NUTRITIONAL CONSTRAINTS AND FUTURE PROSPECTS FOR GOAT PRODUCTION IN EAST AFRICA

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Abstract

Goats are primarily owned by smallholder farmers and pastoralists and contribute significantly to the economy and food supply of the poorest sectors of the society. However, goat production in East Africa is characterized by low productivity levels due mainly to nutritional constraints. Grazing and browsing on natural pastures is the main source of feed in the arid and semi-arid pastoral areas, while crop residues could contribute up to 50% of the total feed supply in areas where mixed crop-livestock production is the dominant farming system. The quantity and quality of fodder available from natural pasture shows seasonal fluctuation. There is an acute shortage of feed supply during the dry season and the available feed during this period is of very poor quality. Poor nutrition results in low production and reproductive performance, slow growth rate, loss of body condition and increased susceptibility to diseases and parasites. Thus, effective utilization of the available feed resources (agricultural and agro-industrial byproducts, natural pastures and browse) and appropriate supplementation of poor quality natural pasture and crop residue based diets appear to be the necessary steps to alleviate the nutritional problems of goats in the region. Different supplementation strategies could be applied depending upon the type, accessibility and price of supplementary feeds in a given area. Fodder conservation practices, particularly hay making, should be developed in order to enable a stable supply of feed throughout the year. Evaluation of the nutritive value of naturally occurring tree leaves and pods, which are commonly used as dry season feed resources, would be important to enhance their proper utilization.

1. Introduction

The majority (95%) of the world's goat population is found in developing countries. Of the total world population of 674.1 million goats, approximately 26.2% are found in Africa. East Africa contains 38.9 and 10.2% of the African and world goat population, respectively (Table 1). Goats are primarily owned by smallholder farmers and pastoralists and contribute significantly to the economy and food supply of the poorest sectors of the society. According to Okello et al. (1996), goats provide about 23% of the total red meat produced in Uganda and goat meat is preferred to beef in terms of palatability and delicacy. Besides of their significant contributions to the economy and food supply of resource poor farmers, their specific biological features such as feeding behaviour, reproductive efficiency and small body size are important characteristics for integrating goats into pastoral and sedentary smallholder production systems.

Table 1. Goat population and production of goat meat and milk in East Africa

Country / Region	Goat population (x 1000)	Meat production (1000 MT)	Milk production (1000 MT)
Djibouti	507	2	-
Eritrea	1,400	5	7

Ethiopia	16,700	62	93
Kenya	7,400	29	93
Somalia	12,500	36	14
Sudan	16,900	39	415
Tanzania	9,682	24	645
Uganda	3,500	15	-
East Africa	68,589	212	1,267
Africa	176,401	670	2,078
World	674,139	3,562	10,144
Share of East Africa			
% of Africa	38.9	31.6	61.0
% of World	10.2	6.0	12.5

Source: FAO, 1997

Goat production in East Africa is characterized by low productivity levels in terms of growth rate, meat production and reproductive performance. Goat meat production in east Africa is only 31.6 and 6% of the goat meat produced in Africa and in the World, respectively (Table 1). Many factors contribute to such low productivity levels. However, poor nutrition is the most important factor. This paper deals with the nutritional constraints and the possible mechanisms of alleviating the constraints.

2. Nutritional Constraints

Nutritional constraints to improved goat production include inadequate feed supply, low feeding value of the available feed resources and reduced efficiency of utilization of the available feed resources. Grazing and browsing on natural pastures and poor quality crop residues are the main sources of feed in most parts of the region. Due to seasonality of rainfall distribution, there is a marked seasonal variation in the quantity and quality of feed supply. There is an acute shortage of feed supply during the dry season and the available feeds during this period are of very poor quality (low in protein and high in fiber content), which results in low digestibility and low voluntary intake by animals. Seasonal shortage of forage on small farms in western Kenya is considered to be a constraint for goat production due to small farm size and overstocking of livestock (Onim et al., 1992; Oteino et al., 1992). In a Participatory Rural Appraisal, low DM intake from grazed forages during the rainy season and uncertain availability and high cost of oil seed cakes were identified to be the main nutritional constraints for dairy goat production in the Uluguru mountains in Tanzania (Ingratubun et al., 2000). The problem is aggravated by a lack of alternative feeds during the critical period. Poor nutrition results in low production and reproductive performance and slow growth rate in growing animals. Undernourished animals are susceptible to diseases and parasites and in extreme cases animals lose body condition and could eventually die.

