FEED SELECTIVITY STUDIES IN SHEEP AND GOATS OFFERED MULTIPURPOSE TREES (MPT)

BY

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ABSTRACT

Four experiments were conducted to evaluate voluntary intake, nutritive value and selectivity of three browse species (*Albizia lebbek, Glyricidia sepium* and *Tamarindus indica*) offered in form of fresh branches to confined sheep and goats.

In experiment 1 voluntary intake of the browses offered as sole diet to the animals was studied. Experiment 2 examined voluntary intake of the browses offered with a basal ration of *Chloris gayana* hay. Preference ranking of the browse species was carried out in experiment 3. In experiment 4, DM degradability of botanical parts of browse species and basal ration (hay) were determined using fistulated sheep and goats.

Twelve mature Black Head Persian (BHP) sheep aged between 21 and 90 months with initial liveweights ranging from 24.4 to 33.2 kg and twelve Small East African goats aged between 31 to 86 months with initial liveweights of 24.8 to 30.2 kg were used. Eight animals (4 sheep and 4 goats) were randomly allocated to each browse type in experiments 1 and 2. In experiment 3, six sheep and six goats selected from animals used in experiments 1 and 2 were used for preference study.

In degradability study (experiment 4), three fistulated sheep and three fistulated goats fed a standard diet were used to determine DM degradability of individual browse parts and hay.

In experiment 1 total DMI of browses (Leaves and bark) in sheep were 46.50 , 79.40 and 48.43 g/kg$W^{0.75}$/ day, for *A. lebbek, G. sepium* and *T. indica* respectively . The respective values for goats were 39.68 , 56.79 and 48.66 g/kg$W^{0.75}$/ day. In experiment 1 sheep consumed more *A.lebbek* and *G.sepium* (bark and leaves) than goats ($P<0.05$) in terms of DMI (g/kg$W^{0.75}$ / day). There was no significant difference between sheep and goats for the DMI of *T.indica* ($P>0.05$).

In experiment 2 when *Chloris gayana* hay was offered in addition to browse species, DMI of *A. lebbek* in sheep increased to 66.06 whereas that of others declined to 64.64 (*G. sepium)* and 35.70 (*T. indica*) g/kg$W^{0.75}$ / day. In goats DMI of the browses also declined to 38.89 (*A. lebbek*), 56.25 (*G. sepium*) and 34.61 (*T. indica*) g/kg$W^{0.75}$ / day. However, total DMI (browse and hay) of sheep and goats observed in this experiment were higher($P <0.05$) than those of experiment 1 (sole browse).

In experiment 3 when all browse species and hay were offered together to individual animals goats consumed more *T.indica* and *G. sepium* (P <0.05) than sheep. The DMI (g /kg$W^{0.75}$/ day) of sheep for *A.lebbek* was higher than that of goats (P<0.05). However, total DMI (browses and hay) for sheep and goats were not significant (P>0.05).

Leaves of all browse species had significantly higher (P <0.05) contents of soluble (**a**=32.2-38.6 vs 18.4-30.7%) and potential (total) degradable matter (**a+b**=67.5-85.6 vs 62.9-79.6%) than barks and hay. Species comparisons showed significant difference in these parameters. It was concluded that *A. lebbek*, *G. sepium* and *T. indica* fed with low quality roughage could improve animal productivity through increased DM intake if mixed browses are offered simultaneously with hay. There is need for further studies on protein degradability and factors limiting browse intake and their effects on actual (growth rates, milk yield etc) animal performance.

DECLARATION

I, ISAAC RASHIDI SAGUTI KHAMA do hereby declare to the Senate of the Sokoine University of Agriculture that the work presented here is my own, and has not been submitted for a higher degree award in any other University.

Signature:..........................

Date: 16/8/1996

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DEDICATION

The thesis is dedicated to my parents; Mamtoi and Rashidi.

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GLOSSARY OF ABBREVIATIONS AND SYMBOLS

ADF	Acid detergent fibre
CELL	Cellulose
CF	Crude fibre
CP	Crude protein
deg.	degradability
DM	Dry matter
DMI	Dry matter intake
EE	Ether extract
g	gramme
h	hour
Ha	Hectare
HEM	Hemicellulose
IVOMD	Invitro Organic matter digestibility
Kg	Kilogramme(s)
LBW	Live body weight.
mm	Milimetre(s)
NDF	Neutral detergent fibre
NFE	Nitrogen free extract
°C	degrees centigrade(s)
μm	micro milimetre(s)
$W^{0.75}$	Metabolic body weight

1.0 INTRODUCTION

Majority of the 6.4 million goats and 4 million sheep in Tanzania are reared under extensive free range system in semi arid and arid areas of the country. These areas receive less than 762 mm. rainfall per annum and form about 67 percent of the Mainland area of Tanzania (Kyomo, 1977). The annual herbage yields of these grasslands ranges from as low as 1 tonne DM/ha.to about 10 tonnes DM/ha. This variation is largely due to the differences in the amount of precipitation received in the grasslands (Rukanda and Lwoga,1978). In addition to low herbage yields, the natural pastures are also characterized by seasonal fall in protein content and digestibility because of the high proportion of *Themeda* and *Hypperrhenia* grass species which grow and mature rapidly (Karue, 1974). The reduction in crude protein content of the natural pastures is more pronounced during the dry season when it may fall below 7 percent of DM (Devendra, 1986) thus limiting feed intake (Egan and Moir, 1965). Indigenous legumes could improve the CP content of the poor quality pasture through nitrogen fixation but these are low in the natural grasslands due to frequent burning and overgrazing.

Furthermore,the grazing land available to traditional grazers has been dwindling particularly in the north of the country due to the opening of large scale farms, ranches, forest and game reserves and expansion of subsistence cultivation into grazing areas due to expanding population (Peterson and Peterson, 1980). As a result, many areas are becoming overgrazed leading to deterioration of the rangelands and lowering of total pasture availability.

As the nutritional value of the existing natural pastures is high for a short period not exceeding four months (Mbwile and Madata, 1984), the majority of the animals are exposed to the long dry season (6 - 7 months) during which only low quality herbage is available. Provision of an alternative source of feed either as a supplement or a substitute to the poor quality pasture should improve their productivity.

Studies carried out to improve voluntary intake of low quality roughages and crop residues in sheep, goats and other domestic animals during the dry season have shown encouraging results (Kitalyi, 1982; Urio, 1981). Unfortunately, the methods used in these studies could not be successfully applied by farmers because they are expensive and inapplicable under extensive range conditions.

However, some pleriminary studies have shown that a leguminous tree, *Leucaena leucocephala* can be a very cheap source of protein supplements for ruminants especially during the dry season (Jones, 1979; Kimambo *et al.*, 1989; Mtenga and Shoo, 1990). In Tanzania Utilization of *L. leucocephala* is limited by psyllid infestation and therefore other tree legumes have to be considered as alternative source of protein supplements.

Komwihangilo (1991) carried out a cafeteria feeding experiment to observe diet selectivity by sheep and goats ffered fresh leguminous forages(*Albizia lebbek, Gliricidia sepium, Leucaena leucocephala* and *Tamarindus indica)*. These forages are commonly found in Morogoro and other areas of the country. They are well known for their good nutrient content and are less subjected to seasonal variation (Mabey and Rose Innes, 1964) and hence could be another sources of protein supplements. Sheep and goats reacted differently both in terms of time spent eating and dry matter intake per day towards the four forages under stall feeding. This observation was in agreement with studies by other authors under range conditions (Lu, 1988).

Komwihangilo (1991) used only a small number of animals which were exposed to the fodder under the study for a very short period (about 11 days). This may have not given reliable results. All forages were offered as supplements to *Chloris gayana* (Rhodes grass) hay and their complimentary effect on total voluntary intake was not considered. Digestibility and degradability of the whole diet and the relationship between the prefered species and overal voluntary intake and performance were not assessed. This study therefore aims at assessing the nutritive value, voluntary intake and selectivity of *A. lebbek, G. sepium* and *T. indica* when offered to stall-fed sheep and goats.

2.0 LITERATURE REVIEW

In Tanzania productivity of sheep and goats is low because the grazing rangelands have pastures of low nutritive value which do not meet the animals' year round nutritional requirements. This inadequacy in nutritive value is mostly observed during the dry season when energy and crude protein contents of the pasture is low. Animals grazing on such pastures obtain low energy and crude protein contents and hence reduce feed intake. The low energy and crude protein contents together with the reduced feed intake of the pastures cause lowered animal productivity (Egan and Moir, 1965).

The lowered animal productivity could be improved by providing supplementary nitrogen which is known to increase cellulose digestibility of the low quality roughage (Campling *et al.*,1962; Elliot and Topps, 1964). In Tanzania and elsewhere, a number of methods have been tried by several workers to improve the nutritional status of ruminant animals during the dry season. The methods include supplementation of cereal crop residues with nitrogenous feeds (O'Donovan, 1983), use of agro-industrial by products such as oil seed cakes (Van Soest,1982; Kitalyi,1982) and chemical treatments of low quality feeds (Urio, 1981)

These methods appeared to be expensive and inapplicable under range conditions. However, in Tanzania there is a wide variety of tree legumes which could be used to supplement the low quality roughages during the dry season. Tree legumes such as *Leucaena leucocephala*, *A. lebbek*, *G. sepium* and *T. indica* have been shown to be possible candidates (Mtenga and Shoo,1988; Kimambo *et al.*,1989; Komwihangilo,1991). These legumes were found to be nutritious and could improve animal performance. Herdsmen can manage to use such trees at relatively less cost, compared to other proposed methods.

2.1 Feeding habits and diet selection in sheep and goats

The animal's ability to choose one or more plant species or plant parts is termed selectivity and is determined by the plant, animal and environmental factors (Malechek and Balph, 1987)

Most studies on diet selection of sheep and goats have been carried out under grazing conditions compared to stall feeding conditions. In these studies it has been found that feeding behaviour and diet selection under range and confinement conditions may not be the same as grazing animals have greater chance of making selection among various forage species than confined animals.

In addition, under intensive stall feeding systems, man controls most of the factors influencing the ingestive behaviour of the animal (Arnold, 1981). However,confined animals also eat selectively when feed availability is not limited (Zemmelink,1980). Factors such as feed availability, seasonal variation, stocking rate, environmental stress, frequency of offer and quantity offered will invariably affect the degree of selectivity in ruminants under grazing and confinement conditions (Lu,1988).

Komwihangilo (1991) noted that when confined sheep and goats were offered four leguminous forages they reacted quite differently towards them both in terms of time spent eating and on average dry matter intake over a specified period of time. More studies under stall feeding are however needed to explore the feeding pattern of sheep and goats. Such studies would help to formulate strategies for exploiting the natural feeding habits which have already been shown to promote the quality of the materials consumed.

2.2 Forage and animal factors affecting voluntary feed intake of sheep and goats

The quantity of forage eaten by an animal is determined by the availability, physical and chemical composition of the forage and nutrient requirements of the animal. Detailed discussion on this aspect has been presented by Forbes (1986). Van Soest (1982) gave a model describing the nutritional limits and the interactions between feed and animal factors determining the foraging patterns of grazing herbivores. This section will highlight only the salient factors -confining the review on aspects of feed properties that are likely to influence feed selectivity.

2.2.1 Forage factors affecting voluntary feed intake

2.2.1.1 Physical factors

Physical processing of the forage such as grinding or pelleting have been reported to increase its voluntary intake (Schneider and Flatt, 1975). The processed forage passes through the rumen at a faster rate thus permitting more forage to be consumed (Laredo and Minson,1975a).

