxic substances in some species can cause problems in unadapted animals, especially if offered in large quantities. It is, therefore, advisable to gradually adapt animals to such feeds.

The protein content of forage legumes is generally related to stage of maturity. Protein content decreases with age while yield increases with age. The appropriate compromise between composition and yield needs to be made. Do not harvest the last regrowth before the dry season starts. This will ensure a better stand during the dry season. The effect of stage of maturity on protein content is presented in Table 7.10.

Table 7.10. Effect of stage at harvest on protein content of legumes.

Grade	Maturity of Legumes	% CP
Prime	Pre-bloom	>20
1	Early bloom	17–19
2	Mid-bloom	14–16
3	Full bloom	11–13
4	Beyond full bloom	8–10

Methods of increasing the supply of forage legumes: The supply of forage legumes can be increased by promoting the integration of forage legumes into the farming system. Integration of forages into the farming system is presented in more detail in the Forage and Pasture section of this handbook. The following conditions need to be considered in integrating forage legumes into a farming system.

- Limited increase in the competition for land and other resources.
- Availability of labor and planting materials at the right time.
- Availability of market outlets and attractive profit margins for sheep/goats and their products.

Many approaches can be used to integrate forage legumes into the farming system. The major ones are:

- **Fodder banks:** Concentrated units of legumes usually planted near homesteads in order to ensure proper management and minimize misuse.
- **Use of forage legumes in crop mixtures:** Involves intercropping in the form of undersowing a cereal with a compatible legume at the right time. This practice has advantages of increasing the nutritive value and yield of the overall material harvested (grain, crop residue and legume).
- **Use of forage legumes in crop rotations:** Provides similar benefits to intercropping forage legumes in crop mixtures. Association of forage legumes in crop rotations has also been demonstrated to improve the nitrogen content of the soil, thereby benefiting future crop production.
- **Incorporation of tree legumes:** Forage tree legumes can be incorporated into the farming system in different forms. These include alley farming, as hedgerows, as a fence line along the homestead, along the borders of crop land and as fodder banks. Browse plants especially leucaena, glyricidia and sesbania need to be developed further for areas receiving good rains. In addition, new feed resources in rangelands should be identified and developed. The leaves of trees can be used as a high quality supplement to crop residues and grazing. Tree legumes such as glyricidia, erythrina and leucaena have great potential as sources of legume fodder, particularly as they are high-yielding perennials and possess deep-rooted systems that may have access to ground water and nutrients that may not be available to smaller leguminous plants.
- **Use of legumes with feed/food value:** Such a tree legume is pigeon pea *(Cajanus cajan)* with the pod serving as food and the leaves serving as animal feed.

Table 7.11. Composition of leguminous trees/shrubs.

Fodder Trees/shrubs	Protein	Fiber
Leucaena – leaves and shoots	22	20
Glircidia – leaves and shoots	23	21
Pigeon pea – leaves and shoots	23	30
Sesbania grandifloria – leaves and shoots	26.9	12.3
Calliandra – leaves/pods/stem less than 8 mm	36/17.9/29.1	

Supplementation with legume straw

Residues of food legume crops such as peas, beans, peanuts, etc., are relatively high in crude protein content and can serve as supplements.

Other **feedstuffs** *of supplementary value*

There are also feedstuffs other than those mentioned above that can be used as supplements. Examples of such supplements are:

- Brewery by-products that could be available to farmers in the vicinity of breweries. Local brewery by-products are also available in many areas.
- Poultry waste is a product that can be used as a supplement for sheep and goats, replacing other protein concentrates, in areas where intensive poultry production is practiced. There could be two types of poultry waste, namely:
  - Poultry litter: a product from poultry farms where birds are raised on floors. It contains poultry

droppings, bedding material and spilled poultry feed. Poultry litter is a product with 15–35% protein depending on the proportion of the above constituents. It is also characterized by its high ash content with substantial levels of calcium, phosphorus, potassium, magnesium, sulphur and copper. This product can thus serve as a good source of fermentable nitrogen and essential minerals to sheep and goats.

- Poultry excreta: obtained from poultry raised on cages. It is free from other constituents (bedding material and generally from spilt feed). As a result, it is higher in its nitrogen content than poultry litter. It can serve as a good supplement in the dry form.

Mineral supplementation

Figure 7.7. Local mineral lick being bagged for sale in the Rift Valley.

Very little is known about the mineral nutrition of sheep and goats in Ethiopia. The limited studies available indicate that clinical and sub-clinical mineral deficiencies are wide spread. It is, for example, known that there is widespread deficiency of sodium, phosphorus and copper in sheep and goats in the Ethiopian Rift Valley area. Mineral deficiencies can result in substantial reductions in performance of sheep and goats. Using plants at a young stage supplies the highest amount of minerals to the animal as mineral content of plants declines with maturity. Mineral supplementation can be done through the use of multi-nutrient blocks that contain the deficient minerals. Ideally, specially formulated mineral supplements are provided in the form of a mineral lick. Such a lick is manufactured in Awassa but it is not widely available in other parts of the country. Supplementation of common salt is widely practiced in many parts of Ethiopia. Salt supplementation is especially useful in hot areas where sheep and goats lose large amounts of salt through perspiration.

Farmers in many parts of the country use local mineral soils as mineral supplements. Supplementation of *Bole* to Arsi sheep resulted in higher gains than unsupplemented sheep and ranked similar to sheep supplemented with a commercial mineral lick. The licks were found to be good in their sodium and copper compositions. Encouraging farmers to regularly feed local mineral licks such as *Bole, megado*, etc., traditionally used in many parts of the country, is beneficial. Goats obtain higher amounts of minerals because they consume more browse and consume a wider array of vegetation than sheep.

7.9.2.2. Fodder conservation

The supply of feed fluctuates in most parts of the tropics. Preserving surplus feed in the wet season for use in the dry season is one method of making the supply of feed to livestock more evenly distributed throughout the year. Any surplus forage should be conserved for use during the dry season when feed supply is scarce and feed quality is poor. Hay- and silage-making are two main methods of preserving forages.

7.9.2.3. Effective utilization of crop residues

Generous feeding: Goats are the most selective feeders of all domestic ruminants. They are able to select the more nutritious leaf and leaf sheath components against the less nutritious stem. Offering crop residues to goats and sheep at a 50% refusal rate instead of the conventional 10–20% results in increased feed intake in terms of quality and quantity. This will lead to improved body weight gain.

Such a feeding strategy of allowing 50% refusal of the residue could be wasteful. The practice is justified only if the rejected straw could also be utilized by less selective ruminants like cattle or alternatively used for other purposes such as fuel, bedding, compost, soil mulch, etc.

Urea treatment: This is one method of improving the feeding value of roughages. It involves spraying a solution of urea onto dry roughage and covering it with locally available materials to create a sealed condition.

7.9.2.4. Proper exploitation of natural browse

The widespread traditional use of browse as an available source of quality feed during the dry season is vital to maintaining seasonal and yearly stability of livestock production in drier areas. Browse supplies goats with the bulk of their nutritive requirements and complements the diet of sheep with protein, vitamins and minerals. Foliage from trees and shrubs in pastoral areas provides more edible biomass than pasture.

Moreover, browse remains green and high in protein content when pastures become dry. Proper and strategic use of these feed resources as supplements during dry periods can help minimize seasonal fluctuation in productivity.

- Plant browse trees.
- Maintain the necessary balance of forage species by selective bush clearing.
- Feed browse either by trimming or lopping leaves and branches or by beating down the fruits or pods.

Acacia species, once mature, produce large quantities of protein-rich seed. Herders move their flocks to these areas during the dry season and feed their flocks on the pods. Herders use long poles to shake pods down from the trees for consumption by their animals. There is scope for storing these pods and using them as a supplement for weaners or for sheep and goats suckling twins. Pods are also a marketable commodity.

Figure 7.8. A herder using a long pole to shake the pods down from an Acacia tree.

Figure 7.9. Acacia pods.

7.9.2.5. Specific strategies for arid and semi-arid areas

Arid areas

Development strategies in arid zones should focus on preserving and improving productivity of the rangelands.

Rangeland improvement techniques include:

- Reduced stocking rates.
- Allowing range vegetation an opportunity for regrowth by:

- controlled and deferred grazing, or
- periodic resting.

- Providing extended and additional watering facilities for stock.
- Reseeding.
- Shrub planting.
- Controlling cultivation in areas unsuited for sustained crop production.
- Moving excess animals to areas of higher forage availability.
- Establishment of a monitoring system to better inform users where grazing is abundant or scarce would help pastoralists use rangelands more productively. This will also warn them of possible future feed shortages due to drought so that they can take steps to mitigate the potential impact of drought on their livelihoods. The following can help to do this:
    - Encourage locally managed and controlled land- and water-management systems.
    - Use of Geographic Information Systems (GIS) to improve management and monitor rangeland use and degradation.
- Give due attention to the development of high potential sites, such as river valleys, for feed production.

Semi-arid and sub-humid areas

The major task here is to improve the utilization of natural forages and crop residues and introduce more nutritious fodder and pasture crops.

Focus should be on:

- The planting and establishment of improved fodder crops, leguminous tree crops, pastures and especially forage crops that will provide more energy and/or protein.
- Use of chemical and mechanical interventions to improve the digestibility of crop residues and other low-quality roughages.
- Use of non-protein nitrogen, bypass protein (protein that is resistant to degradation in the rumen), and other protein supplements to correct dietary deficiencies and to improve protein utilization.
- Mineral supplementation to correct the major and minor mineral deficiencies of grazed forages, fodder crops, and crop residues.
- Use of improved methods of storing high protein or high energy feeds harvested in the wet season for consumption during the dry season.

Exercises / Points for Discussion

1. What feed resources are available in your area?
2. Do farmers supplement their animals? If yes,
    a. *With what?*
    b. *Are all animals supplemented indiscriminately?*
    c. *Targeted to specific categories?*
    d. *Are times of year and/or physiological state considered in supplementation?*
3. Describe the feeding practice in your area — Are there unique experiences you want to share?
    a. *What are the main feeding/nutrition related problems?*
    b. *What attempts have you made to improve the situation?*
    c. *What more will you do after this training?*
4. How is grazing land owned in your area?
    a. *Describe actual problems related to grazing in your kebele.*
    b. *Are there traditional arrangements that can and should be encouraged?*

Transferable Message

Utilization of communal grazing lands can be improved with know-how and cooperation.

1. Teach users of a communal grazing area about the need for collaboration in managing the communal grazing.
2. Show them the problems of the current system of management.
3. Show them options for better utilization.
4. Enquire about traditional practices of utilization and base your improvement proposals on these practices.

7.9.2.6. Improving poor quality roughages

Treatment of roughages

Sheep and goats in tropical environments will have to eat feeds that contain a lot of fiber during most parts of the year. The bulky and fibrous nature of coarse feeds results in poor nutrient supply and reduced intake.

Such feeds have to remain in the rumen for extended periods of time before they are sufficiently digested to move out of the rumen and allow more feed consumption. It is common for animals to lose weight and condition, produce less and even have difficulty breeding when fed on these low quality roughages.

One approach to improving the feeding value of poor quality roughages is through treatment. Treatment of roughages, either physically or chemically, is aimed at rendering the structural constituents more accessible to microbial digestive enzymes in the rumen.

Treatment methods

Physical treatment

The main objective of this method is to reduce the size of the roughage to expose more surface area for microbial degradation in the rumen. This involves hydration (soaking) and chopping.