In the highland and mid-altitude mixed farming areas, the land available for natural grazing and browsing is rapidly decreasing due to the increasing human population and increasing demand for cropping land (Said and Tolera, 1991; Oteino et al., 1992). However, stubble grazing and crop residues could be used as important sources of feed in these situations. For example, in many places of the Ethiopian highlands, cereal crop residues (straws and stovers) are collected and stored by stacking and are fed to animals during the dry season when both the quantity and quality of available fodder from the natural pastures declines drastically. However, effective utilization of crop residues as animal feed is also limited by their seasonal supply and poor

nutritive value (low nutrient content, poor digestibility and low voluntary intake by animals).

Deficiencies of protein and energy are the main nutritional factors limiting productivity of goats in the region. An active microbial population in the rumen is essential to digest and extract the nutrients contained in fibrous feedstuffs. However, when the protein content of the pasture falls below 6-7% during the dry season, ruminal microbial growth (i.e., reproduction) and digestion are limited. This directly restricts protein and energy absorbed by the animal. Furthermore, conditions associated with an insufficient nitrogen supply for ruminal microbes, such as low microbial protein synthesis and intestinal amino acid absorption can limit forage intake, further impairing animal performance (i.e., growth, capacity for maintaining live weight and reproduction). Supplying additional protein during the dry season will increase the microbial growth and rate of fiber digestion often with increased forage intake, thereby improving nutrient absorption for enhanced animal productivity. Indeed before making other supplementation considerations, in most instances, it is most practical and economical to first correct nitrogen deficiencies for ruminal microbes for increased supplies of energy-yielding substrates and amino acids available for use by the host animal. However, in addition to amino acids absorbed in the small intestine of microbial origin, some proteins of feedstuffs are not degraded in the rumen and reach the intestine intact. Furthermore, feedstuffs vary considerably in the proportion of protein not degraded by ruminal microbes, often termed as "bypass" or "escape" protein. For some animals with high production potential, performance can in some instances be elevated beyond that achieved by correcting a ruminal nitrogen deficiency by adding a feedstuff high in escape protein to further increase amino acid absorption and availability to the animal. However, it is important to note that both energy and amino acids are required for protein synthesis by growing animals. Thus, use of high dietary levels of escape protein may necessitate an increase in energy absorption greater than achieved by only correcting the ruminal nitrogen deficiency.

3. Feeding Strategies to Alleviate Nutritional Constraints and Enhance Productivity

3.1 Provision of Supplementary Feed

Because of their inherent nutrient deficiencies, poor quality pastures and cereal crop residues, the main feed resources in East Africa, cannot sustain effective animal production or even maintenance when fed alone, particularly during the dry season. Thus, provision of appropriate supplementary feedstuffs would be an important step to enhance the productivity of goats under smallholder and pastoral production systems of East Africa. Various studies conducted so far on small ruminants have indicated that it is possible to enhance productivity or at least avoid body weight loss during the critical feed shortage periods of the year by supplementing poor quality pastures and crop residues with small quantities of high quality supplements. For instance, Okello et al. (1996) reported that goats fed on unsupplemented elephant grass lost body weight whereas supplementation with cottonseed cake, maize bran or banana peels increased body weight gain (Table 2).

3.1.1 Concentrate Supplementation

Supplementary concentrates such as oil seed cakes, cereals and cereal byproducts provide readily fermentable carbohydrates, nitrogen and other essential nutrients. Besides supplying the deficient nutrients to affect the quantities of nutrients absorbed, it is also possible that some effects of supplemental feedstuffs are due to changes in the array of nutrients available to host tissues, which impact efficiency of nutrient absorption. In the middle Rift Valley area of Ethiopia, Ebro et al. (1998) reported that supplementation of grazing goats with concentrate and(or) lablab hay

resulted in a 23.6% increase in live weight gain compared with unsupplemented goats and that there was no significant difference between concentrate and lablab hay supplements in live weight gain. A study conducted on the effects of various supplements (i.e., cotton seed cake, maize bran, banana peels and leucaena leaves) on weight gain and carcass characteristics of male Mubende goats fed elephant grass *ad libitum* in Uganda (Okello et al., 1996) showed that the goats supplemented with cotton seed cake had the highest growth rate, which was attributed to a higher protein and energy supply from the cottonseed cake. Moreover, supplementation with cottonseed cake and maize bran improved body condition scores and carcass weight compared with the other diets (Table 2).