Physical differences between forage species and forage parts are known to influence intake . The intake of leguminous forages have been observed to be higher than that of grasses of similar digestibility (Crampton,1957). Studies with separated leaf and stem fractions in grasses and legumes have shown that leaves are eaten in greater quantities than stems (Minson,1982). The higher intake of the leaves compared to stems has been found with the sheep fed tropical and temperate grasses (Laredo and Minson, 1975b) and tropical legume (Hendrickson *et al.*, 1981). The higher intake of the leaf fraction was found to be associated with the shorter time the leaf fraction was retained in the rumen compared with the stem fraction.

The relationship between the forage intake and its digestibility is well documented. The rate of dissappearance of the digesta from the reticulorumen depends primarily on its rate of digestion. This implies that the more digestible the food is, the faster it is removed from the rumen. More digestible oat hay has been shown to be consumed in larger quantities than a similar hay of lower digestibility (McDonald *et al.*, 1988). However, voluntary intake may not increase with increasing digestibility as other factors such as energy concentration of the diet may limit intake (Donefer et al., 1963).

2.2.1.2 Chemical factors

Chemical composition of forages are known to influence intake by animals. Water and fibre content of the forage limit intake of nutrients through dietary bulkness and consequent distension of the digestive tract. It is reported that as forages mature there is usually an increase in the proportion of fibre and a reduction in the protein and non-structural carbohydrates of the cell contents. These changes cause intake and digestibility of the forage to be reduced (Van Soest, 1965). Because ofthe low energy density and inadequate protein content, an animal may fail to meet its maintenance requirements (Semenye *et al.*,1986). It is therefore suggested that in order to meet the nutritional requirements of sheep and goats during dry season when both energy and protein are limiting factors in tropical pastures,cheaply available sources of these nutrients such as Multipurpose trees have to be used.

It is reported that when the crude protein content of the forage falls below 6 - 8 percent, pasture intake is depressed (Minson and Milford, 1967). In the dry season, mature forages and crop residues are usually low in crude protein content. Supplementation of these poor quality forages with crude protein or urea has often resulted in improved intake (Minson and Milford,1967). In a study to observe the effect of protein supplementation of low quality hay on the Africanda and Mashona heifers, Elliott (1967) noted an increase in voluntary intake of hay due to protein supplementation. Similar observations have been reported in another study with West African Dwarf sheep given hay supplemented with different levels of protein. However, when the protein supplements were given *ad libitum* to the animals hay intake declined (Adeneye and Oyenuga, 1976b; Minson and Milford, 1967). Mineral defficiences usually cause lowered production and defficient symptoms in animals. The mineral contents of tropical pasture become low during the dry season due to mature age. Mineral supplementation may therefore enhance voluntary intake of the tropical pastures as minerals are reported to stimulate appetite of animals (Underwood, 1977). Minson (1976) reported an increased forage intake by feeding supplementary nitrogen, phosphorus, sodium, sulphur,selenium and cobalt.

Toxic elements, organic or inorganic can also affect voluntary feed intake. The main effects to the animals are ill-health, loss of appetite and sometimes death. Phytochemicals such as tannins form complexes with rumen microbes and enzymes and results into reduced digestibility of the forage (Akin and Rigsby, 1985 cited by Shayo, 1992).

2.2.2 Animal factors affecting voluntary feed intake

2.2.2.1 Genotype

The ingestive capacity of the animal depends on the species, sex, physiological state of the animal such as growth, pregnancy and lactation, and environmental factors such as temperature and disease. It is generally reported that the larger an animal the greater will be the voluntary intake of food. Blaxter *et al* (1966) reported a higher DM intake by steers compared to sheep when they offered oat straw and dried grass and expressed intake in metabolic body weight. The differences in intake between these species appear to be related to the longer mean retention time of the feed material in the rumen and to the higher DM digestibility found in cattle than sheep (Poppi *et al.*, 1981a). The genotype interactions with environmental factors such as temperature and diseases affect voluntary feed consumption of animals. Johnson *et al* (1958) demonstrated the effect of genotype and heat load interactions between Brahman and Shorthorn cattle allowed to grow at 8°C and 27°C respectively. The authors noticed a difference in the voluntary feed consumption per unit body weight of the two breeds. Stresses associated with heat and parasites have been found to depress feed consumption more in *Bos taurus* than *Bos indicus* cattle (Frisch and Vercoe, 1978).

2.2.2.2 Physiological state

Physiological factors such as age, pregnancy, lactation and disease are other animal factors known to affect voluntary consumption of feeds.

The voluntary feed intake has been observed to increase during lactation and in young animals during fast growth phase (Langlands, 1968; Baumgart, 1970). This is brought about by the higher basal metabolism and maintenance energy requirements at these physiological states. A decreased voluntary feed intake has also been observed to occur in late pregnancy (Forbes, 1971) and during disease state (Seebeck *et al.*, 1971).

2.3 Environmental factors affecting voluntary feed intake

High ambient temperatures have been shown to depress voluntary feed intake by as much as 50 percent for sheep having access to feed for only part of the day (Bhattachrya and Hussain, 1974). High humidity, a factor often compounded with high ambient temperatures has been associated with low feed consumption (Johnson *et al.*, 1963). Cattle maintained above 27°C were observed to consume less feed at 70 percent than at 40 percent of relative humidity. When the temperature is below 27°C differences in feed consumption brought about by humidity is reduced.

2.4 Improvement of low quality roughage using proteineous forages

2.4.1 Use of legume forage and grass mixture

The utilization of good quality protein such as groundnut cake and soybean meals by sheep and goats is limited due to competition with monogastric animals, prohibitive price and limited supply. Good quality leguminous forages however can be used as a source of supplementary protein(Devendra, 1986).

In Tanzania, few studies on the practice of feeding grass together with leguminous forages have been conducted. A study carried out by Mero (1985) using mature Black Head Persian sheep to determine the nutritive values of *Chloris gayana* (at various stages of maturity) fed with various levels of mature *Macroptilium atropurpureum* (Var. siratro) has shown an improvement in dry matter intake of the hay by the sheep.

Rukanda and Lwoga (1978) reported a gain in liveweight by dairy heifers of about 0.32 kg/ per day when the animals were grazed on a plot of *Themeda* and *Hyparrhenia* natural grasslands in which *Macroptilium atropurpureum* (var. siratro) and *Stylosanthes guyanensis* (var. stylo) were oversown. The grazing of steers on *Stylosanthes guyanensis* oversown in *Hyparrhenia* grasslands in Uganda was reported to support a gain of 0.29 kg/ per day (Stobbs, 1969). Lack of seeds limits use of this technique country wide in Tanzania (Urio and Sarwatt, 1986).

2.4.2 Use of trees and shrubs

In Tanzania, the use of trees and shrubs for feeding livestock is practised mostly in few regions such as Kilimanjaro and Mbeya in the north and south of the country respectively. In these regions there is scarcity of grazing land as most of it is used for crop farming. Tree branches or their leaves are either offered to confined or grazing animals as sole or supplementary diets (Njombe,1986). In central part of the country, trees and shrubs have been found to be the main feed component in the dry season for animals grazing in the rangelands (Mero and Masaoa,1991), cited by Shayo (1992).

A review on the nutritive value of trees and shrubs of Africa have shown that they are richer in protein and minerals and are generally more digestible than tropical grasses especially during the dry season (Otsyna and Mckell,1985). Appropriate combinations of the trees and shrub leaves with low quality roughage or crop residues have been found to improve DM intake of animals (Adebowale,1992). Such combinations have been found to increase palatability and hence intake of metabolizable energy, nitrogen, minerals and vitamins and improve rumen function. Some of the trees and shrubs have also been found to improve crop production when used as components of alley farming as they can conserve and improve soil fertility (Sumberg,1984; Lulandala and Hall,1986). Le Houerou (1980b) described the nutritional value of trees and shrubs (browse)to be of the order 0.25 to 0.40 feed units (FU) per kg DM. This is believed to support the maintenance requirements of sheep and goats as less feed units are required for their maintenance (0.19-0.35 FU /kgDM per unit of body weight).

Recent exploratory studies on some trees and shrubs in Tanzania have indicated that *Acacia tortilis, Acacia albida, L. leucocephala, A. lebbek, G. sepium* and *T. indica* are nutritious and can improve animal performance (Shoo, 1986; Komwihangilo, 1991; Shayo, 1992). Lack of detailed information on these trees and shrubs is probably the reason for their limited utilization by farmers.

2.5 Agronomy and Nutritive value of *Albizia lebbek, Glyricidia sepium* and *Tamarindus indica*

2.5.1 *Albizia lebbek*

Albizia lebbek is a tree native to tropical Asia, Africa and Northern Australia (Prinsen, 1986). The tree grows in variety of climates and soils. An annual rainfall requirements of about 400 mm favours growth of the tree (Lowry, 1989). The tree can be raised from seedlings, stump planting or even direct sowing (Muthana *et al.*, 1976) . The tree is used extensively to provide shade in cocoa and coffee plantations (FAO, 1981). Total green and dry matter yield per year of the tree have been shown to be 8.54 and 5.54 tonnes per acre respectively (Oakes and Skov, 1962).

The main importance of *A. lebbek* for livestock production lies in the value of its leaves, pods and flowers as forage (Lowry, 1989). The leaves are browsed by sheep and goats and become important as feed towards the end of the dry season (Ralph, 1989). Studies on the nutritive value of *A. lebbek* has been mainly reported in terms of chemical composition (NAS, 1979; Le Houerou, 1980; FAO, 1981) with few digestibility studies of the leaves done in cattle and sheep (Bamualim *et al.*, 1980; FAO,1981; Lowry, 1989).

Table 2.1 gives information on the chemical composition of *A. lebbek* as reported by several authors. The tree contains good levels of CP and minerals. Ganguli *et al* (1964) cited by Skerman (1977) found CP values of up to 29% for leaves in the Tropics. CP contents ranging from 18% to 30% for the leaves have been observed in India and Pakistan (FAO,1981).

Table 2.1: Chemical composition of *Albizia lebbek*

Component	Country	As percent of dry matter								Reference
		DM	CP	CF	Ash	EE	NFE	Ca	P	
Leaves	India	39.6	18.1	26.5	8.0	4.7	42.7	2.02	0.14	3
	Pakistan	31.7	22.0	26.5	7.0	10.0	34.5	1.84	0.20	3
	West Africa	-	22.2	36.6	4.6	1.	34.8	-	-	2
	Tanzania	38.7	21.9	28.3	7.3	2.5	40.0	1.0	0.12	4
	Tropics	-	29.2	25.3	7.5	-	43.8	1.8	0.2	1
Pods	Thailand	41.5	21.1	23.0	4.6	4.6	46.7	-	-	3
	Tanzania	24.3	20.3	34.8	4.6	1.0	39.4	0.52	0.24	4

Sources:

1. Ganguli, Kauli and Namibiar, 1964
2. Le Houerou, 1980
3. FAO, 1981
4. Komwihangilo,1991

In Tanzania CP contents of up to 22% for leaves have been observed (Komwihangilo, 1991). Lowry (1989) reported the CP contents of 23% and 19% for flowers and pods of *A. lebbek* respectively whereas CP values up to 20% have been found for pods in Tanzania (Komwihangilo, 1991) and Thailand (FAO,1981)

2.5.2 *Glyricidia sepium*

Glyricidia sepium is a tropical leguminous shrub believed to have originated in Central America (Little and Wadsworth, 1964). It has now spread to West Africa, West Indies, Southern Asia and some parts of America (Little and Wadsworth, 1964).

The plant flourishes well in wet and warm weather conditions with rainfall and temperature range of 800 to 2300 mm and 22°C to 30° respectively (NAS, 1979). Observations by Chadhokar (1982) have shown that the plant grows on well manured soils as well as on acidic and soils with high clay content. The plant can be established either from cuttings or seeds. Total annual DM yield obtained in different locations seem to vary between seasons (Oakes and Skov,1962; Calub, 1990). Total DM yield of 0.99 and 1.48 tonnes per hectare during the dry and wet seasons respectively have been reported (Oakes and Skov,1962).