Soaking coarse crop residues such as maize stover: Dryness increases time spent chewing per bolus and thus reduces total intake. Hydration has a potential to overcome these constraints. Soaking causes swelling of cell-wall structures, making them more accessible to cellulolytic microbes. In addition, it reduces the dustiness and dryness of the feed. Soaking per se has potential to overcome some of the constraints to intake of maize stover. The voluntary feed intake of chopped maize stover can be improved by 23% by just increasing moisture content from 30 to 60%. Results of work at Bako Research Center indicate that sheep performance improved from losing 54 g/head/day to gaining 21 g/head/day as a result of soaking. Supplementation with 5% linseed meal (fermentable nitrogen source) doubled the consumption of the stovers and resulted in a daily gain of 53 g/head/day.

Chopping: Chopped feed can be easily eaten. Chopping also minimizes selection and facilitates mixing with other feeds. Chopping some of the coarser green feeds such as elephant grass will also increase the amount eaten. Chopping can be done using a machete knife or by special manual or motor-driven choppers that are very efficient. Moistening chopped dry roughages can also improve utilization through increasing intake and digestibility.

a Chopping stover | b. Chopping fodder beet | c. Feeding chopped sweet potato tubers in the southern region

Figure 7.10. Chopping and feeding roughages.

Chemical treatment

Chemical methods are relatively efficient and easy to put into practice. The effects of chemical treatment include hydrolysis of chemical bonds that involve lignin. The chemicals used in treatment of roughages are mainly alkalis. The most effective alkali is sodium hydroxide or caustic soda. It is, however, not commonly used due to its high cost and risk of use.

The most common methods of chemical treatment use either ammonia or urea, which are relatively less effective but are cheaper and less hazardous to use. Moreover, treatment with ammonia or urea has the added advantage of improving the nitrogen content of the treated roughage. Treatment is recommended where roughage constitutes over half the diet or where higher levels of production are desired. The type of treatment will depend on local circumstances.

Ammonia treatment is suitable for large operations such as cooperatives in areas where there is a supply of anhydrous ammonia and where the necessary infrastructure of tankers is available for its distribution. The application of this treatment method will not be discussed in detail because of low applicability under present Ethiopian conditions. Urea treatment is more applicable for smaller quantities of roughage treated on small farms. Urea treatment of crop residues is being practiced in Ethiopia.

Ammonia treatment: Ammonia (anhydrous, gaseous) treatment requires a supply of industrially produced ammonia together with a distribution network. Factors for the success of ammonia treatment include:

- Amount of ammonia used: 2.5–3.5 kg per 100 kg DM of straw.
- Temperature and duration of the treatment: generally, a longer period of treatment is required at low temperatures and shorter period at higher temperatures.
- Moisture level: optimum moisture level for successful treatment is between 15 and 25%.
- Sealing: an air tight seal is required.
- Nature of the forage to be treated: low-digestible roughage.

Figure 7.11. Ammonia treatment from a tanker.

Figure 7.12. Baled straw waiting ammonia treatment.

Urea treatment: The fact that fertilizer-grade urea is available in many developing counties like Ethiopia makes it a preferred treatment technique for improving the nutritional quality of low-quality roughages (LQR) such as crop residues and agro-industrial by products, e.g., bagasse. The simplicity of its application is an added advantage of the technique.

Ammonia is released through urea degradation done by the action of micro-organisms. These micro-organisms are normal inhabitants of LQR that produce urease in the presence of moisture. With adequate moisture and suitable temperature, urea is degraded to ammonia which then permeates through the straw. Nitrogen released through this process is bound to the straw, thus increasing the total nitrogen content. Digestibility of the fibrous LQR is also increased by the action of the treatment.

Table 7.12. Nutritive values of straw before and after urea treatment.

	Before	After
Crude protein	3–5%	7–10%
Digestibility	40–50%	45–55%
Intake		+20–40%

Urea treatment of LQR improves the crude protein content, digestibility and intake of LQRs. The magnitude of improvement is shown in Table 7.12.

The most common recommended level of urea is 5 kg per 100 kg of material (5% urea measured on air-dry LQR). The moisture or water level in the LQR to be treated determines how much water should be added. It may range from 0.3 to 1 liter of water per kg straw with the minimum being applied in areas with water scarcity.

An appropriate level of water is necessary for effective urea treatment as well as packing of the material to exclude air. However, care should be taken to avoid use of excess water as it will lead to risk of mold growth and leaching of urea to the bottom of the pit or trench. Table 7.13 lists the recommended amount of water to be added to achieve a final moisture content of 30%.

Table 7.13. Recommended amount of water to be added to achieve a final moisture content of 30%.

Water to add (liter or kg per 100 kg of residue)	Initial dry matter of LQR (%)	Expected moisture content in the final treated material
23	85	30
30	90	30

With some experience, the initial dry matter content of LQR can be estimated by handling. A very dry material (i.e., 90 or 95% dry matter) is brittle and does not stick to the hands. Conversely, a wetter residue (i.e., 85% dry matter) feels a little sticky and moist. It also tends to bend rather than break easily.

The water to be added per 100 kg of roughage can alternatively be calculated using the following formula:

$$W\ to\ be\ added/100\,kg\ of\ R = \frac{Initial\ \%DM\ of\ R + weight\ of\ U}{100\,kg\ of\ R + W\ to\ be\ added} = \%\ of\ final\ DM\ to\ be\ achieved$$

Where,

W = water
R = roughage
DM = dry matter
U = urea

For example, if:

1. Initial dry matter of roughage = 94%;
2. Final moisture content to be achieved = 50%
3. Urea level = 5%

Then, the amount of water to be added (W) is calculated as:

W = (94 + 5) / (100 + 5 + W) = 0.50
W = (99)/105 + W = 50/100
W = 99 × 100 = 50(105+W)
W = 93 liters of water

Exercise

Calculate the amount of water needed for urea treatment using the following information:

1. Initial dry matter of roughage = 94%;
2. Final moisture content to be achieved = 40%
3. Urea solution used for treatment = 4%

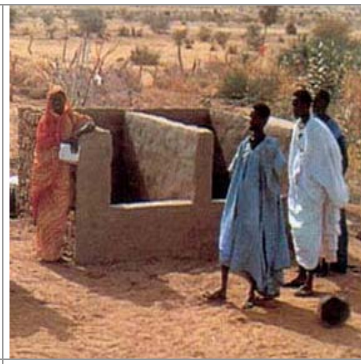
Urea is weighed and dissolved in a measured quantity of water according to Table 7.12. A hanging scale can be used to weigh the urea, and a measuring cylinder or any locally available material can be used to measure water.

Urea is added to the LQR by first mixing the weighed amount of urea in the water to be added. The urea-water solution is then sprinkled on the residue as it is added to the pit in different batches. A good way of doing this is to add 10 kg of residue and then sprinkle the appropriate amount of urea-water solution (this would be 2.3 liters for 10 kg of straw with an initial dry matter concentration of 85%, or 3 liters for dry matter content of 90 %).

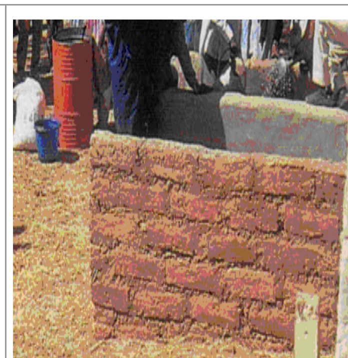
After each batch of LQR and urea-water solution is added to the pit, there should be thorough mixing with a stirring rod/stick or by hand so that the solution is uniformly spread on to the LQR to be treated. This can be done in the pit or on a plastic sheet on the ground prior to packing in the pit.

There are many different designs of pits or trenches for urea treatment. A common recommendation is 1 m wide, at least 2 m long and 1 m deep (Figure 7.13a). A 1 × 2 × 1 m pit will typically hold between 150 and 200 kg of common LQR, with the top of the pile being at or slightly above ground level.

a. An empty 1 × 2 × 1 m pit



b. Above-ground pits



c. Above-ground pit made of bricks

Figure 7.13. Types of pits for urea treatment.

a. Pit lined with *Enset* leaves

b. Pit with grass lining

c. Pit with plastic lining, mixing sprinkled straw

Figure 7.14. Pits with different lining materials.

Figure 7.15. Treatment of traditional stacks and bales of roughage.

The pit should not allow air or rain water to enter the LQR being treated. Therefore, the pit is typically lined with material such as heavy plastic.

A concrete pit, placed above ground, lined with plastic will produce a good result. But concrete, bricks, and plastic may not be available or may be too expensive, in which case, other alternatives can be used. For example, Figure 7.14a shows lining a pit with *Enset* leaves, green ones nearest to the sides of the pit and dried leaves on top, closest to the treated material. In fact, except for the shape, the pit is similar to that normally used in *'kocho'* fermentation. Depending upon availability, banana leaves or bamboo leaves could also be used. In areas with more rain, stacks can be placed against a wall or, as is seen in India, a fine meshed wire such as chicken wire can be used to contain the straw. The treated residue should be packed (Figure 7.16).

It is useful to construct more than one adjacent pit so that treated LQR from one pit can be used while the next pit is being treated. This helps to ensure a continuous supply of treated residue for feeding.

Apart from pits or trenches, plastic bags (Figure 7.16b) that can hold 20–25 kg of treated straw may be used. Such bags have an advantage in that individual bags can be opened when they are actually needed to feed animals.

An airtight condition is easily achieved by applying a plastic cover. When straw is stacked against firm structures (walls, inside pits, meshed wire), it can be compacted by trampling. Wet straw compacts better and will not allow air to enter. Chopping LQR such as maize and sorghum stover before treatment helps better compaction and treatment.

a. Packing *teff* straw mixed with urea-water solution in a pit lined with heavy plastic

b. Packing treated straw in a plastic bag

Figure 7.16. Packing treated straw to remove air.

After sealing the pit with plastic or other locally available material such as green leaves, placing soil over the pit will aid in packing and ensuring that rain water does not enter the treated LQR. Construction of a shade over the pit will further prevent entry of rain water into the pit in high-rainfall areas (Figure 7.17).

Figure 7.17. A shade over urea-treatment pit.

A number of factors influence the length of time needed for most effective urea treatment. One of the most important is outside temperature. Higher temperatures lessen the length of time needed, and cooler temperatures increase the length of time required. Because longer treatment times than necessary do not have adverse effects, it is commonly recommended that the pit remain closed for at least 3 weeks, and preferably 1 month.

Figure 7.18. Treated straw (left) and untreated straw (right).

The effectiveness of the urea treatment process can be evaluated using the following physical measures.

Color: Well-treated roughages will have a uniform, dark-brown color throughout the treated material (Figure 7.18). Dark areas indicate over-dosage while lighter color indicates under-dosage of the urea solution. Non-uniform coloration is a result of the urea solution not spread uniformly during mixing and packing the treated material.

Smell: A strong pungent smell of ammonia should be present when the sealed material is opened. Absence or lack of such odor, a weak smell or presence of a moldy smell indicates poor treatment. The presence of the ammonia smell doesn't generally repulse animals especially if they are used to it.

Texture: Well-treated roughage is soft. A wide variation in texture indicates non-uniform treatment.

Absence of mold: Mold doesn't develop in a well-sealed environment of ammonia. Absence of mold is an indicator of good treatment.

When feeding urea-treated LQR, the pit should be opened from one side as necessary to remove the needed amount of residue. The remaining part should remain closed. This prevents air from entering to minimize chances for spoilage. It is best to open the pit as seldom as possible, such as no more than once per day.

The treated LQR will be higher in digestibility and crude protein than the untreated material. Therefore, some farmers will feed urea-treated LQR to their animals with the highest nutritional requirements, such as lactating or fattening animals. Other farmers will feed limited amounts of the treated LQR as a supplement, with the remainder of diets being untreated LQR or grazed forage.

An adaptation period may be needed for animals that have not previously consumed urea-treated LQR. This allows them to become familiar with the feedstuff and, in particular, with the ammonia odor. The level of treated LQR being fed can be gradually increased over a period of 1–2 weeks, perhaps being mixed with feedstuff previously being given. Adaptation will be most rapid when animals are given little choice. Such an adaptation period is also a good idea when adapting ruminants to any diet containing non-protein nitrogen, although this is rarely a concern for crop residues properly treated with urea. In some cases, residual ammonia might lower intake. In such circumstances, the treated straw should be aerated for a few hours or overnight before feeding to allow the ammonia odor to disappear.