Tessema and Emojong (1984) reported that the body weight gains of sheep and goats grazing pasture in a dryland region of Kenya were increased when urea, molasses and minerals were added to supplemental maize stover. A study conducted in Lesotho (Ng'ambi and Kekena-Monare, 1996) showed that spraying molasses on wheat straw increased voluntary intake of straw by 37% without affecting digestibility. Based on the results, spraying palatable molasses on unpalatable or poorly palatable straw was recommended as a practical method of improving the feeding value of poor quality roughages.

Table 2. Dry matter (DM) intake, body weight (BW) change, body condition score and carcass characteristics of male intact Mubende goats fed elephant grass (*Pennisetum purpureum*) with or without supplements of *Leucaena leucocephala* leaves, maize bran, banana peels and cottonseed cake (Okello et al., 1996)

Parameters	Elephant grass (E) (Control)	Elephant grass + Leucaena leaves	Elephant grass + Maize bran	Elephant grass + Banana peels	Elephant grass + Cotton seed cake
DM intake (g/d)					
Elephant grass	404	335	311	356	336
Supplement		119	222	127	175
Total	404	454	533	483	511
BW gain (kg)	-0.6	-0.7	1.2	2.2	5.6
Body condition score	1.3	1.0	1.5	1.3	2.5
Empty BW (kg)	10.4	11.6	14.3	11.5	16.8
Dressed carcass wt (kg)	5.6	6.6	8.4	6.1	9.5
Dressing percentage	53.5	56.7	58.5	53.0	57.0

However, concentrates are expensive and not readily available in most developing countries. In some East African countries there is a shortage of cereal grains even for human consumption. Agro-industrial byproducts (oil seed cakes and byproducts from cereal processing plants) are in short supply and the availability is limited mainly to the vicinity of the urban centers where the processing plants are located and may not be easily accessible to smallholder farmers, who are scattered in the countryside. The existing poor road network and inadequate transportation facilities exacerbate the problem of distribution of concentrate feeds in the countryside. In general, supplementation with conventional sources of protein and energy is expensive and could usually put ruminant production in direct competition with human beings and monogastric farm animals. According to Anderson (1987) Ethiopia has only limited supplies of oil seed cakes and molasses, which even when efficiently used, cannot boost production for more than a small proportion of the ruminant livestock in the country. Moreover, most smallholder farmers scattered

in the rural areas may not have the necessary economic incentives to use concentrate feeds to increase animal productivity. Thus, critical economic feasibility studies may be worthwhile in goat producing areas where agro-industrial byproducts such as oil seed cakes and molasses are available within the vicinity of the goat farms.

3.1.2 Supplementation with Forage Legumes

Supplementation with forage legumes may include supplementation with herbaceous and shrubby or tree legumes. Forage legumes can enhance the utilization of poor quality roughages in smallholder mixed farming systems. They are rich in protein (both fermentable and bypass protein depending upon the level of tannins) and other nutrients such as minerals and vitamins. In systems with minimal fertilizer inputs, forage legumes have the added advantage of improving soil fertility by fixing nitrogen and thereby enhancing crop yield and reducing the rate of soil fertility decline. Reynolds (1989) reported results from a study in which four levels (200, 400, 800 and 1200 g) of a 1:1 (w/w) mixture of *Leucaena leucocephala* and *Gliricidia sepium* supplemented pregnant and lactating Dwarf West African goats fed a basal diet of chopped *Panicum maximum* plus 50 g of sun-dried cassava peels. Kids were also supplemented after weaning with a reduced level of the browse mixture proportional to their size. At 16-20 wk of age they were given 16 g of cassava peels and 62.5, 125, 250 and 375 g of the browse mixture, whereas the amount of cassava peels increased to 20 g/day and the browse mixture increased to 75, 150, 300 and 450 g at 20-24 wk of age. Browse intake of dams and kids and survival and growth rate of the kids increased with increasing level of supplementation (Table 3). Moreover, productivity (weight of kid weaned/doe/year) increased by 0.64 kg for each 100 g of browse consumed by the does (Reynolds, 1989).