Tables 2.2 and 2.3 show that *G. sepium* as a leguminous tree is rich in protein and calcium which are usually at low levels in non-leguminous forages (Chadhokar, 1982). Age of the plant, harvesting interval, season, geographical location and plant part are known to cause variation in the chemical composition of the plant at different places (Smith and Van Houtert, 1987).

Studies on rumen DM degradability using fistulated sheep have shown that the plant is highly degradable (Minor and Deb Hovell, 1979). Van Houtert (1987 cited by Smith and Van Houtert,1987) found different values in rumen DM degradability of different parts of the plant. He obtained rumen DM degradability values of 72%, 57% and 42% for leaves, stem, bark and leaf petioles respectively.

Available data indicates that *G. sepium* is highly digestible and can improve DM digestibility of poor quality feeds (Ife Goat Research Group, 1984 cited by Smith and Van Houtert, 1987). However, in other studies no improvement in digestibility of poor quality feeds was found (Vearasilp,1981 cited by Smith and Van Houtert, 1987). Recent studies with sheep, goats and milking cows have shown that the tree can improve growth and milk production of these animals without any adverse effects (Chadhokar, 1983).

Table 2.2: Chemical composition of *Glyricidia sepium*

Component	Range(%DM)	Mean(% DM)	Reference
Dry matter	14.0-30.0	21.9	3,2
Crude protein	9.0-30.0	23.0	2
Crude fibre	13.4-33.9	20.7	3,2
Ether- extract	0.9-6.7	3.1	3,2
Ash	6.4-13.3	9.7	3,2
Nitrogen-free extract	37.6-55.7	42.8	3,2
Acid detergent fibre	23.2-34.2	28.7	3,1,4
Neutral detergent fibre	37.6-55.7	42.8	1,5
Cellulose	22.0-24.4	23.6	5
Lignin	7.7-12.7	10.8	5

Sources:

1. Vearaslip, 1981
2. Chadhokar, 1982
3. Falvey, 1982
4. Carew, 1983
5. Kabaija, 1985

Table 2.3: Minerals content of *Glyricidia sepium*

component	Range	Mean	References
Phosphorus (%DM)	0.11-0.27	0.18	1,2,3,4
Magnesium (%DM)	0.21-0.58	0.34	2,3,4
Sodium (%DM)	0.09-0.50	0.25	2,3,4
Potassium (%DM)	2.4-3.4	3.3	2,3,4
Zinc (mg/kg)	22.0-37.0	26.0	3,4
Iron (mg/kg)	259.0-362	207	3,4
Manganese (mg/kg)	40.0-90.0	69.7	2,3,4
Copper (mg/kg)	4.0-7.7	5.8	3,4

Sources:

1. Falvey, 1982
2. Chadhokar, 1982
3. Carew, 1983
4. Kabaija, 1985

2.5.3 Tamarindus indica

Tamarindus indica is probably indigenous to Africa although it is well spread throughout the world (NAS, 1979). The tree is found along roadsides, in backyards and on waste land. It is drought resistant and can grow in a variety of soils.

However, the tree grows slowly with total DM yield at 3 years of age of 0.55 kg DM/m^2/year (Calub, 1990). Table 2.4 shows the chemical composition of different parts of the tree. The leaves and pods contain high levels of CP and calcium which are normally limiting elements during the dry season.

Table 2.4: Chemical composition of Tamarindus indica

Component	Country	As percent of dry matter								Reference
		DM	CP	CF	Ash	EE	NFE	Ca	P	
Leaves	Pakistan	25.2	15.8	23.7	7.9	9.6	43.0	2.86	0.26	2
	India	13.4	17.7	9.5	7.0	2.39	52.4	0.25	-	2
	Tanzania	47.0	11.7	21.0	9.1	3.7	55.0	0.7	0.2	3
	West Africa	78.7	6.3	23.2	3.0	7.6	59.9	0.20	-	1
	Tropics	-	29.2	25.3	7.5	-	43.8	1.8	0.2	1
Pods	Tanzania	41.0	8.7	32.9	9.1	1.0	52.0	0.7	0.13	3
seeds	India	18.3	26.4	3.5	7.4	0.14	44.4	0.30	-	2

Sources:

1. Le Houerou, 1980
2. FAO, 1981
3. Komwihangilo,1991

The leaves are palatable and liked by sheep and goats (Calub, 1990). The CP contents of the whole tamarind seeds have been shown to be 13.13% (Penigrahi *et al.*, 1989) whreas those of leaves range from 11% to 18% of DM (NAS, 1979; Le Houerou 1980; FAO, 1981).

2.5.4 Limitations to the use of *Albizia lebbek, Glyricidia sepium* and *Tamarindus indica* by sheep and goats

Toxicity, pests, diseases and climatic factors can limit utilization of these browses. Phenolic compounds such as tannins which are at variable concentrations (Jong *et al.*, 1989; Penigrahi *et al.*, 1989) in these browses can form indigestible complexes with the dietary protein and thus lower their digestibility. Barks, seeds and roots of *G. sepium* contain toxins which are deleterious to rodents, horses and poultry (Skerman, 1977; Mishra *et al.*, 1977) but not harmful to sheep and goats. Strong repulsive odours reported to be caused by alkaloids in *G. sepium* causes its unacceptability by grazing animals.

It has been shown that the seedlings of *A. lebbek* can be attacked by termites (Muthana *et al.*, 1983) whereas leaves and pods are reported to be infected by Fungal infections (Prinsen, 1986). Aphids and mites are known to attack *G. sepium* (Calub, 1990) whereas *T. indica* is vulnerable to attacks by small beetles, anthracnose and powdery mildew (NAS, 1979; Calub, 1990). These infestations and infections may result into limited availability of the feed and nutrients when animals are most in need. In addition, the diseases, pests or insects and climatic factors may limit extensive establishment of the browses.

2.6 Preference ranking of forages

Studies to identify and quantify some of the characteristics of plants that determine diet selection using trained sheep (Colbrook *et al* 1987 cited by Colebrook *et al*., 1990) have shown that ease of eating, sensory factors such as taste, texture and odour, water content of the herbage and sward architecture are influential in determining diet selection. In his view of grazing behaviuor, Arnold (1981) suggested that diet selection is influenced by a large number of factors such as physical and chemical characteristics of the diet, animal's experience and social environment.

Although sensory factors are very important in determining diet preference (Arnold, 1981),it is suggested that a simple comparison of preference between two feeds does not give a quantitative measure of the difference in preference particularly when one feed is strongly favoured. Each feed has to be compared directly with every other feed to obtain a preference ranking. When feeds of similar dry matter content and particle lenghth are compared preference will be determined largely by sensory factors . This can be quantified by comparing each feed with a set of standard feeds using the method of Kenney and Black (1984) as refined by Colebrook *et al* (1985). These procedures obviate the need to make direct comparisons between each feed and every other feed when establishing preference rankings.

Minson and Bray (1986 cited by Gherardi *et al* 1991) reported that the voluntary intake of a forage is not related to its palatability relative to other forages. Their results indicated that factors which affected the long term intake of a forage were more important than palatability. The above findings contradict those of other workers (Weston and Davis, 1986 cited in Gherardi *et al*., 1991) who proposed that the low palatability of a forage could affect its voluntary intake. However , the interpretation of each of those studies is confounded by other dietary and animal factors that affect intake.

In the study of Weston and Davis (1986), cited by Gherardi *et al* (1991) different forages were compared , and they concluded that the differences in intake were due to factors such as OM digestibility , rates of outflow from the rumen or packing density of the particulate matter in the rumen. However, other studies using intra-ruminal feeding techniques were unable to ascertain the possibility that the low intake rate of a forage presumed to be unpalatable was due to insufficient time for ingestive and ruminating activities (Black, 1984 cited in Gherardi and Black, 1991). Gherardi *et al* (1991) observed that the palatabilty of a forage does affect long term preference. The authors found that sheep when offered a choice between forages consumed more of the more palatable forage. Similar findings were confirmed in grazing studies with steers (Burns *et al*, 1987). They found that when offered a choice between Panicum accessions the steers consumed more of the most palatable accessions. Intake in that study was calculated as the difference between pre-grazing and post- grazing canopy heights.

The total DMI was higher when the sheep were offered a choice between feeds once daily compared to individual feeds every 3 h. As the total amount of feed offered in the preference experiment was far in excess of 20% of the previous days intake (i.e animals were offered equal amounts of the treated and untreated hays), it was possible that the higher intake resulted from the animal's ability to select preferred components of the hay. No evidence of selection within a particular length of hay was observed in the preference experiment. However, the authors were of the opinion that the observed differnces were possibly due to to seasonal fluctuations in intake, as the preference experiment was conducted in summer and the intake experiment during winter and spring. Seasonal effects on the voluntary intake by sheep housed indoors are associated with a seasonal variation in basal metabolic rate such that low intakes are associated wih low rates and high intakes with high rates in summer as it has been shown by Blaxter and Boyne (1982).

Semenye *et al* (1986) carried out a preference study in which six grass species were offered to pregnant does for a duration of one hour twice a day at 08.00h and 04.00h for five consecutive days. The offering was a cafeteria of 12 hanging bundles of grass, two of each species and weighing one kg per bundle. The same was repeated for six proteinaceous species. In that trial palatability ranking judged by intake did not differ by the time of feeding (ranking was not influenced by whether the goats were hungry or not).

Komwihangilo (1991) offered four browse species hanging in bundles to confined sheep and goats in a cafeteria feeding for two consecutive days. Preference ranking based on intake was not in any way related to chemical composition of the browses.

In order to promote dry matter intake (DMI) of animals common forages used by farmers have to be ranked according to their palatability order. Some workers have found that under cut and carry feed system the knowledge of forage ranking has been useful to farmers as it enables them to limit unnecessary forage cuts and wastages (Semenye *et al.*, 1986). In order to make full use of forages of different palatabilities, it is recommended that the least palatable forages be offered first followed by those which are most palatable (Semenye *et al.*, 1986).

In many studies carried out in confined animals, the preference indices of forages or feeds have been determined as the amount of fresh or dry matter intake (g/day) per animal (Semenye et al., 1986) or a proportion of it which contributes to the total diet (Haryanto *et al.*, 1982). The time spent eating on the forages has also been used to estimate feed preference index (Komwihangilo, 1991). Knowledge on preference ranking of multipurpose trees as fodder for livestock under stall feeding is therefore important in order to avoid unnecessary heavy lopping or prunning of the trees.

2.7 Conclusion of the literature review

From this review, it can be seen that the majority of sheep and goats in Tanzania are reared under extensive range system with abundance of low quality roughages which limit their productivity. Most of the proposed methods to improve productivity of these animals have been less fruitful because of practical limitations encountered under range areas.

However, browses such as *A. lebbek*, *G. sepium* and *T. indica* which are easily available or can be established on range areas could be an alternative sources of protein and energy to enhance increased intake and digestibility of low quality roughages. Although feeding of these browses has been practised, very little information on preference, nutritive value, toxic effects and effects on the performance of the animals are known. It is imperative that studies on nutritive value, voluntary intake and selectivity by sheep and goats fed multipurpose trees as sole or supplementary diet to hay are main areas of interest in the present study.

3.0 MATERIALS AND METHODS

3.1 Objectives of the study

The study was carried out with four main objectives:

a) To establish the voluntary intake of three browse species offered to sheep and goats as sole diets.

b) To establish the voluntary intake of the three browses offered in addition to a grass hay based diet.

c) To establish the ranking order of preference of the three browses by sheep and goats when all were offered with grass hay diet.

d) To establish rumen degradability of the three browse species and the grass hay.