By treating with urea, animal performance can be increased or a greater number of animals can be fed with the same level of performance (i.e., growth or milk production). Animals fed urea-treated LQR may require no supplemental concentrate or will need lower levels to achieve a desired level of animal performance compared with animals fed untreated LQR. Feeding urea-treated LQR alone will lead to some increase in production, but the full potential will only be realized when the correct supplements are added. A supplement of bypass protein such as cottonseed cake or *nougseed* cake is required for high performance.

There has to be a good economic reason for a farmer to feed treated straw, and the effect has to be visible. For these reasons straw treatment has been most successfully undertaken when fed to responsive animals as a basal diet, for example, in fattening programs. The following points require attention to promote this technology.

- The cost of sealing the pit can be reduced by using cheap local materials to create the required airtight conditions.
- Strategic feeding of treated residues (e.g., to pregnant and milking animals) should be encouraged.
- Adequate explanation and demonstration is necessary.
- Adaptation to local conditions should be made; e.g., use of local measurements for the amount of urea and residue to be treated.

The treatment of crop residues can be done any time as long as the residue, water and urea required for the treatment are available. The best period recommended, however, is just after harvest, because:

- water and forage supplies are still available at this time;
- the farmer has ready cash for purchasing the urea and the time to do the treatment: a family of 4 can treat about 1 ton of straw in 4 hours;
- the treatment operation can be carried out whilst the traditional stack is being constructed; and
- the weather is conducive.

Exercises / Points for discussion

Have you previously tried to demonstrate urea treatment of roughages to farmers in your *kebele*?

1. If yes, what is your experience?
2. If not, why?

Transferable Messages

Urea treatment of roughages improves poor quality roughages and sheep and goat performance.

1. Select 5 model farmers from different areas in your *keblele* and convince them about the value of treating low-quality roughages with urea.
2. Demonstrate urea treatment to the model farmers.
3. Ask the model framers to treat roughage at their farms following the demonstrated procedures.
4. After one month, organize a demonstration for other farmers at each of the model farms on the procedures of treating and using treated roughages to feed sheep and goats.

Supplementation using urea and molasses

Reasons for using urea and molasses

The micro-organisms in the rumen synthesize enough protein to meet maintenance requirements of ruminants provided there is sufficient nitrogen and energy available in the rumen for their growth and development. Urea is a non-protein nitrogen (NPN) product which can be used as a nitrogen source when transformed to ammonia by the micro-organisms in the rumen. Molasses, which is an excellent carrier for urea, can be the supplementary energy source.

The nitrogen from urea is used by rumen microbes to make protein known as microbial protein, which is later utilized by the host ruminant when the microbes are digested by the ruminant in the small intestine. The microbes also require sulphur (S) to use nitrogen efficiently. It is not necessary to add sulphur where high levels of molasses are fed because of the sufficient level of sulphur in molasses. Supplements based on a low-cost mixture of molasses and urea were developed and used in different countries for this reason.

Methods of feeding urea supplements

Methods of feeding urea have primarily been concerned with providing it in sufficient quantities to be of value to the animal, and at the same time reducing the risk of mortality from urea toxicity. The following guidelines should be followed for use of urea in sheep and goat diets.

Table 7.14. A typical basic liquid mixture of urea and molasses.

Ingredients	Parts by weight
Urea	1
Water	10
Molasses	10

- Do not include urea at more than 1% of the total diet or 3% of the concentrate portion.
- Do not use urea in creep diets because of reduced intake of creep diet or potential urea toxicity.
- Introduce urea into the diet gradually over a two- to three-week period.
- Feed urea-containing diets at regular intervals for efficient utilization.

Urea can be supplemented to sheep and goats in different forms. Some of these methods are described below.

Urea supplement as a liquid in troughs

This involves feeding urea and molasses in troughs placed in the grazing area. This is a cheap and simple method of feeding urea that requires low labor. It involves use of a roller-drum lick feeder. Urea intake is regulated by changing the concentrations of the components of the mix. A typical basic liquid mixture is shown in Table 7.14.

Roller drums like that shown in Figure 7.19 can be used for cattle. For sheep, a type of wooden float has been developed for use with troughs, as sheep are unable to rotate the large drums. Some farmers have developed a very light small drum for sheep with apparently successful results.

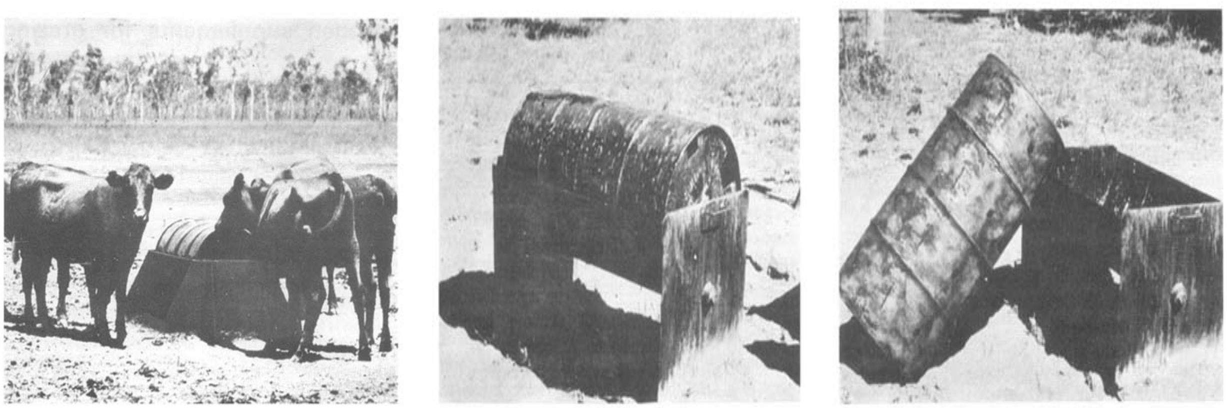


Figure 7.19. Cattle licking a roller drum.

Urea supplement as a block lick

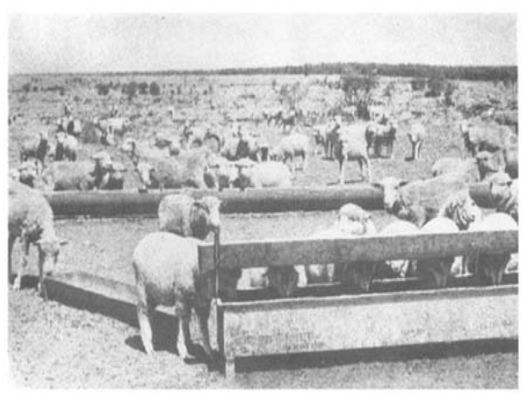


Figure 7.20. A lick-feeder for sheep that has a slatted wooden float on the surfaces of the liquid in a trough.

Mixtures of liquid molasses and urea, which provide fermentable nitrogen, and are a good source of minerals, have been used for many years. Molasses in the liquid form is difficult to transport (requiring expensive tanker trucks), to store (requiring storage tanks), to handle (is highly viscous) and to distribute to animals (troughs or other receptacles needed). The “solidification” of molasses is a way of solving the difficulties encountered in distributing and feeding molasses and also allows for the incorporation of various other ingredients.

As the name suggests, these are lick blocks that contain urea, molasses, vitamins, minerals and perhaps other nutrients. The feeding of the blocks is a convenient and inexpensive method of providing a range of nutrients, which may be deficient in the diet, that are required by both the rumen microbes and the animal. The ingredients are designed to provide a wide rage of nutrients to cover all potential deficiencies.

Urea molasses blocks (UMB) have proven to be an excellent tool for the improvement of ruminant feeding. They are cheap, relatively safe and a practical means of supplying nutrients. They create an efficient rumen ecosystem which favors the growth of young animals and milk production. They also improve conception rates and the size of offspring. The urea molasses block technology should be encouraged in Ethiopia to make better use of available feed resources at the small farmer level.

The common ingredients used in making feed blocks are:

- Molasses
- Urea
- Fibrous feeds such as wheat bran
- Salt
- Cement (a binding agent).

Molasses is used to induce animals to eat the block drawn by its sweet taste. It also provides energy and some other nutrients such as minerals like sulphur. The block should not contain more than 40–50% molasses or it will break too easily and take too long to dry.

Urea, known to farmers as fertilizer for crop production, is used to make the blocks. It is advisable that the amount of urea be limited to 10% to avoid poisoning. Urea is essential in improving digestibility and providing protein. Cereal bran is the most common fibrous feed used. The bran provides protein and helps hold the block together. Finely chopped straw, bagasse, or finely ground leaves from leguminous shrubs (*leucaena*, *calliandra*, etc.) can substitute for cereal bran.

Urea

Molasses

Wheat bran

Figure 7.21. The major ingredients.

Salt in the range of 5–10% is added to the blocks to supply minerals and to control the rate of consumption. Calcium carbonate and dicalcium phosphate can be added to provide additional calcium and phosphorus.

Cement is used to make the block hard. About 10–15% is sufficient. Higher levels make the blocks too hard. Cement also provides calcium. Clay such as that used in brick-making can be mixed with cement to improve block hardness and reduce drying time. It can also reduce cost of making the block.

Other ingredients can be added to provide additional nutrients. Oilseed cakes or brewery by-products can be added to supply protein. Trace mineralized salt can be used to provide additional minerals that may be lacking. Use of trace mineralized salt is recommended in the Rift Valley area. Alternative ratios of combining ingredients to constitute various formulations of blocks are shown in Table 7.15.

Table 7.15. Practical examples of formulae for making urea molasses blocks (composition in %).

Ingredients	Alternative Formulae												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Wheat bran	25	25	27	35	40	40	23	25	23	25	25	35	22
Molasses	40	50	10	20	10	5	50	45	50	31	34	39	50
Urea	10	10	8	8	10	10	5	15	10	10	10	10	9
Salt	4	5	5	8	5	5	5	5	5	3	3	5	5
Quick lime		5	5	5	7	7	5	0	10			6	
Cement	10	5	10	5	5	10	10	10	10	15	15	5	14
Triple phosphate							2	0	2				
Dicalcium phosphate	1		5		3	3				3			
Oilseed cake			15							13	13		
Clay				20	20	20							
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

How to make urea molasses blocks

Urea molasses blocks (UMB) can be manufactured on the farm. Manufacture is easy and simple and different processes exist which may be used according to local conditions. The manufacturing can be divided into four stages:

1. Preparing the components
2. Mixing
3. Molding
4. Drying

Preparing the components

The amount of the different ingredients depends on the size of the block to be manufactured and the formula to be used. Table 7.16 shows the amount of ingredients to be mixed to make 1, 5, 15 or 25 kg of block based on formula alternative "A" in Table 7.15.

Table 7.16. Amounts of ingredients to mix to make different sizes of UMB.

No.	Ingredient	%	Size of block to be made			
			1 kg	5 kg	15 kg	25 kg
1	Molasses	40	400 g	2 kg	6 kg	10 kg
2	Urea	10	100 g	0.5 kg	1.5 kg	2.5 kg
3	Bran	25	250 g	1.25 kg	3.75 kg	6.25 kg
4	Cement	10	100 g	0.5 kg	1.5 kg	2.5 kg
5	Oil cake	10	100 g	0.5 kg	1.5 kg	2.5 kg
6	Mineral mix	1	10 g	0.05 kg	0.15 kg	0.25 kg
7	Salt	4	40 g	0.2 kg	0.6 kg	1 kg
	Total	100	1,000 g	5,000 g	15,000 g	25,000 g
8	Water (to mix the cement)		40 g	0.2 kg	0.6 kg	1 kg

Mixing

Good mixing is crucial for good block-making. Urea must be mixed thoroughly by breaking up lumps to avoid pockets of high concentration that could harm animals. Do the following to mix the ingredients.