Table 3. The effects of leucaena and gliricidia browse supplementation on growth and survival rates of West African Dwarf goats (ILCA, 1988; Reynolds, 1989)

Treatment groups*	Browse intake (g DM/d)		Growth rate (g/d)		Survival rate to 24 wk
	Dam	Kids	Birth-16 wk	16-24 wk	
1	143	39	17.4	14.0	0.36
2	254	83	28.7	20.1	0.46
3	554	160	25.9	20.9	0.82
4	719	246	31.9	28.3	0.94

Table 4 shows that supplementation of goats fed a basal diet of Napier grass with sun wilted tree foliage stimulated growth rate. Additional benefits have occurred when protected soybean meal was supplemented. Wilting or drying improves the feeding value of the foliage from fodder trees. This may be due to increase supplemental protein reaching the intestine intact because of decreased solubility in ruminal fluid or perhaps formation of initial Browning reaction products that are not degraded by ruminal microorganisms but are available in the intestines (Leng, 1997). In addition, a reduction in anti-nutritive factors may also have had impact.

Table 4. Effect of supplementary dry foliage and/or protected protein (formaldehyde treated soybean meal [SBM]) on growth rate of goats fed a basal Napier grass diet (van Eys et al., 1986, cited by Norton, 1994)

Napier grass intake (g/kg BW/d)	Supplement intake and type (g/kg BW/d)	Gain (g/d)
33.4	0	-1
29.4	4.2 (*Gliricidia sepium*)	20
29.1	4.2 (*Leucaena leucocephala*)	22
26.1	3.9 (*L. leucocephala*) + (2.7 g/kg SBM)	45
30.2	4.1 (*Sesbania grandiflora*)	20
33.6	3.8 (*S. grandiflora*) + (2.7 g/kg SBM)	52

A study conducted at Awassa College of Agriculture in southern Ethiopia (Tolera and Sundstøl, 2000) showed that supplementation of sheep fed a basal diet of maize stover with *Desmodium intortum* hay improved total dry matter, crude protein and metabolizable energy intakes, nitrogen retention and body weight gain of the animals (Table 5). The animals fed unsupplemented maize stover had inadequate intake of crude protein and metabolizable energy resulting in negative nitrogen balance and body weight loss. Thus, provision of sufficient amounts and the right combination of protein and energy appears to be a critical factor for enhancing productivity of goats. The use of fodder from both herbaceous and shrubby or tree legumes as a supplement of crop residues and poor quality pastures creates an opportunity to minimize body weight losses during the dry season and to enhance productivity. Integration of forage legume production into small-scale mixed farming systems could improve soil fertility, crop yields and herbage quality, making the system more productive and sustainable.

Table 5. Dry matter (DM), crude protein and metabolizable energy intake, nitrogen retention and body weight gain of sheep fed a basal diet of maize stover supplemented with graded levels of *Desmodium intortum* hay (Tolera and Sundstøl, 2000)

Variable	Level of supplementation (g/head/day)			
	0	150	300	450
DM intake (g/kg $W^{0.75}$/day)				
Maize stover	43.2	38.5	33.6	22.9
Total diet	43.2	53.8	63.1	66.3
Crude protein intake (g/head/day)	12.1	29.8	47.2	62.4
Nitrogen retention (g/day)	-2.2	0.1	1.7	4.4
Metabolizable energy intake (MJ/day)	1.9	3.9	5.3	6.4
Body weight change (g/day)	-32	9	34	44

To make supplementation adaptable by smallholders the production of forage legumes should be integrated into the existing production system without markedly increasing competition for land and other resources. The following are different mechanisms of achieving this goal.

a) Use of legumes in crop mixtures: Intercropping of forage legumes with cereals tends to increase the crude protein level of the total fodder available after grain harvest of the primary crop. This usually involves undersowing of a cereal crop with legumes after the cereal crop is fully established to avoid competition.

b) Fodder banks: Fodder banks are concentrated units of legumes established by pastoralists adjacent to their homesteads to serve as supplements to dry season grazing.