3.2 Location of the study

The study was carried out at the Sokoine University Farm at about 550 metres above sea level. The annual rainfall ranges from 600mm to 1000mm whereas minimum and maximum temperatures are from $15c^0$ to $35c^0$. Natural pastures comprise of *Hypperrhenia rufa*, *Chloris gayana* and *Pennisetum purpurium*

3.3 Experimental animals.

Twelve mature Black Head Persian sheep aged between 2 years and over 7 years with liveweight range of 24 to 33 kg were obtained from Department of Animal Science and Production (DASP) farm. Another group of 12 goats (local meat type) of similar age and weight range were also obtained from the same source. The wide ranges in age and weight were deliberately taken to provide the widest possible body sizes for the intake and preference studies. Earlier studies (Komwihangilo, 1991) had shown that the order of preference may be associated with body sizes- presumably reflecting the foraging strategies of small ruminants under range conditions.

3.4 Forages, their source and preparation

Basal diet, Rhodes grass (*Chloris gayana*) hay was procured from Dairy Farming Company (DAFCO) - Ruvu farm in Coast Region. Branches of *Albizia lebbek* and stumps of *Glyricidia sepium* were obtained from established trees in the campus. Natural stands around the campus were used to obtain Tamarind branches.

All the trees were at different phenological stages at the start of the study. Main and small branches which were close to each other within a tree were selected for cutting in a particular day. Such cutting methods ensured uniformity in foliage offered to the animals in a day.

Cutting of branches was done early in the morning of each experimental day before commencement of the study.

They were then collected to the experimental site ready for feeding.

3.5 Management before the experiment

Before the start of the study the experimental house together with pens for animals were thoroughly cleaned with water mixed with a disinfectant. The liveweights of individual animals were recorded before they were randomly placed to the pens. Their ages were determined using available birth records.

The animals were treated against internal and external parasites using Ivermectin (Merk and Co.,1986). Clean water and mineral licks were offered *adlibitum*.

3.6 Voluntary intake of browse species

Three feeding experiments were conducted. In the first experiment browses were offered to sheep and goats as sole diets. In the second experiment, *Chloris gayana* hay was offered to the animals in addition to the browse. In third experiment each animal was given branches of all the three browses and *Chloris gayana* hay.

3.6.1 Experiment 1: Voluntary intake of browse species offered as sole diets

3.6.1.1 Experimental procedure

Eight animals, four sheep and four goats were individually penned and randomly assigned to three browse trees (*Albizia lebbek*, *Gliricidia sepium* and *Tamrindus indica*) simuteneously. Branches of these browses were hung for the animals to browse and were offered *ad libitum* at 09.00 h daily for 21 days after a 10 day pretrial feeding period. Sample branches of the offered browses were mechanically separated into leaves, pods, bark and wood which were then weighed individually. Every morning at 07.00 h. refused branches of each browse were mechanically separated into botanical parts and weighed. Voluntary intake of each botanical parts by an animal was estimated as the difference between the amount offered and refused.

3.6.1.2 Data collection

Ten percent of daily samples of the offered and refused browse parts were bulked for 3 days and oven dried at 60°C for 48 hours for partial DM determination. Using the determined DM values, total fractional intake by an individual animal was calculated by difference. Moisture losses due to evaporation were not measured. However, it was assumed that this loss was the same in all browses.

3.6.1.3 Chemical analyses of browses

The chemical components of the offered browses were determined as described in section 3.7

3.6.1.4 Experimental design and statistical analyses

The experiment was arranged as a 3 x 2 factorial layout in which treatments represented *Albizia lebbek, Gliricidia sepium* and *Tamarindus indica*. The observed daily intake of these browses were measured in sheep and goats. The data were analysed using the General Linear Program Model (SAS, 1988). The following underlying statistical model was used:

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$$

where:

A_i = effect of i^{th} species of animal

B_j = effect of j^{th} species of browse

AB_{ij} = effect of interaction of i^{th} animal species and j^{th} browse species

e_{ijk} = residual specific for the k^{th} individual of the i^{th} species assigned to j^{th} browse.

3.6.2 Experiment 2: Voluntary intake of browse species offered with *Chloris gayana* hay

3.6.2.1 Experimental procedure

In this study, the voluntary intake of *Chloris gayana* hay and browse species were determined. The same animals used in the first experiment were exposed to the *Chloris* *gayana* hay and browses. The hay was offered at 5% of the liveweights of the animals. A preliminary period of 10 days during which all animals were introduced to the feeds preceded the experiment. This was followed by a 21 day data collection period. Mechanical separation of the offered and refused branches of the browses was done as described in section 3.6.1.2

3.6.2.2 Data collection

The DM intake of the browses and the hay were calculated as described in section 3.6.1.2.

3.6.2.3 Chemical analyses of browses and hay

The chemical analysis of the browses and hay was determined as in section 3.7

3.6.2.4 Experimental design and statistical analyses

The arrangement of the experiment and data analysis were carried out as described in section 3.6.1.4

3.7 Chemical analyses of browses and hay

Samples of leaves, pods and barks of browse species and hay offered to sheep and goats were ground to pass through a sieve size of 1mm for determination of chemical components. The AOAC (1990) procedures were used to determine crude protein, Ether extract, Ash and Dry matter contents. The procedure of Astrup (1975) was used to determine crude fibre content whereas Nitrogen free extract was determined by substraction (Schneider and Flatt, 1975). The procedure of Goering and Van Soest (1970) were used to analyse NDF, ADF and ADL contents Helmicellulose (HEM) was calculated as the difference between NDF and ADF, whereas cellulose was determined as the difference between ADF and ADL. The *in vitro* digestibility method as described by Tilley and Terry (1964) was used to determine organic matter digestibility of the feeds (IVOMD). Metabolizable Energy (MJ/kgDM) was calculated as outlined by McDonald *et al* (1988) as follows:

$ME(MJ/kgDM) = 11.78 + 0.00654CP + 0.000665EE^2 - 0.00414EE \times CF - 0.0118TA$, Where: EE=ether extract, CP=crude protein, CF=crude fibre and TA=total ash (all expressed as g/kgDM).

3.8 Experiment 3: Study on the ranking order of preference of the three browses

The aim of this experiment was to establish the ranking order of preference of the three browses by sheep and goats when all were offered with *Chloris gayana* hay to each individual animal.

3.8.1 Experimental procedure

All the three browses with grass hay were provided to each animal for a preliminary period of 10 days and a collection period of 14 days. Six sheep and six goats were randomly selected among the animals used in the first two experiments. Their initial and final livebody weights were recorded. Feeds were offered as explained in section 3.6.1.1.

3.8.2 Data collection

Determination of the DM intake of the browses and hay was done as described in section 3.6.1.2

3.8.3 Experimental design and statistical analyses

The design of the experiment and analyses of data were done as explained in section 3.6.1.4.

3.8.4 Chemical analyses of browses and hay

Chemical components of these feeds were determined as described in section 3.7.

3.9 Studies on rumen degradability of browses and the hay.

The aim of this study was to evaluate DM degradability of the browses (*Albizia lebbek, Gliricidia sepium* and *Tamarindus indica*) together with Rhodes grass.

3.9.1 Animals and feeding

Three mature Blackhead Persian (BHP) sheep and three Small East African goats fitted with permanent cannulae were used. They were fed a standard diet (Table 3.1) with roughage to concentrate ratio of 70:30. The hay was cut, air dried and chopped before feeding. Animals were penned in individual metabolism crates. Clean water was offered *ad libitum.*

Minovit and super maclic (Wellcome, 1991) were provided as source of minerals and vitamins for the animals. Their compositions are shown in Table 3.2. These were included at a level of 1%of the DM of the standard diet.

The animals were given the standard diet for 14 days to attain stable rumen environment before commencement of data collection . The concentrate mixture was fed once at 09.00h . The hay was fed twice at 09.00h and 14.30h at the rate of 0.75 kg to 1.00 kg per animal at each feeding time. All the animals received the same diet during the experimental period.

Table 3.1: Chemical composition of ingredients of the standard diet used for rumen degradability.

Feedstuff	%DM	% DM				
		CP	CF	EE	Ash	NFE
Brachiaria sp. hay	61.40	2.77	37.01	1.13	10.76	9.73
Maize bran	89.80	10.89	6.02	10.80	4.89	57.2
Cotton seed cake	94.80	31.32	22.14	7.66	6.22	27.46

Table 3.2: Composition of mineral/vitamin premixes used in degradability studies rations.

Minovit[1]	
Vitamin A	7,500,000 IU
Vitamin D_3	1,150,000 IU
Vitamin B_1	1,000 mg
Vitamin B_2	2,750 mg
Vitamin B_{12}	5 mg
D - calcium pantothenate	500 mg
Vitamin E	2,500 mg
Vitamin K	1,500 mg
Niacine	12,500 mg
Manganese oxide	16,130 mg
Potassium iodide	353 mg
Cobalt sulphate	286 mg
Zinc oxide	12,500 mg
Copper oxide	1,283 mg
Ferrocarbonate	20,323 mg
Carrier to	1,000 g

Maclic supper[2]

Elementary (%)						
Ca	P	Na	Cl	Mg	Cu	Co
20.46	12.00	10.26	15.83	2.0	0.16	0.02
Fe	K	I	Zn	Mn	S	Sc
0.5	0.008	0.002	0.5	0.4	0.38	0.001
Compound (%)						
CaO	P_2O_5	Nacl	Ca/P ratio			
28.64	27.48	26.09	1.7:1			

Source:
[1]Values provided by manufacturer (Wellcome 1991)
[2]Guaranteed analysis of Maclic super as provided by the manufacturer (Wellcome 1991)

The study was performed using the nylon bag technique (Orskov *et al.*, 1980). Nylon bags (mean pore size 60 μm and effective size 7.5 x 10 cm) made of H 5075 nylon filter cloth were used. Each feed sample was incubated in three sheep and three goats under the study. Two bags containing the sample (2g) were introduced into the rumen of each animal for each incubation time.

The bags were removed at intervals of 12, 24, 48, 72, 96 and 120 hours and washed in running water until the washing was clear. They were then dried to constant weight at 70°C for 48 hours. The zero hour. bags with test feed were soaked in tap water for 2 hours at room temperature to determine water soluble fraction.

The amount of feed degraded was determined as the difference in weight (DM) between the bags with feed samples before incubation and dried bags with feed residues. The observed degradability values at each incubation time were subjected to one way analysis of variance and the following underlying statistical model was used:

$$Y_{ij} = \mu + A_i + E_{ij}$$

where:

μ = overall mean

A_i = overall effect due to treatment

E_{ij} = residual (Error term).

The degradability characteristics of browse parts and hay were determined as outlined by Orskov and McDonald (1979) as follows:

$$P = a + b\ (1-e^{-ct})$$

where:

P = the percentage of dry matter degraded after time t,

a = water soluble fraction (%)

b = not water soluble but potentially degradable fraction (%)

c = rate at which b is degradable (rate constant) (h^{-1})

3.9.2 Data analyses

NAWAY computer package was used to obtain the fitted values for DM losses. General Linear Model (GLM) procedures for statistical analysis (SAS, 1988) were used to analyse the degradability data.

4.0 RESULTS

4.1 Health of animals

One goat went off feed in the group offered *A. lebbek* as a sole diet in experiment 1 and had to be removed from the group. Other animals remained healthy throughout the study period in all experiments.