- Weigh the amount of ingredients needed based on the formula of the block.
- Add urea to the molasses while continuously mixing.

- ♦ Mix the urea with molasses thoroughly by stirring for about 20 minutes.
- ♦ The molasses can be heated in the sun to improve handling and mixing.
- ♦ Never add water to molasses. It has to be thick.

- Add bran and any other fibrous material such as *nougseed* cake, if it is part of the formula, and mix thoroughly.
- Make the cement into a paste with water prior to adding to the rest of the ingredients.
- Mixing the salt with cement accelerates hardening.

High levels of molasses and urea tend to decrease block hardness. Check block hardness after drying and make the following adjustments to the formula.

If the block is too hard, reduce the proportion of cement or clay and slightly increase the proportion of molasses. If too soft, increase cement or clay and reduce molasses.

Figure 7.22. Mixing urea, molasses and bran.

Casting and molding

Once the ingredients are thoroughly mixed, place the mixture into molds. Any local container, such as tin cans or small buckets can be used as a mold. Using a plastic sheet to line the molds will make block removal from the mold easier.

Wooden mold – Debre Zeit Research Center

PVC tube mold – Debre Zeit Research Center

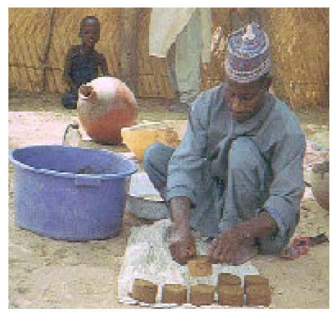
Mold made of metal sheets – Holeta Research Center

Machine for making solid construction blocks

Figure 7.23. Different types of molds.

Molding using wooden bars

Molding using small tin cans



Removing molded blocks for drying

Figure 7.24. Molding urea molasses blocks.

Example of steps of molding urea molasses blocks using sheet metal molds

The mold

Step 1. Filling the mold

Step 2. Compacting

Step 3. Opening the mold

Step 4. Removing block from the mold

Step 5. UMB ready for drying

Figure 7.25. Steps of molding urea molasses blocks using sheet metal molds.

Drying and storage of urea molasses blocks

Remove the blocks from the molds after 24 hours and place on racks to dry. Leave the blocks to dry for at least 5 days depending upon the weather condition.

Figure 7.26. Drying urea molasses blocks.

Characteristics of a good urea molasses block

A block is considered good when it fulfils the following:

- Ingredients are well-distributed throughout the block.
- It does not have lumps of urea and lime.
- It is hard enough to resist being squashed between fingers or breaking when a person steps on it.
- The sticky molasses can be felt when holding the block. The amount of molasses needs to be increased if the block doesn't feel sticky.

Feeding and intake of urea molasses blocks

Blocks should be fed as a lick so that only the top surface is accessible to animals. This prevents animals from pushing the blocks around, breaking them up and consuming large chunks that could cause urea toxicity.

Figure 7.27. Sheep licking urea molasses blocks (Technique being used by farmers after demonstration by ESGPIP trained *Kebele* Development Agents.

Blocks should be introduced to animals slowly and should be fed after animals have consumed adequate forage. This prevents animals from consuming too much at any one time. **Urea molasses blocks should never form the main diet.** They are meant to be a supplement to a basal diet of forage. Allow access by animals for one hour per day during the first week of adaptation, two hours during the second week and free access after the third week. Some animals may need to be forced to consume the blocks by preventing access to lush feed other than dry roughage during the adaptation period.

Block hardness will affect its rate of intake. If too soft, it is consumed too rapidly and there is the risk of toxicity. If too hard, intake may be too little. Urea at high levels is unpalatable. High levels of urea in urea molasses blocks may reduce intake of the block as well as of straw due to the bitter taste.

High levels or imbalances in minerals may result in excessive consumption in a short time, also leading to urea poisoning. Precautions should be taken to avoid this problem of over-consumption in drought-prone areas, particularly towards the end of the dry season when feed is scarce.

Precautions while supplementing with urea molasses blocks

It is essential to note the following while supplementing urea molasses blocks.

- Feed to **<u>ruminants only</u>** (sheep, goats, cattle, camels).
  - ♦ Do not feed to monogastrics, i.e., horses, donkeys, or pigs.
  - ♦ Do not feed to young ruminants less than six months of age (lambs, kids).
- Blocks should be used as a supplement and not as the basic ration.
  - ♦ A minimum of coarse forage in the rumen is essential.
  - ♦ Never give blocks to an emaciated animal with an empty stomach. There is the risk of poisoning

due to excessive consumption.

- The amount of blocks fed to sheep and goats should be limited to 100 g/day.
- Blocks should never be supplied in ground form or dissolved in water as this can result in over-consumption.
- Supply sufficient amount of water.

Transferable Messages

In *kebeles* where ingredients for making urea molasses blocks (UMB) are available, making and using UMB supplementation improves performance of sheep and goats.

1. Demonstrate to farmers on how to make and use UMB.
2. Demonstrate to small-farm urban/peri-urban youth on how to manufacture and supply UMB to farmers as a business venture.

7.10. Strategies for Sheep and Goat Feeding and Management during Drought

Many parts of Ethiopia experience extended periods of drought, leading to shortages of fodder and water. During these periods, sheep and goats are unable to meet their nutrient needs for maintenance and will begin to lose weight as body reserves are depleted. As this happens, the females do not come into heat and so do not breed. Those already pregnant will produce very weak lambs and kids. During very long dry spells animals will die, with the youngest, weakest and oldest dying first.

In most cases, no single strategy will be sufficient to solve this problem. Each situation will require a unique set of strategies. Some common options are discussed below. The options to employ and their degree of implementation depend on the prevailing circumstances.

7.10.1. Selling stock

This option should almost always be the first measure taken in the early period of drought. As the drought progresses, stock should be sold by class, starting with finished young stock, then replacement stock, aged stock and older breeders, until a nucleus of healthy, young, sound, breeding females — most valuable for restocking when the drought ends — remains.

The timing of selling stock and the condition of the stock at sale are important considerations. Prices received are likely to be better if stock is sold early in the drought before the market becomes congested with a high supply of animals. Stock should be in reasonable condition to fetch higher prices. This strategy is more effective for prolonged droughts.

Selling only a small percentage of stock may be necessary during short droughts. This will normally be compensated by increased performance per animal of the remaining stock as a result of reduced stocking rate.

7.10.2. Supplementation

Supplementary feed can be provided only if it is available in drought-stricken areas. This usually means that the transport of feed into these areas must be organized by the government or an aid program. Concentrates are preferred to roughages for drought feeding because of higher nutrient density.

7.10.3. Maintenance feeding

In a short drought, maintenance feeding is likely to be a low-cost strategy. However, maintenance feeding can be expensive if the drought is prolonged. This strategy is more successful if implemented in association with reduction of animal numbers before commencing feeding.

Protein-rich concentrates, enough to satisfy about half of the animals' maintenance requirements, should be given provided that there is still some poor quality vegetation available. If the drought worsens, the complete maintenance requirement will have to be fed by means of supplementary feed. If the protein content of the available concentrate is low, it may be necessary to feed a protein supplement such as urea at the rate of a few grams per day. Oilseed cake has been demonstrated to be especially useful for stimulating roughage consumption during a drought. When a limited quantity of supplement is available, it should be supplied to those members of the flock that are most needy.

7.10.4. Humane destruction

Humane destruction of livestock is another strategy which may be applicable at times of very low livestock prices, or when animals are unfit to be transported. Humane destruction should be carried out when animals are approaching a condition too poor to survive. Decreasing competition for feed will help the remaining animals to stay in better condition and be more productive following the drought.

7.10.5. Adjusting grazing strategies during drought

Below is a list of strategies to help producers avoid crisis in times of drought. It is best to assess options at the first sign of drought.

- Adjust stocking rate to the carrying capacity of dry years. Reduce stocking rate early. Increase stocking rate gradually after the drought, over a period of 1–3 years.
- Graze areas with limited water reserves first.
- Rest pastures or delay grazing in all pastures periodically. Lengthen pasture rest periods during slow or no growth times. Plants can withstand severe grazing if followed by proper rest periods. These rest periods allow plants time to replenish tissues above and below the ground.
- Maintain emergency pastures that can be used during emergencies.

7.10.6. Adjustment of animal management

The following changes in animal management are useful to improve utilization of feed resources during drought.

Parasite control: Animals under nutritional and heat stress are less resistant to parasites than under normal conditions. Strategic deworming during a drought will relieve some of the nutritional stress on the animal and "clean up" the herd for the next favorable season.

Herd segregation: Young animals are not able to compete with mature ones for pasture or supplemental feed. Drought feed is costly and it is important to feed only those animals that really need it. Vulnerable classes can be segregated and given preferential treatment. The older, dry animals can be moved to poorer pasture or range areas.

7.10.7. Early weaning and creep feeding

Creep feeding: Creep feeding is simply providing supplemental feed separately to young animals while they are still suckling. Creep rations should contain 12–13 MJ/kg of metabolisable energy with a protein content of between 13 and 16% depending on the protein levels in the forage.

Early weaning: Grazing forages decline rapidly in quality and quantity during droughts. Early weaning and disposal of weaned lambs/kids during drought periods will help reduce pasture requirements and help breeding animals maintain their body condition. This is critical in improving conception rates.

7.11. Cactus (*Opuntia* spp.) as an Emergency Feed Resource in Arid Areas

7.11.1. Characteristics of cactus

Getting appropriate plant species to grow in arid areas is a permanent concern. Cactus is such a plant that can play this role. Cacti are more efficient than grasses or legumes in converting water to dry matter due to their specialized photosynthetic mechanism. Cactus plantations create living fodder banks to feed animals during drought and to combat desertification. The increased importance of cacti in arid zones is because of their ability to:

- be relatively drought-resistant, survive and remain succulent during long droughts;
- produce large quantities of fodder during the rainy season, which can be utilized during the dry season;
- have a high carrying capacity;
- supply succulent fodder to animals during droughts;
- tolerate severe utilization and have high recovery ability;
- have low establishment and maintenance costs;
- tolerate a wide range of soil and climatic conditions, so that they can be planted where the production of ordinary fodder crops is uncertain;
- produce forage, fruit, and other useful products; and
- prevent long-term degradation of ecologically weak environments.

Figure 7.28. Spineless cactus varieties.

Cactus fruits are consumed by humans as an emergency food during food shortage periods. This is a widespread practice in many parts of Tigray and some parts of Hararghe. *Opuntia* cladodes (young leaves) behave like common forage crops and have the following characteristics:

- They have high contents of water (90%), ash (20%) and calcium (1.4%), soluble carbohydrates and vitamin A.
- They are poor in crude protein (4%), fiber (10%) and phosphorus (0.2%).
- Their digestibility is comparable to a good forage crop, with average digestibility ranging from 60 to 70% for organic matter, 35–70% for crude protein and 40–50% for crude fiber.
- Cactus cladodes are highly palatable, with average daily consumptions of 6–9 kg for sheep and goats. Cactus intake does not reduce intake of fibrous feed. Cactus consumption improves rumen conditions which enhances the intake of fibrous feed.
- The high moisture content of cactus cladodes helps mitigate the problem of animal watering in

dry areas. Research clearly shows that water intake is nil when daily cactus intake by sheep is about 300 g of dry matter.

- Feed values of spiny or spineless cactus are similar. Spines are not a limiting factor because they can be removed.
- Cactus, fed in any form during an emergency, will keep animals alive.