c) Use of forage legumes in crop rotation: The association of forage legumes in crop rotation has the added advantage of improving the nitrogen status of the soil, thereby benefiting crop production as well.

d) Incorporation of adaptable, productive and nutritious forage tree legumes in the farming system: Forage tree legumes could be established in the form of alley farming, as hedge rows or as a fence line around the homestead and along the borders of cropland or as a fodder bank. The leaves of trees can be used as high quality supplements to crop residues and poor quality grass. The level of incorporation may range from 20-75% depending upon the nutritive value of the basal roughage diet and the supplement and the desired level of animal productivity.

e) Incorporation of trees that have both food and feed value into the farming system. Pigeon pea is an example of a leguminous tree that could serve both as a source of human food (the pods) and as animal feed (the leaves).

However, the extent to which farmers adopt production of high quality perennial forages and fodder trees depends on security of land tenure and on availability of labor and planting materials at the right time. Moreover, the willingness and commitment of smallholder farmers to invest in supplementary feed or forage improvement measures depends upon availability of market outlets and favorable price margins for livestock and livestock products, in this case goats.

3.1.3 Legume Straw Supplementation

Legume crop residues (cowpeas, peas, peanuts etc.) are relatively high in protein (about 10% or more) and, thus, they can serve as supplements of low quality roughages such as poor quality pastures and cereal crop residues. Macala et al. (1996) studied the effect of supplementing three (0, 300 and 600 g/day) levels of peanut hay on the performance of lactating Tswana does grazing natural pastures during the dry season and on the growth rate of their kids (Table 6). Supplementation of does with peanut hay resulted in higher daily gain and milk production compared with unsupplemented does. The amount of milk produced increased with increasing amounts of peanut hay supplemented. Moreover, kids that were supplemented with peanut hay had higher daily weight gain and final weight at weaning.

3.1.4 Other Feedstuffs Used as Supplements

There is a variety of agricultural and agro-industrial byproducts that could be used as supplementary feedstuffs depending upon the production system of a given area. Brewery byproducts and household wastes constitute important sources of supplementary feed. This is particularly important for farmers residing in the proximity of commercial breweries or for landless farmers maintaining a small number of dairy or dual-purpose goats. In addition to commercial breweries, small scale home brewing is also practiced in most localities and villages. There is a tradition of feeding the byproducts from home brewed beverages to lactating animals in different parts of Ethiopia in order to increase milk production. Reject fruit and vegetables could also be an important source of feed for goats in areas where horticultural crops are grown and marketed. Dropped coffee leaves could be a minor source of feed, whereas coffee pulp and hulls represent a relatively underutilized feed resource in coffee growing areas.

Other agricultural byproducts such as sweet potato vines, cassava leaves, banana leaves and peels, sugar cane leaves and enset (*Ensete ventricosum*) leaves could also serve as important sources of supplementary feed during the dry season. Sweet potato is traditionally grown to provide tubers

for human consumption and the vines can be used as useful supplementary feed for goats in areas where the crop is grown. Sweet potato vines have a high nutritive value, with a crude protein content of over 20% and a digestibility of about 70% (Oteino et al., 1992). Because of very high water content (86%), sweet potato vine is more appropriate for growing kids than for lactating does. Goats on sweet potato vines do not require additional free water. However, when the vine is offered to a lactating doe as a sole diet it can only support sub optimal levels of production because of DM intake limitations. Enset leaves and byproducts play a significant role in supplementing the diet of farm animals, especially in drought years, in the enset growing areas of southern Ethiopia.

Table 6. Performance of lactating Tswana goats supplemented with different levels of peanut hay and growth rate of kids suckling these does (Macala et al., 1996).