4.2 Chemical composition of feeds

Chemical composition of *Chloris gayana* hay and different parts of *A. lebbek, G. sepium* and *T. indica* offered to confined sheep and goats are shown in Tables 4.1a and 4.1b. Leaves had highest levels of CP. Among the leaves that of *A.lebbek* contained the highest level of CP (22.2%) followed by *G.sepium* (20.0%) and *T.indica* (12.3%). The CF contents varied among the browse parts and hay and increased as the CP values decreased and vice versa.

Higher levels of ash content were found in *G. sepium* leaves and bark than in other browse parts and hay. The pods of *A. lebbek* and *T. indica* had the least values of ash. Levels of NDF, ADF, HEM and CEL were higher in hay than in leaves and barks of the browse species.

Table 4.1a: Chemical composition of different parts of *A. lebbek*, *G. sepium*, *T. indica* and *C. gayana* hay offered to sheep and goats as % DM (Means ± std) in experiment 1-4.

Feed		DM	CP	CF	EE	Ash	NFE	Ca	P
A. lebbek	Leaves	37.1±3.1	22.2±0.2	31.5±0.3	1.8±0.1	9.7±1.0	34.5±0.5	2.7±0.07	0.3±0.03
	Bark	52.4±2.2	13.1±0.1	41.0±0.1	1.1±0.1	8.7±0.2	36.1±4.1	1.5±0.08	0.3±0.01
	Pods	21.4±1.2	22.9±0.2	30.2±0.5	0.7±0.1	4.6±0.4	42.3±4.3	1.9±0.04	0.4±0.03
G. sepium	Leaves	31.5±1.0	20.0±0.4	17.7±0.5	3.4±0.2	10.4±0.9	48.6±1.6	1.8±0.11	0.4±0.01
	Bark	36.8±3.4	10.7	36.5±0.5	1.5±0.2	11.2±0.7	40.2±0.7	2.9±0.24	0.4±0.02
T. indica	Leaves	33.4±1.6	12.3±0.4	22.9±0.3	3.8±0.2	9.6±0.7	52.9±2.9	2.9±0.12	0.4±0.07
	Bark	46.2±0.6	5.2±0.2	44.7±0.5	1.5±0.3	8.3±0.4	40.3±2.8	1.9±0.01	0.4±0.01
	Pods	29.8±0.2	8.7±0.3	33.9±0.5	1.0±0.1	5.7±0.3	53.0±4	0.3±0.06	0.3±0.04
C. gayana	hay	93.9±3.9	3.4±0.1	39.6±0.4	0.8±0.2	9.1±0.6	40.9±7.9	1.5±0.02	0.3±0.07

Std-standard deviation

Table 4.1b: Chemical composition, IVOMD and ME of different parts of *A. lebbek* , *G. sepium*, *T. indica* and *C. gayana* hay offered to sheep and goats (Means±std) as % DM.

Feed		NDF	ADF	ADL	HEM	CELL	IVOMD	ME[1]
A. lebbek	Leaves	68.4±1.6	34.5±0.2	10.7±0.2	34.0±1.0	23.8±0.2	50.4±1.2	7.9
	Bark	63.5±3.5	46.5±0.3	16.4±0.6	17.1±2.1	30.1±1.9	41.4±0.6	6.4
	Pods	50.2±1.8	33.4±0.3	10.8±0.3	16.8±0.4	22.6±0.6	61.9±0.1	9.9
G. sepium	Leaves	65.8±1.2	26.2±0.3	14.8±0.2	39.6±0.6	11.4±0.4	52.1±1.6	8.2
	Bark	64.7±0.3	42.2±0.4	22.0±0.8	22.5±2.5	20.2±0.8	54.8±0.9	8.6
T. indica	Leaves	52.3±2.3	35.9±0.2	21.0±0.3	16.4±1.8	14.9±0.3	45.8±3.9	7.1
	Bark	69.8±0.2	61.0±0.3	33.3±1.2	8.8±0.2	27.8±2.2	40.3±1.5	6.2
	Pods	47.2±2.8	34.6±1.2	19.3±0.5	14.7±0.7	13.6±0.4	43.9±1.5	6.8
C. gayana	Hay	82.5±3.5	49.0±0.3	8.4±0.7	33.5±0.5	40.6±0.9	36.4±0.4	5.5

[1] Calculated ME (MJ/KgDM)

Std-standard deviation

However, higher values of IVOMD and ADL were observed in the leaves and barks than in the hay.

4.3 Voluntary intake

Data on DM intake of selected botanical parts of the offered browse species and hay by individual sheep and goats are presented in Appendix 3. Least squares means for DM intake of sheep and goats are given in Tables 4.2, 4.3 and 4.4. The voluntary intake patterns are given in Figures 1 to 8.

Sheep had higher total DM intake ($P < 0.05$) than goats in all intake experiments (1 to 3). When the DM intake of the sole browses (leaves and bark) was considered, (Table 4.2) the amount of *G. sepium* consumed was higher ($P < 0.05$) than that of *T. indica* and *A. lebbek* of sheep. Goats showed similar trend with DM intake values being lower ($P > 0.05$) than those of sheep. Observation on DM intake of botanical parts of the browse species offered as sole diets showed that the DMI of *T. indica* leaves was higher than those of *G. sepium* and *A. lebbek* for sheep and goats (Table 4.2 and Figures 1 to 3). *A. lebbek* pods and pods and bark of *T.indica* were not eaten at all by both sheep and goats.

Table 4.2: LSmean dry matter intake (DMI) of sheep and goats offered sole browse species.

	Species		s.e.m(±)	Significant level
	Sheep	Goats		
Number of animals	12	11		
Mean liveweight (Kg)	28.50	26.54	3.4	
Browse DMI(g/$KgW^{0.75}$)				
Albizia lebbek				
Leaves	25.64	23.38	1.23	NS
Bark	20.86	15.30	1.26	*
Leaves + Bark	46.50	39.86	1.74	*
Total intake (as % LBW)	1.96	1.80	-	-
Glyricidia sepium				
Leaves	43.14	31.41	1.21	*
Bark	36.44	25.39	1.24	*
Leaves + Bark	79.40	56.79	1.71	*
Total intake (as % LBW)	3.39	2.54	-	-
Tamarindus indica				
Leaves	48.43	48.66	1.24	NS
Bark	-	-	-	-
Leaves + bark	48.43	48.66	1.24	NS
Total intake (as % LBW)	2.1	2.2	-	-

* Significantly different ($P<0.05$)
NS Not significant ($P>0.05$)
Mean for individual browse is based on 4 animals.

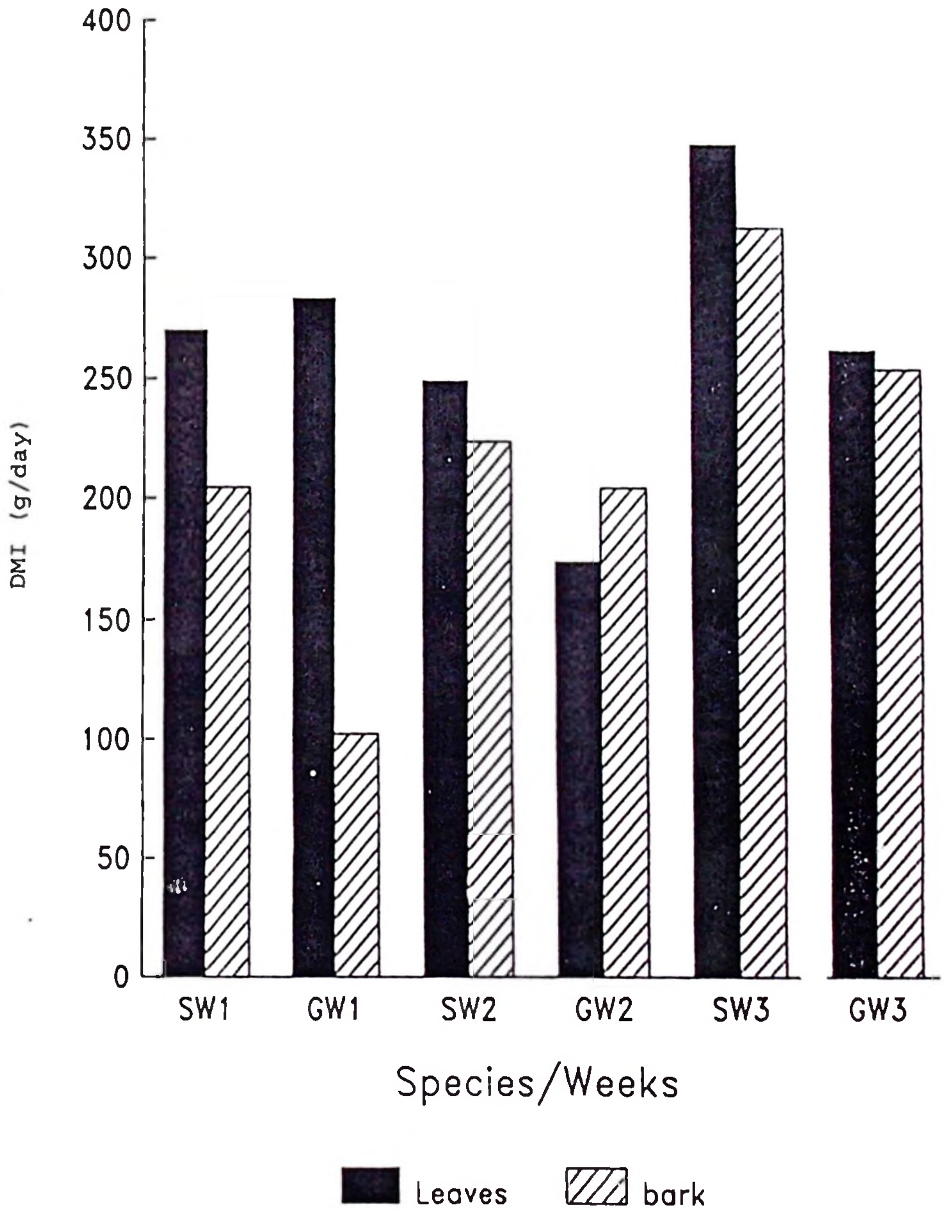

Figure 1 Mean weekly DMI (g/day) of *A. lebbek* by sheep (S) and goats (G). (W1-W3=week 1 to 3).