As a consequence of its composition and other characteristics, the following should be observed when feeding cactus:

- Cactus should be supplemented with an appropriate and cheap nitrogen source. Moreover, a special mineral supplement is required to provide sufficient sulphur and phosphorus to maintain an appropriate Calcium to Phosphorus ratio.
- Cactus is rich in soluble carbohydrates and Ca, but poor in P. Therefore, it is recommended to:
  - limit the amount of grain and molasses in the diet to avoid decreasing rumen cellulolytic activity, and
  - feed animals with fibrous feeds (straw, hay, etc.) before giving the cactus.

a. Manual chopping of cactus (Tunisia).

b. Small electrical chopper (Brazil)

Figure 7.29. Chopping *Opuntia* pads.

7.11.2. Some practical considerations

Spines: The spines from spiny varieties of cactus can be removed through burning individual pads or chopping large pads using tools and machines. In some countries like Mexico and the USA, the whole standing plant is burned before grazing.

Laxative effects: A laxative effect appears when the volume of cactus in the diet is high (more than 50–60% of the DM intake). This problem is easily solved by feeding small amounts of straw or hay prior to cactus distribution; this is sufficient for normal transit.

Different varieties are available for use. For best results, some cactus varieties, such as *Opuntia* pads, need to be chopped before feeding to animals.

7.12. Feeding Different Classes of Small Ruminants

Little information is available on the nutrient requirements of animals at various physiological states under tropical conditions. The amounts of energy and protein or amino acids supplied to the animal determine productivity. Both energy and protein must be supplied in sufficient quantities and balanced to meet requirements and optimize feed utilization. Energy in ruminants is largely supplied by volatile fatty acids (VFA) that arise from the rumen fermentation of all types of organic matter, though the majority comes from carbohydrates. The principal way of increasing VFA energy is to increase intake and/or the rumen degradability. This can be accomplished by supplementation with a nitrogen source or, in the case of poor quality roughages, urea treatment.

Table 7.17. The first limiting nutrients for different physiological functions of sheep and goats.

Physiological function	Limiting nutrients
Growth (lean tissue)	Amino acids
Growth (fattening)	Energy, amino acids
Puberty (egg and sperm production)	Energy, amino acids
Pregnancy	Energy, amino acids
Lactation	Energy, amino acids

7.12.1. Productive functions and the need for supplementary nutrients

Growth: Growing animals have a very high requirement for amino acids for tissue synthesis. High growth rates cannot be supported by the products of fermentative digestion alone. Bypass protein supplements are essential.

Reproduction: The growth of the fetus has little effect on the dam's protein and energy demand until the last third of gestation when most fetal tissues are formed. It appears that rumen function, even on diets of low digestibility, can support the birth of a viable offspring of normal weight. Urea supplementation can enhance milk production to a level that ensures survival of the offspring. But to allow the young animal to grow, milk yield must be further stimulated by feeding a bypass protein source.

Milk production: The major constraint to milk production from diets based on crop residues and agro-industrial by-products is the availability of nutrients to provide the glucose for lactose (milk sugar) synthesis. A dietary source of lipid can reduce any imbalance caused by relative deficiencies of glucogenic energy in the end-products of rumen digestion. For many feeding systems in the tropics, the level of fat in the diet could be a primary constraint to milk production.

7.12.2. Feeding different classes of animals

A balanced feeding program for sheep and goats should contain forages, hay, grains, browse and shrub plants and a source of bypass protein. Keep the following points in mind while feeding different classes of animals.

- Balance feed availability and number of animals kept.
  - ♦ Adjust the number of animals to the level of feed.
  - ♦ Produce more feed to meet requirements.
- A ration that is modified whenever necessary to meet the changing requirements of animals during different stages of the reproductive cycle is usually more economical.
- The amount of feed supplied should be accurately adjusted to the requirements of the animal so that feed is not wasted by feeding more than the animal needs.
- Feeds of similar nutritive values/properties can be interchanged based on prices in order to obtain each essential nutrient from the cheapest available source.

Experience and observation will show what feeds animals like and how much they will eat. Some guidelines for feeding different groups of animals are indicated below.

- **Adult breeding males:** Adult males used for breeding need to be well-fed to maintain their body condition for mating. Breeding males need to be supplemented beginning two weeks before start of breeding. They shouldn't, however, be allowed to become too fat. Breeding males need to be supplied with plenty of water and allowed to exercise. Supply of good pasture is enough when not being used for mating. Feed as follows starting two weeks before and during breeding season:

- ♦ Grass/crop residues, free choice (as much as they can consume).
- ♦ Supplement legumes, up to 1 part for every 4–6 parts of grass/residue consumed.
- ♦ Alternatively, supplement a handful (about 250 grams) of concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt. The allowance should be higher (400–600 g) if the male is large and is serving a large number of females.

- **Dry breeding females:** A dry female that has recently been weaned from her lambs/kids can be maintained on good quality pasture or fed good quality hay depending on her physical condition at weaning. Very thin animals that are adversely affected by the stress of lactation (especially those that gave birth to twins or triplets) need supplementation in addition to forage for adequate preparation for the next breeding and conception. Thin breeding females should be flushed before breeding. Flushing is the practice of feeding the ewe/doe so that she starts to gain weight about two weeks before breeding. Flushing may increase lambing percentage and embryo survival. Flushing can also reduce mortality of offspring. Flushing works best on females in poor body condition.
- **Young, replacement females:** Young females selected for breeding need extra feed for growth so that they will be large enough and in good shape for breeding. They should be fed as follows:
  - ♦ Grass/crop residue, free choice.
  - ♦ Supplement legumes, up to 1 part for every 3 parts of grass/residue consumed.
  - ♦ Supplement a handful (250–300 g) of a mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt.
- **Pregnant females:** Pregnant females need feed to support the growth of the fetus. They shouldn't be fed to become too fat. Females that are too fat will have trouble lambing/kidding.
  - ♦ Females in early pregnancy should receive:
    - o Grass/crop residue, free choice.
    - o One part legume for every 3 parts grass/residue.
    - o A handful of concentrate, 200 g/head/day mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt or 500 g of wheat bran.
  - ♦ **Females in late pregnancy (2–3 weeks before the due date):** This is by far the most critical period during which correct feeding is important as the fetus grows fastest at this stage of development. They should receive:
    - o Free access to good pasture and other roughage.
    - o One part legume for every 3 parts grass/residue.
    - o Concentrate, 250–400 g/head/day mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt or 1 kg wheat bran depending on condition of the animal.
- **Lactating females:** The requirement of these classes of animals is similar to females in late pregnancy. Their rations should generally contain 14–16% crude protein. They have high requirements for milk production. They should receive:
  - ♦ Grass/crop residue, free choice.
  - ♦ One part legume for every 3 parts grass/residue.
  - ♦ Concentrate: 250–300 g/head/day mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt or 1 kg wheat bran. The level of concentrate should be higher for high milk producers. An allowance of concentrates at the rate of one third of the amount of milk produced is necessary.
- **Young lambs/kids before weaning:** Newborn lambs and kids should be supplied with colostrum within the first hour after birth. Colostrum helps protect them against diseases due to its content of

antibodies and high nutritional value. For the first few weeks of life, all a lamb/kid needs for nourishment is its mother's milk. Hay, water and protein supplements should be placed near the lambs/kids so that they start to eat and drink. Young ones can begin to consume other feeds at about six weeks of age. They should be fed the best quality feeds available to help them grow and get them accustomed to eating feeds other than milk. The feed needs to be of high quality because they can eat only small amounts. They should receive:

- High quality young forage, free choice.
- Supplementary legumes as much as are available.
- Free choice supply of concentrate. The concentrate should be fed in creep feeders so that only the lambs/kids can consume it. This prevents the adult animals from eating the feed intended for the young animals.

A simple creep feeder used by farmers around Ambo (on-farm trial supported by the ESGPIP)

Lambs eating a supplement in the creep while the dam is kept out

Figure 7.30. Creep feeding increases weaning weights and helps with early weaning.

- **Weaned lambs/kids:** Weaning involves removing young ones from the milk diet to other forms of feed. This separation can be stressful. Lambs/kids are very vulnerable to disease and growth depression at the time of weaning unless they are weaned on to high quality feeds. Weaning at two to three months of age depending upon management is possible. Abrupt weaning is unnatural and should be avoided. Ideally, weaned lambs/kids should receive:
- High quality young forage, free choice.
- Free choice supplementary legumes.
- Free choice concentrates. They can be started with 70 g/day of mixed concentrate or 150 g wheat bran, and the amount can be increased as they grow.

Transferable Messages

1. Feeding animals by separating them into groups with similar physiological requirements gives them the attention they need and substantially improves feed resource utilization.
2. Creep feeding as a management tool reduces lamb/kid mortality. It also improves growth at this stage of development when they have fast growth rates.

7.13. Intensive Feeding of Sheep and Goats before Slaughter

Intensive feeding of sheep and goats before slaughter under Ethiopian situations can be categorized into two systems:

Production of conditioned animals: This system is intended for the supply of animals of acceptable condition to the slaughterhouses for ultimate export. These animals may also go into a finishing operation targeted at supplying the local market.

Finishing: This is the process of feeding sheep and goats to slaughter weight with adequate finish (fat deposit). This targets the local market, which has high demand for fat animals.

The operation of large feedlots by export slaughterhouses is becoming feasible. The principal functions of such feedlot operations are to assemble large numbers of sheep and goats, often with different backgrounds, and produce a homogenous product. The following guidelines will serve these operations and also small farmers that want to fatten smaller numbers of sheep and goats.

7.13.1. Advantages of fattening

Fattening is one strategic feeding option that can have the following advantages under Ethiopian conditions:

- Technically, it is quite simple and within the capabilities of small farmers to implement; moreover, the results are highly visible. This helps ensure farmers' confidence in the technique. Other techniques such as feeding to boost reproductive performance are less convincing because the farmer may not be sure that the extra feed resulted in any benefit.
- Benefits can be realized within a short period unlike other animal production activities.
- Fattening generates cash income that is eagerly sought by farmers.
- Fattening is generally profitable because the value per kilogram of live weight increases as both weight and condition increase.

7.13.2. Fattening systems

Traditional systems: Farmers generally condition their animals and market them. This feeding operation takes a very long time because it is generally based on low quality feeds. It is also associated with huge fluctuations in the weights and conditions of the animals depending on feed availability. Several improved traditional systems are in use, but they are not widespread. For example, systems of sheep fattening exist in the Adillo area of the southern region where conditioned animals are fattened by feeding sweet potatoes and other high value ingredients. These fattened animals fetch very high prices.

Agro-industrial by-product-based fattening: Fattening of sheep based on agro-industrial by-products is also practiced around the Adama area. This system can be promoted to other similar areas that have agro-industrial by-products. Fattening using agro-industrial by-products, such as sugar-processing by-products, is feasible in places like Wellega where valuable feed resources such as molasses and corn (grain and residue) are widely available. Protein sources like oilseed cakes can be purchased from nearby processing plants, and/or forage legumes can be grown in the area. Brewery by-products are also available from the Bedele Brewery to serve as protein sources. The Horro sheep breed, one of the fast-growing breeds in Ethiopia, is also indigenous to this area. Table 7.18 shows examples of rations for areas where by-products are available. Local equivalents of the weights indicated can be used whenever scales are not available.

Table 7.18. Molasses-based rations.