Variables	Level of supplement (g)		
	0	300	600
Does			
Initial weight (kg)	37.0±2.0	37.7±2.0	36.9±2.0
Final weight (kg)	30.3±2.4	37.4±2.4	40.7±2.4
Weight change (kg)	-6.7±1.02	-0.3±1.02	3.8±1.02
Daily weight gain (g)	-72.8±0.01	-3.3±0.1	41.3±0.01
Milk yield (kg/day)	1.15±0.11	1.71±0.1	2.16±0.1
Kids			
Initial weight (kg)	7.0±0.93	6.0±0.77	6.0±0.87
Final weight (kg)	11.6±0.76	14.6±0.64	17.5±0.71
Weight change (kg)	4.6±0.55	8.6±0.46	11.5±0.51
Daily gain (g)	50±11	93.5±0.01	125.0±0.01

3.1.5 Molasses-Urea Supplementation

Dry mature pasture or cereal crop residues given alone are unbalanced in nutrients and do not create the environment for efficient rumen function and thus do not ensure an efficient utilization of absorbed nutrients. Feed intake and the nutrients absorbed from such diets are insufficient to even meet the maintenance requirements of the animals and thus animals are prone to lose weight if they do not receive additional nitrogen and mineral supplements. Thus, supplementation with fermentable nitrogen, energy and minerals enhances rumen microbial growth and voluntary feed intake of animals fed low quality roughages. Molasses-urea blocks added to such an unbalanced diet ensure animal's maintenance requirements because they enhance efficient ruminal fermentation. Anindo et al. (1998) showed that supplementation of molasses-urea blocks improved the daily feed intake, body weight gain and body condition score of grazing sheep in Ethiopian highlands. The addition of bypass protein (e.g., cottonseed meal, noug cake) results in a synergistic effect that could considerably improve the average daily gain of ruminants, and they become much more efficient in using the available nutrients. Moreover, molasses could serve as a carrier for urea and mineral supplements.

3.1.6 Mineral Supplementation

Mineral deficiencies could result in depression of animal performance. According to Kabaija and Little (1988) sub clinical mineral deficiencies are widespread and responsible for yet unestimated, but probably great, economic losses in livestock production. However, mineral status of grazing

animals in most African countries has received very little attention. In general, most forages and crop residues used as livestock feed in the Rift Valley areas of Ethiopia are deficient or marginal in sodium, phosphorus and copper (Kabaija and Little, 1988; Tolera and Said, 1994; Abebe et al., 2000). Thus supplementation regimes involving these elements are likely to produce beneficial results. A typical example would be supplementation with multi-nutrient blocks. In some parts of southern Ethiopia, local mineral soils such as *Bole* and *Megadua* may supply adequate or even excess amounts of most of the essential minerals except phosphorus (Tolera and Said, 1994).

3.1.7 Use of Poultry Litter as Supplementary Feed

Poultry litter is a significant byproduct of poultry production, which is a mixture of poultry excreta, bedding material, feathers, spilled feed, etc. Poultry litter is high in crude protein, ranging from 15 to 35% of dry matter. Thus, poultry litter can serve as a source of nitrogen in ruminant diets and the potentially digestible nitrogenous compounds in the litter are very soluble and are rapidly degraded to ammonia in the rumen. Moreover, poultry litter is characterized by a high ash content and could be an excellent source of essential minerals such as calcium, phosphorus, potassium, magnesium, sulfur and copper, thereby lessening the need for mineral supplementation (Goetsch and Aiken, 2000). Thus, poultry litter could play a significant role replacing protein concentrates in goat feeding in areas where large- scale poultry production is practiced.

3.2 Strategic Use of Supplements

Feed supplements such as concentrates, forage legumes and mineral supplements are generally less abundant and more expensive than the basal roughage diets. Thus, strategic and efficient use of small amounts of high quality supplements would be vital to balance nutrient deficiencies, improve rumen function and enhance the efficiency of feed utilization from low quality roughages. This could be achieved by identifying and providing critical nutrients that are deficient in the basal diet. The first priority would be to supply rumen microbes with rumen degradable sources of nitrogen and other essential nutrients to enhance fermentative digestion in the rumen. The efficiency of utilization of absorbed nutrients and animal performance could be further enhanced by adding small amounts of bypass protein (Preston and Leng, 1987).

Preferential supplementation of the physiologically most vulnerable groups of animals with the available high quality supplements would be another strategy to increase the efficiency of utilization of limited resources. For instance, priority could be given to lactating does or to pregnant animals during the last one-third of the pregnancy period. In this way it could be possible to minimize losses and increase overall productivity.

4. Fodder Conservation

The benefits of improved fodder production cannot be fully realized unless there is some form of fodder conservation for the dry season. Thus, it is important to have a suitable fodder conservation method for smallholder farmers. Any surplus forage should be conserved as hay, which could be used during the dry season when both feed supply is scarce and feed quality is poor. Grasses and legumes for making hay should be cut and left to dry in the field for two to three days. Then the dried hay should be safely stored under a shade either after baling or in a loose form. Fodder conservation can enable a stable supply of feed throughout the year.