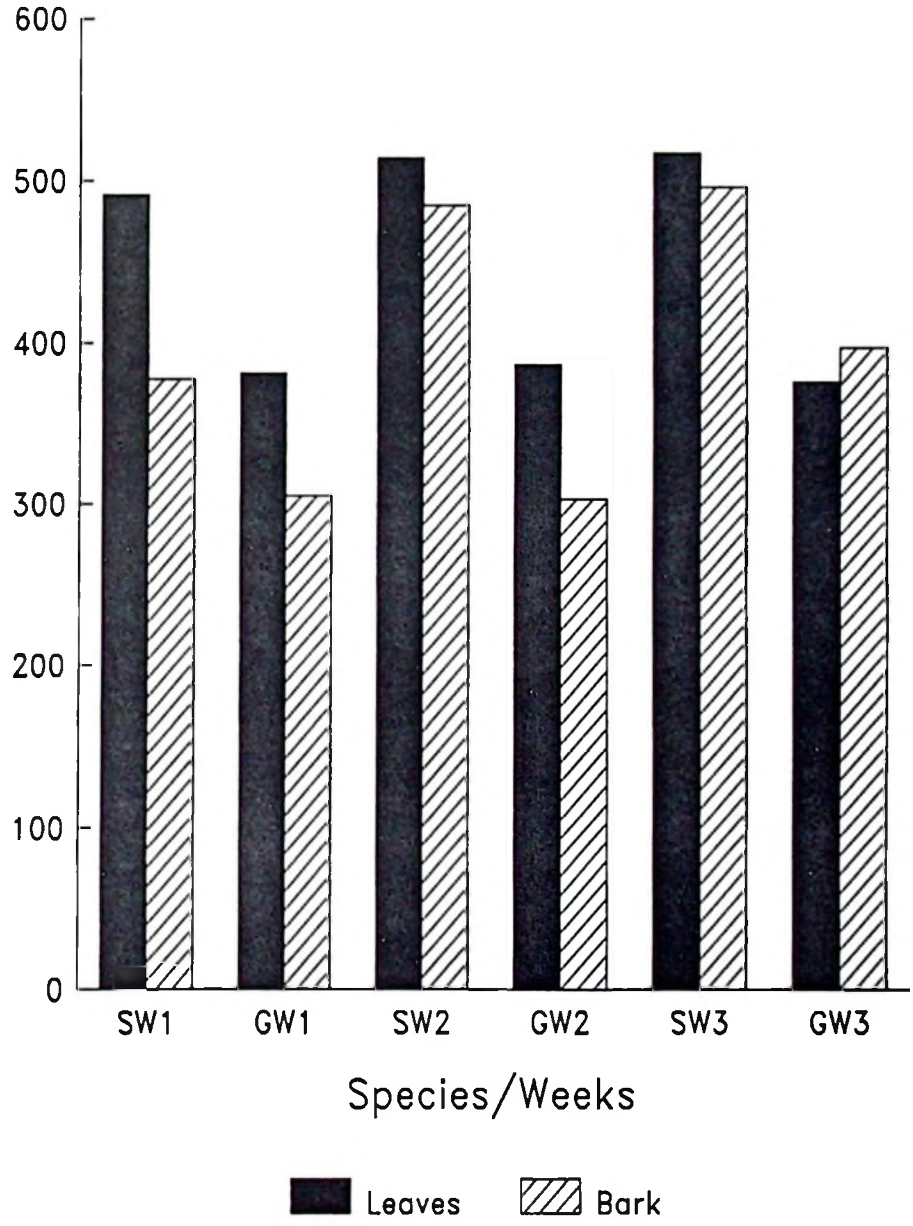

Figure 2 Mean weekly DMI (g/day) of G. sepium by sheep (S) and goats (G). (W1-W3=week 1 to 3)

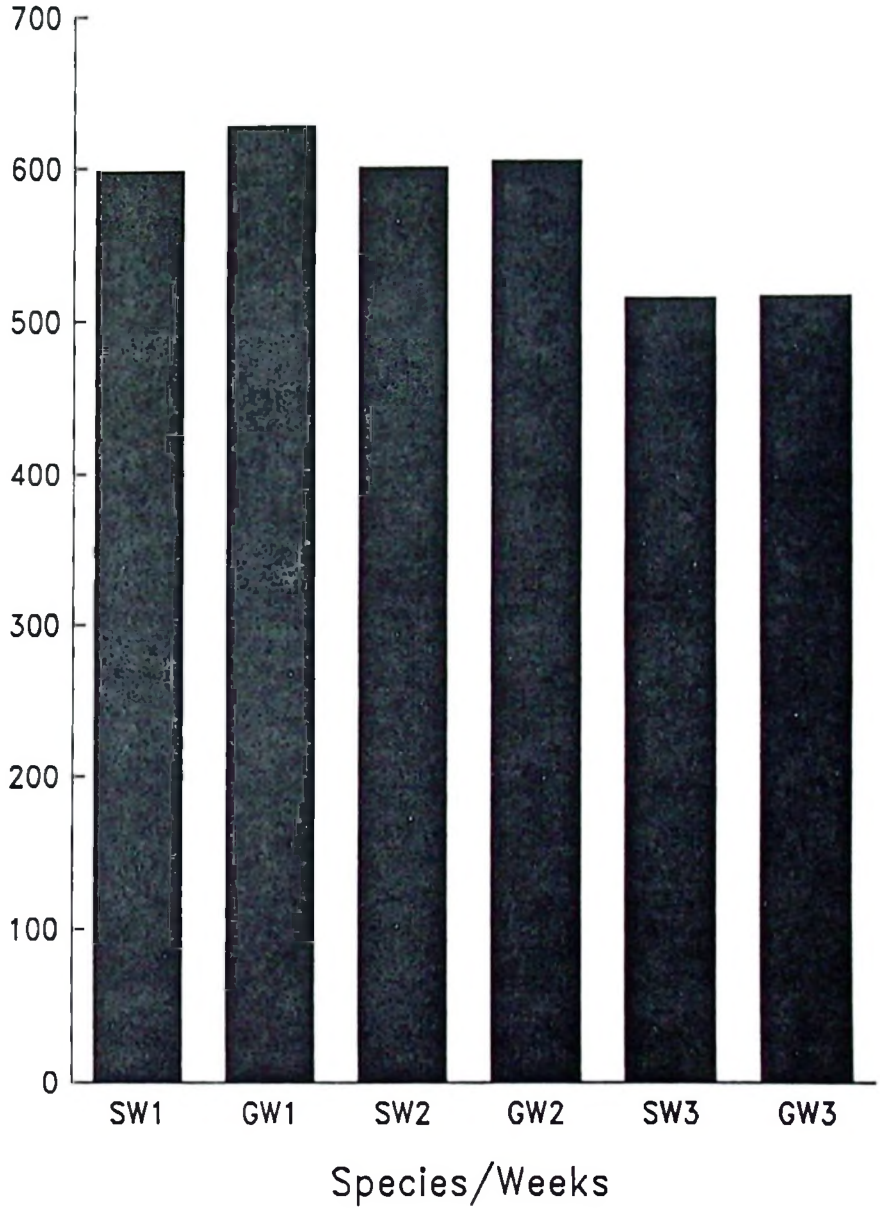

Figure 3 Mean weekly DMI (g/day) of T. indica by sheep (S) and goats (G). (W1-W3=week 1 to 3)

In experiment 2, DM intake of browses (leaves and bark) declined (except *A. lebbek*) when *C. gayana* hay was offered in addition to the browses (Table 4.3 and Figures 4 to 6) in relation to experiment 1 (Table 4.2). Total DMI increased in sheep and goats (Table 4.3)1. There was no statistical difference between sheep and goats for the DM intake of *G. sepium* and *T. indica* leaves ($P > 0.05$) whereas that of *A. lebbek* leaves was significantly different (Table 4.3 and Figures 4 to 6). The DM intake of bark in sheep and goats was significantly different for *A. lebbek* and *G. sepium* (Table 4.3 and Figures 4 and 5).

Table 4.3: LSmean Dry matter intake (DMI) of sheep and goats offered browses and hay.

	Species		s.e.m(±)	Significant level
	Sheep	Goat		
Number of animals	12	12		
Mean liveweight (Kg)	27.93	25.83	3.1	
Forage DMI (g/KgW$^{0.75}$)				
Albizia lebbek				
Leaves	41.40	25.80	1.42	*
Bark	24.66	13.09	0.88	*
Leaves + Bark	66.06	38.89	-	
Hay	40.16	41.02	2.13	NS
Total	106.22	79.82	3.43	*
Total intake (as % LBW)	4.5	3.7	-	
Glyricidia sepium				
Leaves	39.13	37.16	1.51	NS
Bark	25.51	19.09	0.94	*
Leaves + bark	64.64	56.25	-	
Hay	40.15	37.45	2.28	NS
Total	104.79	93.70	3.28	NS
Total intake (as % LBW)	4.4	4.3	-	
Tamarindus indica				
Leaves	35.70	34.61	1.44	NS
Bark	-	-	-	
Leaves + Bark	35.70	34.61	-	
Hay	37.08	46.95	2.18	*
Total	73.60	80.48	3.13	NS
Total intake (as % LBW)	3.1	3.7	-	

* Significantly different ($P<0.05$)
NS Not significant ($P>0.05$)
Mean for individual browse is based on 4 animals

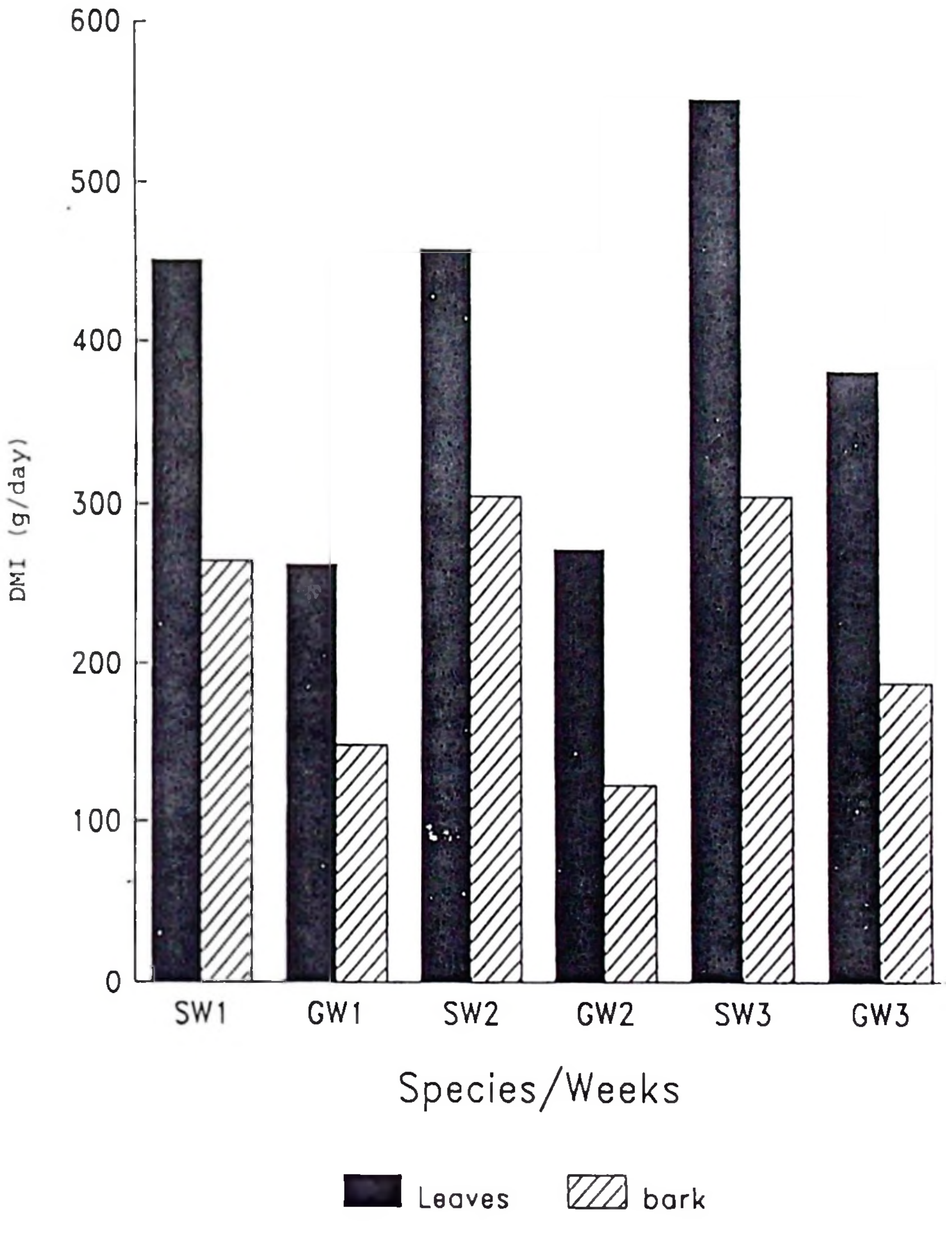

Figure 4 Mean weekly DMI (g/day) of *A. lebbek* offered with *C. gayana* hay to sheep (S) and goats (G). (W1-W3=week 1 to 3).