Ingredient	Ration I	Ration II	Ration III
Straw	Ad lib	Ad lib	Ad lib
Molasses	350 g	250 g	200 g
Oilseed cake	125 g	100 g	–
Brewer's dried grain	–	–	200 g
Urea	10 g	–	–
Molasses urea block	–	Free choice	Free choice

7.13.3. Feeding management of finishing sheep and goats

- The fattening program should be started after the necessary feed supplies are secured. Underfeeding and incorrect timing are the most common causes of failures in fattening activities.
- The objective in a fattening operation is to convert as much of the feed to body tissue as possible. It is thus necessary to minimize the movement of animals during the fattening period. They should be allowed only limited exercise.
- The animals should have shelters that protect them from adverse environment. The shelter need not be expensive and can be made of locally available materials.
- The success of a finishing operation depends on the first two weeks after arrival of animals. They may have traveled long distances and will be stressed, hungry, and thirsty. It is recommended that the following guidelines be followed during this period.
  - Right after arrival, rest the animals for a few hours in a dry, clean, sheltered area with access to fresh water. Then offer grass hay or mixed grass–legume hay.
  - Hand-feed salt during the first two weeks, then provide trace mineral salt in a separate feeder. Afterwards, these supplements can be mixed in the complete diet, but salt should continue to be provided *ad libitum* (free choice).
- Animals should have feed available at all times including evenings. If there is no feed left in the morning, feed supply for the following day should be increased.
- Adjust the animals to the fattening concentrate diet over a two week period by feeding the concentrate after the animals consumed enough roughage to provide bulk. Gradually increase the intake of the diet every two days, while providing free access to the basal roughage diet.
- Drench for internal parasites and treat for external parasites before the start of the feeding operation. This will improve feed utilization and performance.
- Sort the animals by weight/size and feed in uniform weight groups.
- Cull non-performing animals.
- Feed for 90–120 days. The length of the feeding period depends upon the desired animal condition. What is desired for the export market may be just conditioning without the amount of fat desired by the local market. Thus, animals for export can be sold at a time when the desired condition is attained.
- Water should be available at all times. Inadequate water supply will affect performance.

7.13.4. Selection of sheep and goats for finishing

- Select animals that are healthy and have no visible physical defects. Avoid emaciated animals as their poor condition may not entirely be due to nutritional factors. Emaciated animals often take a long time to recover. Target animals with medium body condition.
- The animals should have a large skeletal frame (long legs, loin, etc.) capable of producing a heavy carcass.
- Avoid animals that are too old. Check that the teeth are sound. This has implications on feed utilization. It is advisable to select sheep/goats aged between 2 and 4 years for fattening.
- Castration influences the fattening process. Castrated animals deposit more fat while uncastrated animals have more muscular growth. The selection of castrated or uncastrated animals depends on the final product desired and market conditions.

7.13.5. Feedstuff for growing and finishing sheep and goats

Finishing can be accomplished with diets containing different proportions of roughages and concentrates. The proportion depends on the type of feeds available, the desired length of feeding and the types of animals to be finished.

- Concentrates:
  - Concentrates are fed for energy. Grains and grain products commonly fed are shelled corn, wheat, sorghum and oats. Liquid feedstuff, such as molasses, can also be used as a source of dietary energy. Alternative energy sources, such as beet and citrus pulp can be fed to growing and finishing sheep and goats, but in most situations performance will not equal that obtained from grains and grain by-products. The use of these feeds depends on the price differential in utilizing them for fattening compared to other alternative uses.
  - High-protein concentrate sources most commonly fed are *nougseed* cake, cottonseed cake, linseed cake, sunflower seed cake, brewer's grains, distiller's grains and other similar feeds.
- Roughages:
  - A wide variety of roughages can be fed to growing and finishing lambs. The amount of roughage to feed depends on the objective of feeding the roughage. The roughage may be added to simply add bulk or contribute to the feeding value. The role of roughage in short-term intensive feeding is generally to provide bulk.

7.13.6. Weight of animals

Weights of animals at the start of the feeding operation govern the duration of feeding and the types and amounts of feedstuff needed. Lightweight (15–20 kg) animals can use more roughage, whereas heavier lambs (>25 kg) require more concentrates and a shorter feeding period. Therefore, lightweight sheep and goats are more desirable for conditioning based on a larger proportion of roughage, whereas heavier animals perform best where high concentrate diets are used.

Finishing heavier animals (>30 kg initial weight) in dry lot allows for rapid turnover and more efficient use of facilities. There are many practical feeding programs based on available feedstuffs that will produce the most efficient gains at least cost (Table 7.19).

Table 7.19. Sample feeding programs for finishing in a dry lot.

Ingredient	Diet I (%)			Diet II (%)			Diet III (%)		
	Weight (kg)			Weight (kg)			Weight (kg)		
	To 30	30-40	40 to market	To 30	30-40	40 to market	To 30	30-40	40 to market
Ground corn	52	62	72	49	59	69	60.5	60.5	59.5
Ground cobs	20	10	–	–	–	–	–	–	–
Chopped grass hay				33	23	13	–	–	–
Oilseed cake	11	11	11	11	11	11	10	10	10
Dried legume hay	10	10	10	–	–	–	23	23	23
Liquid molasses	5	5	5	5	5	5	5	5	5
Dicalcium phosphate	1	1	1	1	1	1	1	1	1
Trace mineral salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Transferable Message

Short term intensive feeding based on locally available feedstuffs is an economically more feasible activity than keeping animals for long periods of time on maintenance-level feeding.

1. Demonstrate to farmers the cost-benefit of short term fattening versus keeping animals for long periods of time;
2. Demonstrate to farmers that this can be a viable business venture.

7.14. Feeding Management

Feeding sheep and goats is both a science and an art. While diets are scientifically formulated, experience in the feeding and management of small ruminants is important in gaining optimum feed utilization. Feed should be stored and used as carefully and economically as possible. Proper care should be taken during storage and handling to avoid spoilage and loss; in feeding techniques and livestock management to avoid wastage; and in ensuring that different types of feeds are used in the context of a balanced feeding system. Some principles and applications of feeding management of sheep and goats are presented below.

7.14.1. Improving feed utilization and efficiency

- If livestock are to make the best use of feed, they must be healthy and correctly handled. Routine control of epizootic diseases and internal and external parasites are important to achieve efficient use of feedstuff.
- Feed animals based on their requirements. Both overfeeding and underfeeding result in feed wastage.

7.14.2. Proper storage of feed

- Stored feed must be kept dry and protected from animals, moisture and fire.
- Cover hay stacks with thatching or other material.
- Store feed in a well-ventilated area to avoid mold development and excessive heating.
- Feeds, especially concentrates, should be stored on pallets to avoid direct contact with the floor, which could cause spoilage.
- Buy concentrate feeds only in quantities required for one month.
- If possible, concentrate feeds should be stored as individual ingredients. Mixing should be in quantities that can be used in a one-week period. Mixed feeds spoil faster.
- Baled fodder is simpler to handle and requires less storage space compared with loose fodder. It is, therefore, advisable to bale roughages. Baling can be done on small farms using a box baler without requiring expensive equipment.

7.14.3. Adapting sheep and goats to new feeds and increasing consumption of less palatable feeds

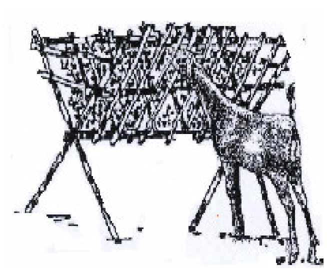
- Sudden diet changes, especially switching from a diet high in roughage to concentrate, should be avoided. Dietary changes should be gradual. The micro-organisms in the reticulo-rumen that help sheep and goats utilize feed require time for adaptation. The sudden introduction of a new feed can lead to scouring and loss of condition or even death in severe cases. A new feed or a feed that is not highly palatable should first be given in very small amounts with the quantity being increased progressively over a period of up to 15 days. There are, for example, observations that sheep and goats initially can refuse to consume some multipurpose trees and other feeds that have a strong smell. Some suggestions for use of new feeds are given below:
  - Always present the new feed when animals are hungry.
  - Mix new or less palatable feed with feeds the animals like to consume. The level of the new feed can be increased gradually. Mixing with feeds such as molasses or salt can shorten the adaptation period.
  - If the above strategies do not work, one can try forcing the animals to eat the new feed or go hungry. If they are persistent in their refusal, another approach or a different feedstuff may need to be used.

7.14.4. Separate feeding and/or grazing

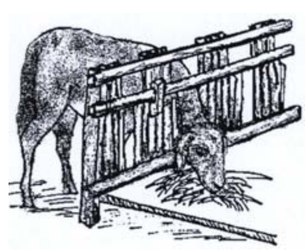
- It is common for all classes of sheep and goats to graze together on communal land. This does not allow for feeding different classes of animals differently. For example, pregnant or lactating females should be fed differently than breeding males that should receive a maintenance diet.
- Individual animals within groups of sheep or goats differ in their nutritional needs. When feed resources are limited, animals with highest requirements should be targeted. For example, young stock and pregnant females have special needs and should be treated differently from other animals. Young lambs and kids need additional feed supplementation especially if they are born as twins or triplets. This can be done by using creep feeders that only allow access to the supplement by young animals.

7.14.5. Presentation of feed

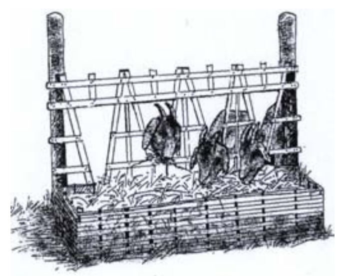
- Little attention is given to the method of presentation of feed in improving feed intake and feed utilization. However, it has a crucial role in terms of its effect on the amount of feed eaten as well as the amount wasted. Sheep like to graze while goats like to browse. Raising the feed offered to goats high above the ground and simulating a browsing situation, by tying bundles of feed from a tree or barn roof, may stimulate feeding behavior. It will also help keep the feed clean and reduce wastage.



Hay rack for goats (adopted from Peacock, 1996)



Hay rack for sheep



Hay rack made of bamboo

Figure 7.31. Different types of hay racks.

7.14.6. Feeding based on palatability

- If a feed has high nutritive value, but low palatability, its dry matter intake will be low. Where farmers cut and carry forage of different species, it is important to know forage palatability ranking. Some farmers are aware of this fact and make use of forage ranking effectively. They do this by offering the forage of the lowest palatability first and that with highest palatability last.

A keyhole barrier made of wood

7.14.7. Provide fresh feed

- Supplying fresh feed in smaller quantities more often will help stimulate consumption compared with offering larger amounts at one time.

A "tombstone" barrier made of wood

Figure 7.32. Different types of barriers and racks that reduce wastage

7.14.8. Minimize wastage

- *Sanitation:* Under confined or tethered feeding situations, a clean and dry floor will mean less wastage. Feed that falls to a clean floor is more likely to be acceptable if offered again than feed contaminated by mud and feces. Sheep and goats are selective feeders and easily refuse to eat dirty or smelly feed. Feed that is refused by sheep and goats may, in most instances, be used for cattle, which are generally less selective. This is one way of effectively utilizing available feed resources
- Chopping: Feeding roughages in the chopped form reduces wastage and improves feed utilization. Chopping green feed and stover has the following advantages:
    - ♦ Reduces selectivity.
    - ♦ Permits thick-stemmed material to be easily eaten.
    - ♦ Can increase consumption of unpalatable feeds.
    - ♦ Allows for mixing with other ration components.
    - ♦ Uneaten, coarse bits of chopped fodder may be added to dung cakes and so are used as fuel.
- Poor feeding techniques:
    - ♦ When dry fodder is fed loose in the field, wastage will be less if distributed little by little so that the stock eat it all and wait for more.
    - ♦ Long hay and straw should be fed from racks or mangers; feeding on the ground, apart from being wasteful, is a health hazard.
- Provision of appropriate feeders:
    - ♦ Feeding on the ground results in considerable feed wastage and contributes greatly to the spread of disease, especially internal parasites. If sheep and goats are able to stand in their feed or in their feeders, they will inevitably defecate and urinate in the feed. Feeders need to be raised off the ground and constructed in such a way to keep the animals out as much as possible. Provision of appropriate feeders also reduces competition. There must be enough space at the feeder for all sheep and goats to be fed easily without fighting. Young animals should be fed separately from older ones to avoid competition and trampling.
    - ♦ Feed troughs for concentrate and hay racks for forage feeding are required. The size of racks and troughs is decided by the body size of the sheep and goats. Approximately 30–40 cm per animal is the minimum. Movable troughs are usually 2–4 m long. Fodder should not be put on the ground for sheep and goats. A feeding rack can be made from wood or other locally available material such as bamboo. The rack should be high enough to prevent adult sheep and goats from putting their heads in it and from jumping into the rack. The bottom should be above the normal head height.
    - ♦ It should be noted that the feeding behavior of goats is different from that of sheep and a barrier is needed to prevent animals from jumping into the trough. In a system called 'tombstone or keyhole barrier', each animal puts its head through an individual wooden barrier to eat without being able to push its body into the trough. Suggested dimensions for a concentrate trough is 30 cm wide with sides 15 cm high and standing on 15 cm legs.