5. Effective Utilization of Crop Residues

5.1 Generous Feeding to Allow Selective Consumption

In smallholder mixed farming systems, crop residues play an important role as livestock feed. This is a situation that is likely to increase as more grazing land is put under cultivation due to the rapidly increasing population pressure. However, cereal crop residues are characterized by low nutrient content, high fiber content, low digestibility and low voluntary intake. The nutritive value of crop residues is influenced by stage of maturity at the time of harvest, plant morphological components (leaf:stem ratio) and variety of the crop. The varietal differences in the nutritive value of crop residues could be due to differences in the relative proportions of the botanical fractions in the whole straw/stover and due to differences between and within these fractions in their chemical composition, digestibility and acceptability by animals.

The smaller size of goats and sheep compared to cattle gives them an apparent disadvantage because maintenance energy requirement relative to live weight is higher for small ruminants compared with large ruminants, while intake capacity for roughage feeds is not. Under conditions of grazing/browsing, this size-linked disadvantage is alleviated by the ability of goats and sheep to select a more nutritious diet than their counterpart cattle. Goats are the most selective feeders of domestic ruminants. A study conducted on barley straw and sorghum stover showed that goats and sheep, when given the opportunity to select, are able to select the more nutritious leaf and leaf sheath components and against the less nutritious stem (Aboud et al., 1991, 1993; Owen, 1994). The same study showed that offering crop residues to goats and sheep at 50% refusal rate, instead of the conventional 10-20% rate, resulted in increased feed intake (both quantitatively and qualitatively) and body weight gain (Table 7).

Table 7. Effect of amount of chopped sorghum stover offered on DM intake and growth rate of goats in Ethiopia (Aboud et al., 1991)

Parameters	Amount of stover offered (g/kg BW/d)					
	Goats			Sheep		
	25	50	75	25	50	75
Number/treatment	7	7	7	8	8	7
Initial weight (kg)	15.4	16.3	16.3	14.7	16.3	16.5
Stover refused (g/kg offered)	152	427	571	51	318	526
Stover intake (g DM/kg BW/d)	19.9	26.3	29.1	22.1	31.1	32.5
Growth rate (g/d)	9.4	23.4	31.6	28.2	54.1	62.2

However, such a feeding strategy allowing goats to reject about 50% of the straw offered could be wasteful and the practice is justified only if the rejected straw could also be recycled through animals (fed to less selective mature and large ruminants) or used for some other purposes (e.g., as a source of fuel in the case of maize and sorghum stovers). The refusals can also be used for bedding and(or) incorporated in the soil, which could enhance the complementarity of crop and goat production. However, refused stovers, which would tend to be dominated by the stem fraction, would contain high C:N ratios and could be slow to decompose under field conditions. In the future, rejected straws and stovers (from generous feeding) might have a value for industrial processing into products such as paper products, hard boards, egg trays, etc.

5.2 Urea Treatment

Urea treatment consists of spraying a solution of urea onto a dry mass of straws and stovers and covering with locally available materials in order to form a hermetic seal. Urea treatment is a relatively simple method of chemical treatment of crop residues. If the ambient temperature is sufficiently warm, the urea hydrolyzes to gaseous ammonia and carbon dioxide in the presence of water and the enzyme urease. The optimum application rate of urea is between 4 and 6 kg of urea per 100 kg of straw on a dry matter basis. The ideal moisture content and ambient temperature for ureolysis lie between 30 and 50% and 30 and 40^0C, respectively. In a typical tropical climate, treatment can be completed in a 2-3 week period. However, a longer period might be required at higher altitudes (Chenost and Kayouli, 1997). Urea treatment improves the nitrogen content, digestibility and DM intake of the low quality roughages by ruminants. The technique has been successfully used in China and south east Asia with beneficial results. However, the degree to which animal performance could be improved by urea treatment is limited (Animut et al., 2000), primarily to that resulting from hemicellulose solubilization and accompanying increase in ruminal fiber digestion and(or) intake. Likewise, the efficiency of utilization of nitrogen added in the process may not be high without dietary addition of other feedstuffs because of the relatively high ratio of ruminally available nitrogen to ruminally fermentable organic matter. Moreover, availability and price of urea could be a limiting factor hindering adoption of the technique in many African countries.