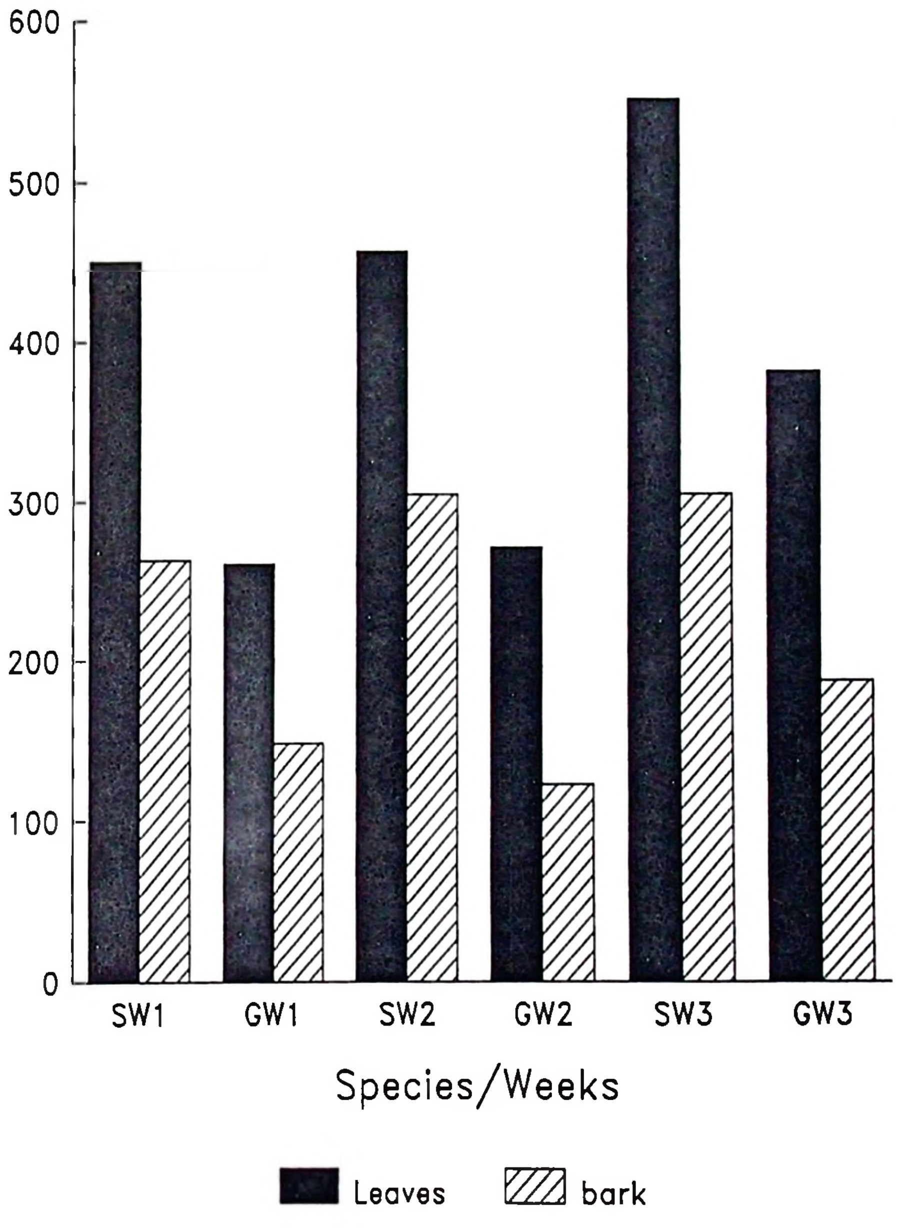

Figure 5 Mean weekly DMI (g/day) of *G. sepium* offered with *C. gayana* hay to sheep (S) and goats (G). (W1-W3=week 1 to 3).

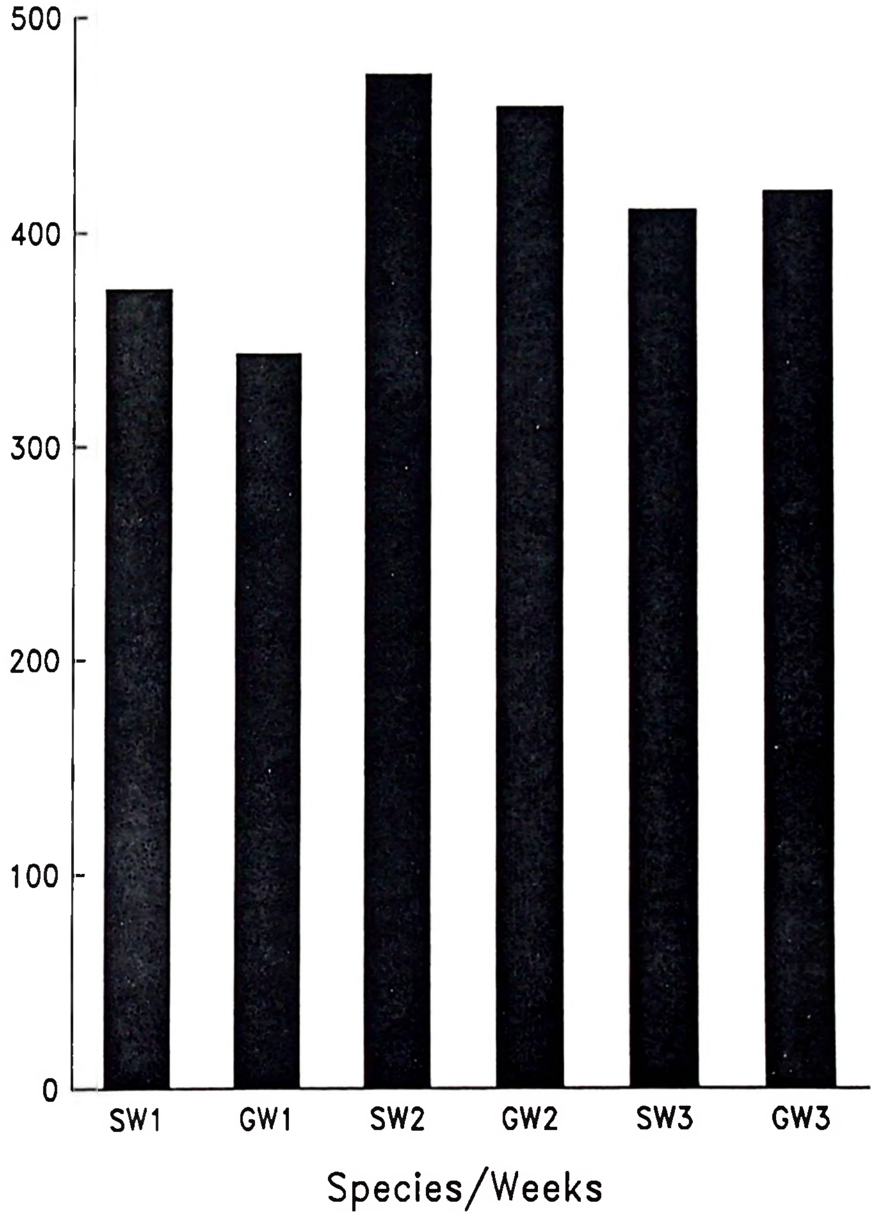

Figure 6 Mean weekly DMI (g/day) of *T. indica* offered with *C. gayana* hay to sheep (S) and goats (G). (W1-W3=week 1 to 3).

4.4 Preference ranking of browse species

Least Squares Means for DM intake of different botanical parts of the three browse species and hay offered to sheep and goats are presented in Table 4.4.

Ranking order of preference when calculated as percentage contribution of each browse specie (leaves and bark) to the total DM intake (Table 4.4 and Figures 7 and

Table 4.4: LSmean dry matter intake (DMI) of sheep and goats offered all three browses and hay.

	Sheep		Goats			
	Quantity DMI (g/kg$^{W0.75}$)	Percent Contribution to total diet	Quantity DMI (g/kg$W^{0.75}$)	Percent Contribution to total diet	S.e.m (±)	Significance level
Number of animals	6		6			
Mean liveweight (kg)	29.7		26.0	-	3.1	-
Botanical Fractions						
Albizia leaves	27.56	22.87	22.64	19.10	1.14	*
Albizia bark	11.87	9.85	6.12	5.16	0.68	*
Albizia leaves + Bark	39.43	32.72	28.77	24.27	1.44	*
Glyricidia leaves	15.64	12.98	19.06	16.08	1.14	*
Glyricidia bark	4.46	3.70	6.43	5.42	0.68	*
Glyricidia leaves +Bark	20.09	16.67	25.49	21.50	1.44	*
Tamarindus leaves	34.24	28.41	40.30	33.99	1.14	*
Hay	26.74	22.19	24.00	20.24	0.95	NS
Total	120.50	100	118.56	100	2.2	NS
Total intake (as %LBW)	4.9	-	5.3	-	-	-

* Significantly different ($P<0.05$)
NS Not significant ($P>0.05$)

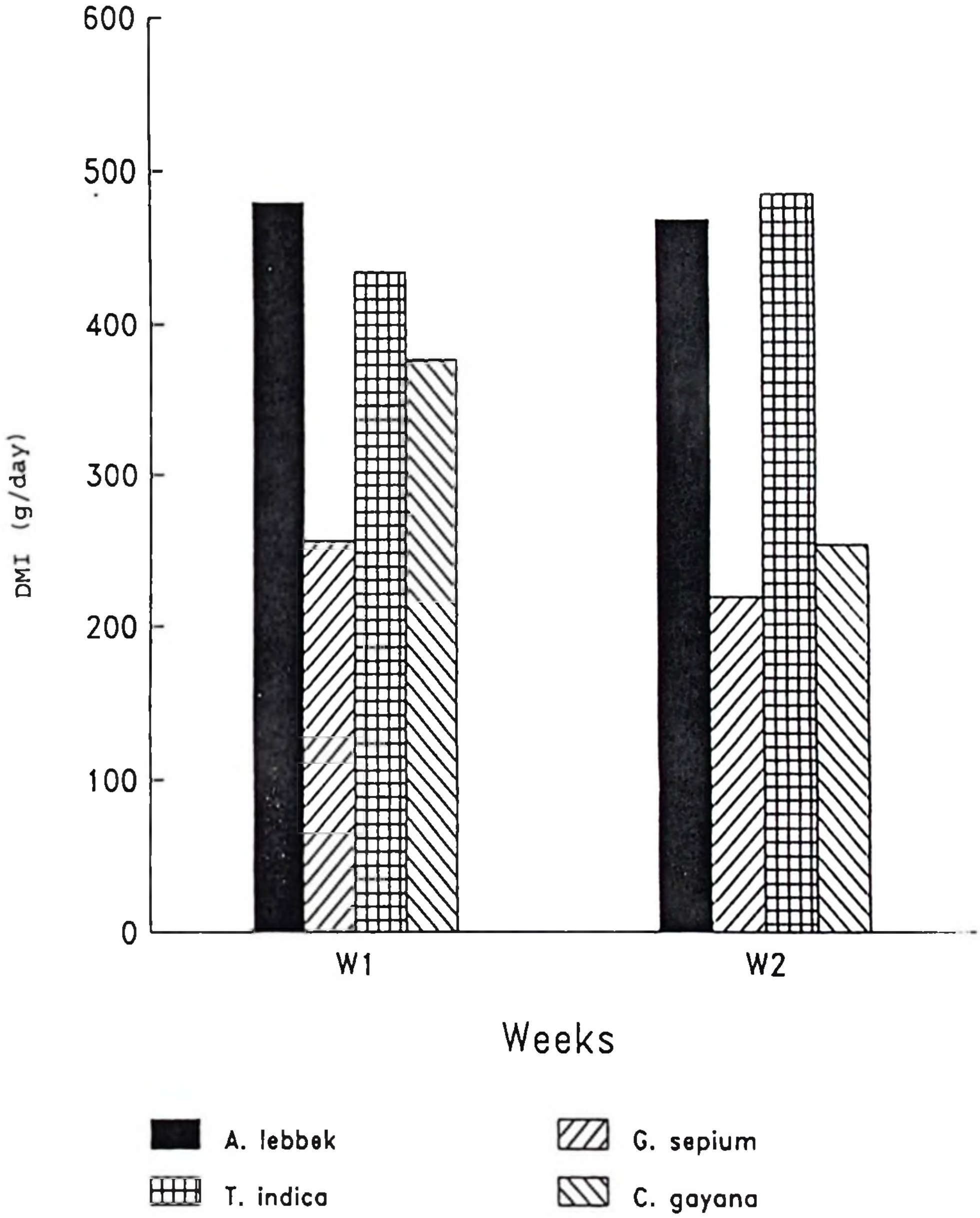

Figure 7 Mean weekly DMI (g/day) of all browses offered with hay to sheep (S). (W1-W2=week 1 to 2).