In general, lowered troughs are not desirable because mud or soil can get into the trough and sheep and goats are tempted to put their feet in. When only a limited amount of supplementary feed is given, it is essential that the trough is long enough to allow all sheep to eat at once. Some troughs are fitted with a yoke to restrain animals during the short period of supplementary feeding. Such structures allow individual recording of the amount of concentrate consumed by an animal.

- ♦ **Feed racks:** Racks should be used wherever possible. Hay, crop residue, as well as cut green vegetation (if using cut-and-carry system), can most easily be fed in racks made with slatted sides and hung so that the feed is presented off the ground and at approximately head height. Galvanized metal racks are more durable than racks made of wood, but are more expensive. There should be enough feeder space for all animals to eat at the same time. Providing more than one feeder is a good option.


A hay rack made of wood


A different make of rack


Hay rack made of metal

Figure 7.33. Different types of hay racks.

- The height of the rack will depend on the height of the animals. The rack should be high enough for the animals to reach up and pull the feed down. Do not place the racks too high. If animals are constantly reaching up to get at the hay, dust and particles from the hay will get into their eyes, and the irritation caused by the sharp particles can result in an unpleasant condition called "Red Eye". Racks can be constructed using materials available in the area; tree branches, bamboo, etc. The width between the bars depends on the type of feed offered. The rack can be constructed as a mobile free standing structure or attached to a wall for support. Placing a tray or another rack underneath will help to catch feed that falls through and so prevent contamination on the ground. A feeding space of 30 cm per animal is generally allowed. Feeding animals in smaller groups can serve to give adequate chance for all. Portable mobile racks can be used for field-feeding.

♦ **Feeding troughs:** Dry supplements and feeds that are chopped to small sizes should be fed on feeders that do not have gaps. Waterproof containers like a plastic bucket or a similar container can be used for wet feeds. Raising and providing support to such feeders will minimize spillage. There are various designs for feeding troughs. Round bottom or U-shaped feeders are easier to clean than feeders with square bottoms. Metal or hard plastic pans or containers are useful for hand feeding small numbers of animals. Old car tires cut in half can also be used.

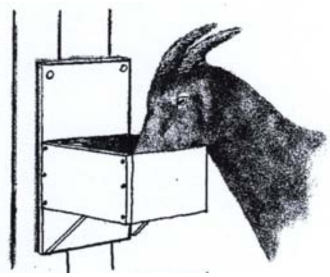

A feeding trough made of burrowed wood

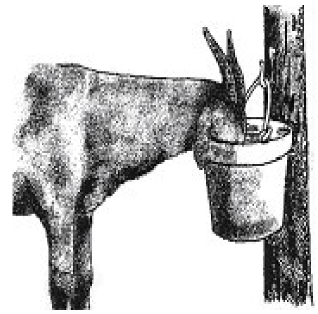

Trough made of metal sheet


Trough made of half-cut barrel


Trough made of PVC pipe used for feeding salt

Figure 7.34. Different types of feeding troughs.





a. Feeding trough fixed to a pole for goats

b. Watering trough fixed to a pole

Figure 7.35. Raised feeding trough and waterer for goats.

- Feeding racks and troughs placed on grazing areas should be:
  - Sited on hard-packed ground or on a well-drained part of the field, and
  - Shifted regularly to reduce damage to the sward.
- Housed stock should receive their feed and fodder in troughs and racks. Racks are often fitted above the trough or manger so that any feed which falls from the rack is held in the trough.

- Provision of shades:
  - ♦ Appetite of animals will be depressed if the place where they are fed is hot and exposed to the sun. They will eat more in a cool and shady place than in a place exposed to direct sunlight. It is, therefore, advisable to locate feeders under the shade.

Transferable Message

Proper storage by baling hay and crop residues saves storage space and reduces wastage.

Proper feeding management reduces wastage and improves feed utilization and performance of sheep and goats.

1. Chopping feedstuff.
2. Use of feeding troughs/racks to reduce wastage.
3. Feeding animals of similar nutritional requirements in groups.

7.15. Characteristics and Feeding Values of Some Common Feeds for Sheep and Goats

7.15.1. Cereals

Barley: Is easily digestible and therefore well suited for all kinds of animals. It contains more protein, lysine and fiber than corn.

Corn: Constitutes the basis for concentrate rations in many countries. It is the cereal with the highest metabolisable energy content which categorizes it among the best energy sources. It is low in protein and especially deficient in the amino acid, lysine. Its utilization is limited only by the need to limit the energy/protein balance. Utilization rates are commonly between 60 and 70%.

Millet: Millet is equivalent to sorghum as an energy source and higher in its lysine content. It may be used as feed for livestock and poultry. It should always be ground.

Oats: Has the lowest metabolisable energy content among the cereals. It is a bulky feed with high percentage of crude fiber. It is a palatable and digestible feed that also stimulates digestion. Oats has higher crude protein content than most grains and is the most balanced in terms of amino acids.

Sorghum: The composition of sorghum is close to that of corn. It is, however, richer in cellulose and less rich in fats. Sorghum may contain tannins, which have a depressing effect on the digestibility of feeds. The content varies considerably (0.2–3%) depending on the cultivars. Considerable variations in protein and starch contents also exist between varieties. Sorghum should be ground for efficient utilization.

Wheat: Wheat is usually not used extensively in animal rations due to its value as human food and the associated high cost. It is the best cereal grain for feeding animals next to corn. Wheat is usually best at levels not exceeding 50% of the concentrate mix in sheep and goat diets because of digestive upsets that may develop.

7.15.2. Cereal by-products

Brewer's Dried Grains (BDG): The dried and extracted residue of barley malt alone or in a mixture with other cereal grains or grain by-products resulting from the manufacture of beer. It has a high crude protein content of 16–24% of dry matter. It also has a high cellulose content of 9–20% of dry matter. BDG has about 80% of the energy content of barley grain but is not as palatable as the original grain. It is chiefly used interchangeably with other feeds of similar bulk in finishing rations.

Brewer's Dried Yeast (BDY): Is the dried, non-fermentative, non-extracted yeast of the botanical classification *Saccharomyces* resulting as a by-product from the brewing of beer. BDY must not contain less than 35% crude protein. It is an excellent source of highly digestible, good quality protein.

Grain Screenings: Consists of 70% or more of light and broken grains along with weed seeds and other foreign material that is separated with a screen in the cleaning of grain. Quality varies according to the percentage of weed seeds and other foreign material. Most grain screenings are incorporated in ruminant rations. Screenings are normally limited to 15–20% of feedlot rations.

Wheat Bran: Is the coarse outer covering of the wheat kernel separated from wheat in commercial milling. It is rich in niacin, Vitamin B1, phosphorus and iron. A large part of the phosphorus is phytin phosphorus. Wheat bran is widely used in horse rations because of its bulky nature and laxative effects. It is also a favored supplement in sheep rations.

Wheat Middlings: Is a by-product of the milling industry. Consists of the fine particles of bran, shorts, germ and flour. Wheat Middlings should not contain more than 9.5% fiber. It is deficient in calcium, carotene, and Vitamin D, but is widely used as a potential grain replacement in rations for all animal species.

Wheat Shorts: A similar product to wheat bran and middlings but lower in its crude fiber content (max. 7%) and richer in its energy composition because it contains the finer wheat milling by-products including a larger proportion of flour.

7.15.3. By-products of oil mills

Cottonseed meal: Is the finely flaked residue that remains after most of the oil from cottonseed has been extracted. The nutritive value of this meal varies a great deal according to the manufacturing technique used. The crude protein content of the decorticated meal can range between 40 and 50%. Cottonseed meal is low in lysine, methionine and tryptophan and deficient in Vitamin D, carotene and calcium but rich in phosphorus. It is an excellent protein supplement for ruminants, since they can tolerate gossypol and do not require lysine and tryptophan in the diet.

Groundnut meal (Peanut meal): Can contain 45–50% crude protein depending on the method of oil extraction. It is low in methionine, lysine and tryptophan. It is also low in calcium; carotene and Vitamin D. Groundnut meal is palatable and contains high quality protein. The meal can be contaminated with molds, especially *Asperigillus flavus* that excretes a toxin known as aflatoxin. It shouldn't be stored for more than six weeks since this product tends to spoil when held too long, especially in warm moist climates.

Linseed meal (Flax meal): Is low in the amino acids lysine and tryptophan. It is also lacking in carotene and Vitamin D, and only fair in the content of calcium and B-vitamins.

***Nougseed* meal:** Is a product comparable in feeding value to undecorticated peanut meal. It is very palatable and can be included in concentrate mixtures for all classes of livestock.

Rapeseed meal: May be used as a protein supplement for all classes of livestock. It may be used at maximum levels of 20% in rations.

Sesame seed meal: Has analytical characteristic similar to groundnut meal. It is a little oilier, richer in cellulose and a little poorer in total crude protein content. It has high methionine content and, thus, an excellent quality plant protein supplement suitable for all animal species. No toxic factor is known in this meal. The color of the expeller meal varies with the variable color of sesame seed varieties.

Soybean meal: Is a product obtained by grinding the flakes that remain after extracting most of the oil from soybeans. It has the highest nutritive value of any plant protein source. The preponderance of soybean meal is explained by its richness in the "indispensable" amino acids, notably lysine. The heat treatment of soybean meal improves its digestibility and destroys the toxic anti-trypsin factor (ATF), of which small amounts are present in crude soya. It contains 40–50% crude protein, is very palatable and, thus, suitable for all animal species.

Sunflower meal: The variation in feeding value is considerable due to differences in crude fiber and the method of extraction. It is a suitable protein supplement for all animal species. Crude protein content ranges from 35 to 40%.

7.15.4. Sugar refinery by-products

Cane molasses: Is a by-product of the manufacture of table sugar from sugarcane. It is a good energy source but low in protein. It is very palatable and an excellent appetizer. It may be fed to any animal species. Molasses is used mostly as a binder to mixed feeds to be pelleted. It also helps to reduce dustiness of mixed concentrate.

7.15.5. Feeds of animal origin

Dehydrated poultry litter: Is poultry manure mixed with litter material from poultry managed under the litter system of management. It is dried immediately after removal from the poultry house and preferably milled and run over a magnet to remove stray metal scraps. Is a low-cost palatable feed that is fair in energy but high in protein and minerals. Quality varies with the type of litter material used.

Poultry Manure: Is produced in cage systems of poultry husbandry. Fresh manure is about 30% crude protein on a dry matter basis. The digestibility of crude protein and organic matter for ruminants is about 80 and 65%, respectively. Initially, the rumen organisms require an adaptation period of about three weeks to fully utilize uric acid, which is the main nitrogenous compound in the manure. Poultry manure intended for feeding must be dried immediately as fresh manure ferments very quickly.

7.15.6. Roughage sources

Bagasse, sugarcane: Is the fibrous residue of sugarcane that remains after the juice is pressed out. It is one of the principal by-products of the sugar-making process. It may be used as low quality roughage.