5.3 Thinning and Leaf Stripping from Maize and Sorghum

The interactions between crop and livestock production systems are very strong in densely populated and intensively cultivated mixed farming areas. Thinning and leaf stripping from cereal crops such as maize and sorghum could serve as important sources of feed. Usually farmers use a high seeding rate as a safeguard against germination losses and the extra seedlings are eventually thinned out at weeding and are useful sources of feed, particularly for small ruminants. A survey conducted in Hararghe highlands of eastern Ethiopia (Abate and Yami, 2000) revealed that thinning of maize could provide as much as 67-89% of the diet of fattening oxen during the months of August-September, whereas thinning of sorghum provided about 44-55% of the diet during the months of October and November. A study conducted in western Kenya showed that between 350 and 1000 kg DM/ha can be generated from maize crop with a mean crude protein content and in vitro DM digestibility of 210 g/kg and 59%, respectively. Additional feed can be produced after the silking stage from those plants that will have aborted or failed to set seed (Oteino et al., 1992).

The study from western Kenya also showed that leaf stripping of maize could begin about 90 days after planting with the removal of one leaf per plant per week, starting with the bottom leaves. According to Oteino et al. (1992) four leaves, including the flag leaf and the leaves subtending the cob, should be left on each plant. If properly implemented this procedure can give about 800 kg DM/ha. With a crude protein content of 12.8% and in vitro DM digestibility of 64%, fresh maize leaves have higher nutritive value than grass hay (Oteino et al., 1992; Semenye et al., 1993). Abate and Yami (2000) also showed that leaf stripping from maize and sorghum plays a significant role in the diets of fattening oxen in the Hararghe highlands.

6. Proper Exploitation of Natural Browse

In many parts of east Africa, farmers and pastoralists traditionally lop branches of trees and use them as supplementary feed for their animals during the dry season. Tree foliage has been used as animal feed since the early days of human history and is being increasingly recognized as a potentially high quality feed resource for ruminants, particularly as a source of protein (Leng,

1997). The leaves and pods from naturally occurring trees (natural browses) are sources of good quality feed during the dry season when herbaceous forages are in short supply. Foliage from trees and shrubs appears to be the preferred forage for goats. In harsh and arid conditions, trees provide more edible biomass than pasture and the biomass remains green and high in protein when pastures dry off and senesce. Trees can tap water and nutrients deep in the soil profile because of their deep-rooted nature. The leaves and pods from fodder trees and shrubs usually have a higher crude protein and a lower fiber content than dry grass forages and cereal crop residues.

Thus, proper and strategic use of these feed resources as supplementary feed during the dry season can help to minimize seasonal fluctuation in productivity. Considering the increasing human population, shrinkage of pastureland and deceasing availability of land for forage production and, the cost and unreliable availability of oil seed cakes, tree foliages have immense potential as protein and energy supplements to improve productivity of goats and other ruminants during the dry season. However, the gradual decrease in the number of browse trees and shrubs and inadequate management systems to optimize utilization of the existing trees and shrubs appears to be a problem in this regard. Thus, efforts should be made to improve the availability of browse during the dry season by planting browse trees and maintaining the necessary balance of the species present by selective bush clearing and making browse available to the goats either by trimming or lopping leaves and branches and beating down fruits or pods.

7. Conclusion

Natural pastures and agricultural byproducts are the main feed resources for goat production in east Africa. Grazing and browsing on natural pastures is the main source of feed in the arid and semi-arid pastoral areas, whereas crop residues could contribute up to 50% of the total feed supply in areas where mixed crop-livestock production is the dominant mode of production. The quantity and quality of fodder available from natural pasture shows seasonal fluctuation. Thus, effective utilization of the available feed resources (crop residues, natural pastures and browse) and appropriate supplementation of poor quality natural pasture and crop residue based diets appear to be the necessary steps to alleviate the nutritional problems of goats in the region. Evaluation of the nutritive value of naturally occurring tree leaves and pods, which are commonly used as dry season feed resources, would be important to enhance their proper utilization.

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