Barley straw: Is usually superior to wheat straw but inferior to oat straw in feeding value. May be fed to sheep and goats as a maintenance ration.

Bean straw: Varies widely in quality. It is satisfactory as a roughage source.

Corncobs: Are low quality roughage. May be fed to cattle or sheep except for feedlot animals in which case they should be limited to very small quantities.

Corn husks: Are the most digestible of the corn residues that rank as follows: husks, leaf, cob and stalks.

Corn stover: Is the mature corn plant from which the ears have been removed.

Oat straw: Is the most nutritious and palatable of the cereal straws. It may constitute up to half the roughage of breeding and stocker cattle, provided the other half consists of good legume hay.

Peanut hulls: The outer covering of peanut seeds. Are high in fiber, but have 8% protein on a moisture-free basis. These may constitute up to 10% of lamb finishing rations.

Pea straw: Is the residue remaining after separation of the seeds by threshing mature peas. It is worth about 2/3 of legume hays.

Sorghum stover: Consists of the stalks and leaves left after removing the mature sorghum heads. It may be grazed in the field, stored as dry roughage or ensiled. It is commonly fed to beef cattle. After harvest, sorghum will send up new shoots if the moisture is favorable. The prussic acid content of these shoots may be toxic to grazing animals.

Soybean hulls: Are the outer covering of soybean seeds. They are high in fiber and fair in protein content. The hull constitutes some 8% of the seed weight. Soybean hulls are incorporated in commercial feeds primarily because of their high fiber. They are best suited for use by growing sheep.

Soybean straw: Is the residue remaining after separation of the seeds by threshing mature soybeans. It is a high-fiber, low-protein and high-lignin product. It should be fed with good quality hay at about a 1:1 ratio.

Wheat chaff: Includes the husks, hulls, joints and small fragments of straw that are separated from the seeds in threshing of wheat. It is bulky, high in fiber and low in protein.

Wheat straw: Is the residue remaining after separation of the seeds by threshing of wheat. It is best fed with good quality legume hay at about a 1:1 ratio.

Glossary of Nutrition Technical Terms

Ad libitum: A feeding system where animals are given unlimited access to feed. Synonymous terms include full feeding, free choice, self-feeding.

Air-dry basis: Expression of the composition of a feedstuff. This may be actual, i.e., referring to feed that is dried by means of natural air movement in the open or assumed dry matter content. Assumed to be 90% dry matter.

Animal protein: Protein of animal origin derived from slaughterhouses and animal product processing plants that can be used as ingredients in feed mixtures.

Anti-nutrients: Some feed ingredients and potential feeds contain factors that inhibit the digestive process, causing reduced growth, diarrhea or pasting. They limit the amount of some feed ingredients that can be added to the final feed. The anti-nutritional factors in some feed materials such as beans can be destroyed by heat treatment (cooking).

Anti-oxidant: A chemical compound that prevents oxidative rancidity of polyunsaturated fats; added to feed ingredients or feed mixtures for protection against oxidation.

Appetite: Desire to eat; could also be used to refer to the weight of feed dry matter consumed as a percentage of live weight.

As fed: Refers to feed as normally fed to animals.

Available nutrient: A nutrient that can be digested, absorbed and used in the body for some useful purpose.

Average daily gain (ADG): The mean daily increase in the live weight of an animal.

Balanced daily ration: A combination of feeds fed at one time or in portions at intervals, that will provide the essential nutrients in such amounts as will properly nourish an animal for a 24-hour period.

Balanced ration: A combination of feeds that provides the essential nutrients in the proper amounts and proportions to adequately nourish a particular animal.

Biological value: The usable proportion of the protein of a feed or feed mixture by an animal. It is a measure of protein quality. A protein that has a high biological value is said to be of good quality.

Blend: A mixture, such that the constituent parts are rendered indistinguishable from one another.

By-product feeds: Secondary products from plant and animal processing and industrial manufacturing that may be used for animal feeding.

Cake (press cake): Material resulting as a by-product from the processing of oilseeds to remove oil using the mechanical or expeller method.

Calorie: amount of heat energy required to raise the temperature of one gram of water from 14.5 to 15.5°C used as a measure of feed energy.

Chaff: Glumes, husks, or other feed covering together with other plant parts, separated from seed in threshing or processing.

Commercial feeds: Feeds mixed by commercial feed manufacturers that specialize in the business, as opposed to home-mixing.

Compaction: A condition when feed in the stomach and intestines of an animal becomes closely packed causing constipation and/or digestive disturbances.

Complete ration: All feedstuffs (forages, grains, processed feeds etc.) combined in one feed mixture that is nutritionally adequate for a specific animal in a specific physiological state, sometimes referred to as a total mixed ration.

Concentrate: A class of feedstuff low in fiber (<18% crude fiber).

Creep: An enclosure or feeder used for supplemental feeding of nursing young that excludes their dams.

Crop residue: Portion of plant growth that remains after harvesting a grain or seed crop, e.g., straw, stalks, husks, cobs, etc.

Deficiency: Lack or shortage of one or more basic nutrients.

Diet: A feed or mixture of feed ingredients including water regularly offered to or consumed by an animal.

Digestibility: The proportion of feed that is not excreted in the feces and, thus, assumed to be absorbed.

Digestion: Process of changing food to a form that can be absorbed from the digestive tract by the body tissues (mainly the intestines).

Diluent: An edible substance used for mixing with and reducing the concentration of nutrients and/or additives to make them more acceptable to animals, safer to use and more capable of being mixed uniformly in a feed mixture.

Dry-matter basis: An expression of the level of a nutrient contained in a feed on the basis that the material contains no moisture. Synonymous with 100% dry-matter basis, moisture free, oven dry.

Energy feeds: Feeds high in energy and low in fiber (<18% crude fiber), e.g., grains.

Expeller process: A process for the mechanical extraction of oil from oilseeds involving the use of a screw press.

Feed (feedstuff): Any naturally occurring material suitable for feeding animals.

Feed additives: Non-nutritive products that improve animal performance or preserve feeds.

Feed conversion efficiency: Measure of the efficiency of feed utilization. It is expressed as units of feed per unit of animal product — meat, milk or eggs.

Feeder's margin: Difference between the cost per unit weight of feeder animals and the selling price per unit weight of the same animals when finished.

Feeding standards: Estimates of nutrient requirements for a specific function in a given environment.

Feedlot: A lot or plot of land on which animals are fed or finished for marketing.

Fibrous feed: Feed high in cellulose and/or lignin.

Finish: To fatten a slaughter animal. The term may also refer to the degree of fatness of such an animal.

Flushing: The practice of supplementing breeding animals two weeks prior and for one or two weeks after breeding to improve fertility.

Fodder: Coarse feeds such as corn or sorghum stover.

Forage: Vegetative parts of plants fed to livestock in the fresh, dried or ensiled form.

Formula feed: Feed mixture consisting of ingredients mixed and processed in specific proportions.

Free choice: A feeding system by which animals are given unlimited access to the separate components or groups of components constituting the diet.

Full feed: A situation where animals are being offered as much feed as they will consume safely without going off-feed.

Gestation ration: Ration given to pregnant animals during the last trimester to provide the additional nutrients needed for proper growth of the fetus and to keep the mother fit for optimum milk production.

Grits: Coarsely ground grain from which the bran and germ have been removed. Usually screened to uniform particle size.

Hulls: Outer covering of dry grain or other seed, especially when dry.

Ingredient: Constituent feed of a feed mixture.

Joule: A measure of energy. It is the work done when a force of one Newton is applied through a distance of one meter. 4.184 Joules = 1calorie.

Laxative: Feed that induces bowel movement and relieves constipation.

Limiting amino acid: An essential amino acid of a protein that shows the greatest percentage deficit in comparison to the amino acids contained in the same quantity of another protein selected as a standard.

Maintenance ration: The minimum amount of feed required to maintain the essential body processes at their optimum rate without gain or loss in body weight or change in body composition.

Mash: An expression of the physical form of a mixture of ingredients in the form of a meal.

Meal: An expression of the physical form of an ingredient that has been ground or otherwise reduced to a particle size somewhat larger than flour.

Mechanically extracted: Fat extraction procedure from oilseeds by the application of heat and mechanical pressure.

Medicated feed: Any feed that contains drugs for prophylactic or therapeutic purposes.

Metabolic body weight: Measure of body size expressed as the body weight of the animal raised to the three-fourths power ($W^{0.75}$).

Micro-ingredient: Any ration component normally measured in milligrams or micrograms per kilogram or in parts per million (ppm), e.g., trace minerals, vitamins.

Non-protein nitrogen (NPN): Nitrogen that comes from sources other than protein but may be used by ruminants and can, thus, form part of ruminant rations, e.g., urea.

Nutrient: Any chemical substance in feed that has specific functions in the nutritive support of animal life.

Nutrition: The process of digesting, absorbing and converting feed into tissue and energy. It can also refer to the study of this process.

Nutrient requirements: Minimum nutrient needs of animals without margins of safety for maintenance, growth, reproduction, lactation and work. Nutrient requirements plus a safety margin is called "nutrient allowance."

Off-feed: Not eating with normal healthy appetite.

Palatable feed: Feed that is well-liked and is eaten with relish.

Pellets: Agglomerated feed formed by compacting and forcing the material through openings by a mechanical process.

Plant proteins: A category of feeds of plant origin high in their protein content, e.g., cottonseed meal, peanut meal, etc.

Production ration: Additional allowance of ration for production over and above maintenance requirements.

Protein supplements: Feedstuff that contain more than 20% protein or protein equivalent.

Protein quality: A term used to describe the amino acid balance of a protein. A protein is said to be of good quality if it contains all of the essential amino acids in proper proportions and amounts needed by a specific animal.

Ration: The total amount of feed or a mixture of feeds allotted to an animal for a 24-hour period with no reference to quantity or quality.

Roughage: Feedstuff of plant origin that is high in crude fiber but low in digestibility and protein.

Scalping: Removing larger material by screening.

Solvent extraction: A method of extracting oil from oilseeds using solvents.

Supplement: A semi-concentrated source of one or more nutrients used to improve the nutritional value of a balanced ration, e.g., protein supplement, mineral supplement.

True protein: A compound that will completely hydrolyze to amino acids.

Zero-grazing: Feeding of green fodder as green chop in a lot or stall.

References

Banerjee, G.C. 1982. A Textbook of Animal Husbandry. Oxford and IBH publishing Co.

Close W and Menke, K.H. 1986. Selected Topics in Animal Nutrition. DSE. pp. 170.

Devendra, C and Burns, M. 1983. Goat Production in the Tropics. Commonwealth Agricultural Bureau. Pp. 183.

Devendra, C. 1986. Feeding systems and nutrition of goats and sheep in the tropics. In Adeniji, K.O., and Kategeli, J.A. Proceedings of the Workshop on the Improvement of Small Ruminants in eastern and southern Africa. 18–22 August 1986. Nairobi Kenya. pp.91–110.

Gatenby, R.M. 2002. Sheep. The tropical Agriculturalist Series. McMillan publishers. pp.178.

Gipson, T. A., Merkel, R. C., Hart, S., Williams, K. and Sahlu, T. 2005. Meat Goat Production Handbook. American Institute for Goat Research, Langston University, USA.

Nelson, R.H. 1979. An Introduction to the Feeding of Farm Livestock. 2nd ed. Pergamon press. pp 156.

Peacock C. 1996. Improving Goat Production in the Tropics. A manual for development workers. OXFAM (UK and Ireland) and FARM_Africa, United Kingdom.

Roger C. Merkel and Subandriyo. 1997. Sheep and Goat Production Handbook for Southeast Asia. viii +214 pp.

Steel, M. 1996. Goats. The Tropical Agriculturalist Series. McMillan publishers, UK. Pp.152.