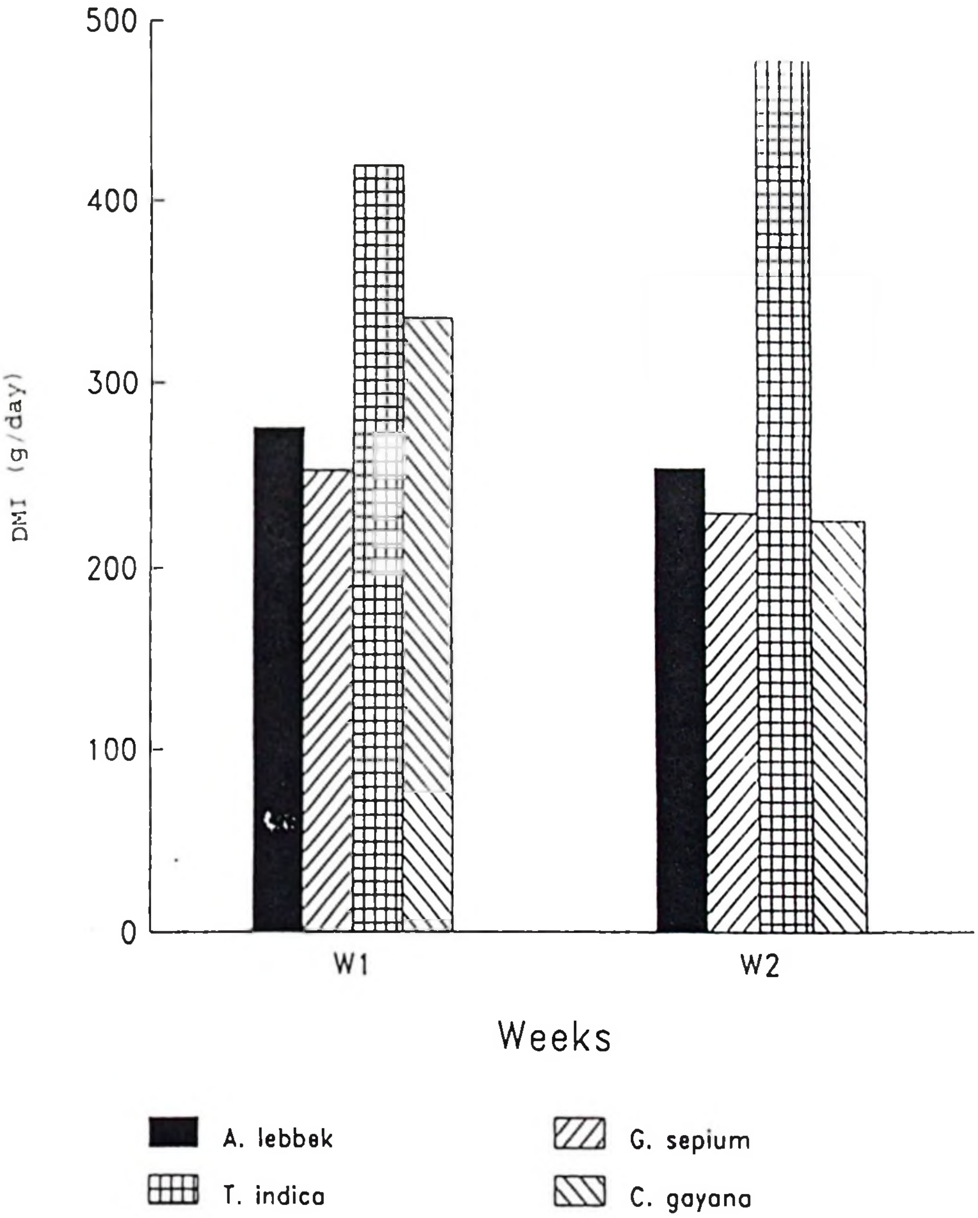

Figure 8 Mean weekly DMI (g/day) of all browses offered with hay to goats (G). (W1-W2=week 1 to 2).

8) indicated that *A. lebbek* ranked first (32.72%) followed by *T. indica* (28.41%) and *G. sepium* (16.67%) in sheep. In goats the ranks were *T. indica* (34%), *A. lebbek* (24.27%) and *G. sepium* (21.50%).

Goats ate more (P <0.05) *G. sepium* and *T. indica* than sheep when DM intake of each browse specie (leaves and bark) was considered. Sheep consumed more (P <0.05) *A. lebbek* than goats. When DM intake of botanical parts of the three browse species was considered it appeared that more (P<0.05) leaves than bark were eaten by both sheep and goats (Table 4.4).

4.5 Degradation characteristics

Rumen Dry matter losses from the nylon bags of various browse parts and hay incubated in the rumen of sheep and goats fed a standard diet are given in Appendix 5. The derived degradation constants from the fitted exponential equations are presented in Table 4.5. There were greater DM losses from the nylon bags between 48 -72 hours of incubation for the majority of the browse parts and hay than at between 0-48 hours. The degradation patterns varied greatly among the forage parts and hay as dipicted in figures 9 to 11.

Table 4.5: Degradability characteristics of feedstuffs[1].

Feed	LSMean degradability constants (%)				RSD	48 h degradability (%)
	a	b	a + b	c		
A. lebbek leaves	32.16^{c}	35.32^{c}	67.48^{b}	0.08^{a}	1.11^{b}	65.73^{c}
G. sepium leaves	38.61^{a}	46.97^{d}	85.57^{a}	0.07^{a}	1.35^{b}	83.42^{e}
T. indica leaves	36.62^{b}	37.11^{c}	73.73^{b}	0.05^{b}	2.17^{d}	70.70^{b}
A. lebbek pods	37.99^{b}	32.33^{c}	70.32^{b}	0.03^{c}	2.53^{c}	58.46^{d}
T. indica pods	36.31^{b}	24.71^{b}	61.02^{c}	0.03^{c}	2.00^{d}	53.85^{a}
C. gayana hay	18.40^{d}	44.53^{d}	62.92^{c}	0.02^{d}	3.35^{c}	37.47^{g}
A. lebbek bark	26.58^{e}	52.98^{a}	79.56^{a}	0.03^{c}	5.08^{a}	56.04^{a}
G. sepium bark	30.73^{c}	44.91^{d}	75.64^{b}	0.05^{b}	1.90^{d}	72.48^{b}
T. indica bark	19.52^{d}	55.66^{a}	75.19^{b}	0.01^{d}	2.24^{d}	42.48^{f}
S.e.m (±)	0.80	2.44	2.72	0.01	0.46	0.79

[1] As derived from an equation $P = a + b\,(1-e^{-ct})$ after incubation in rumen of sheep and goats

Values within columns bearing the same superscript are not statistically different ($P>0.05$).

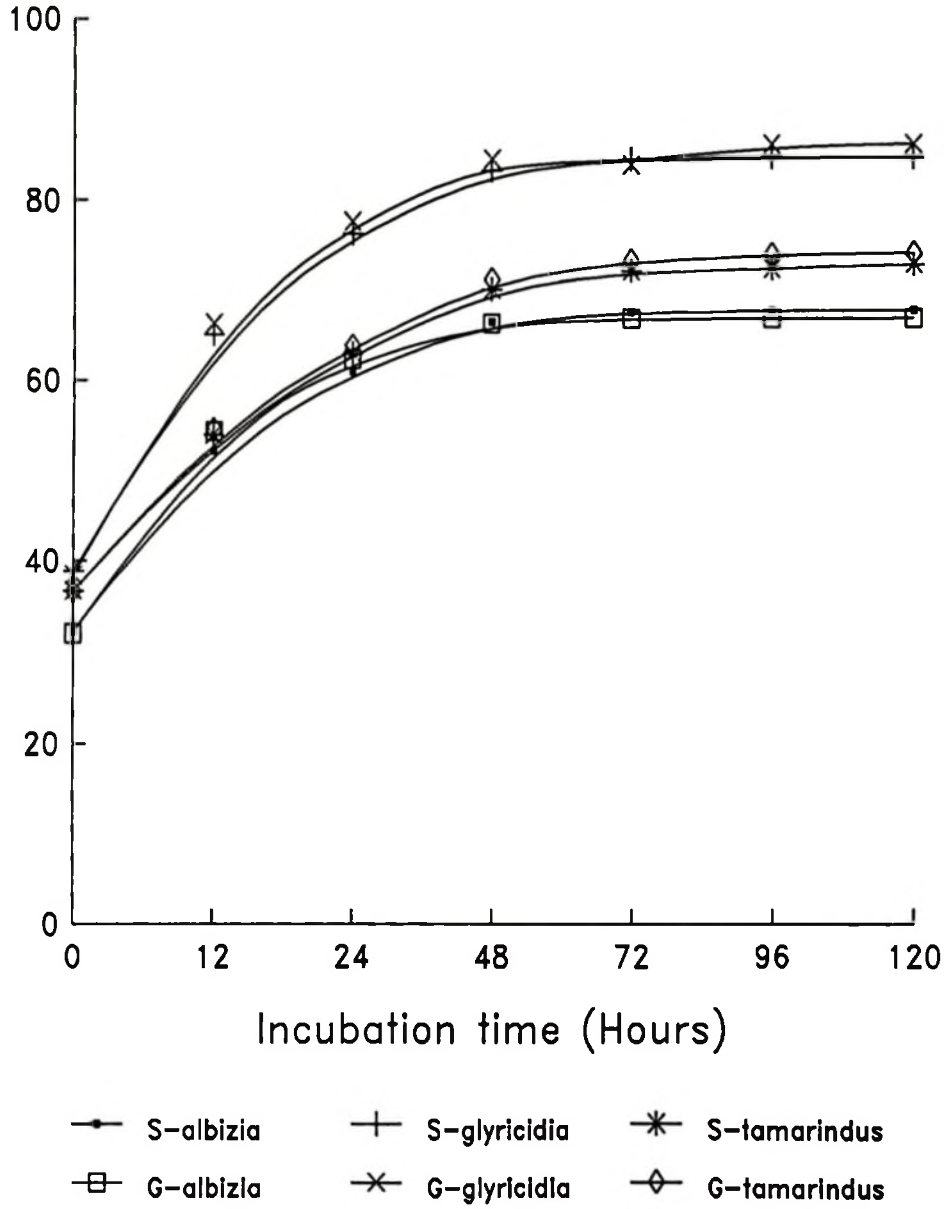

Figure 9 DM degradability of browses leaves by sheep (S) and goats (G) fed standard diet.

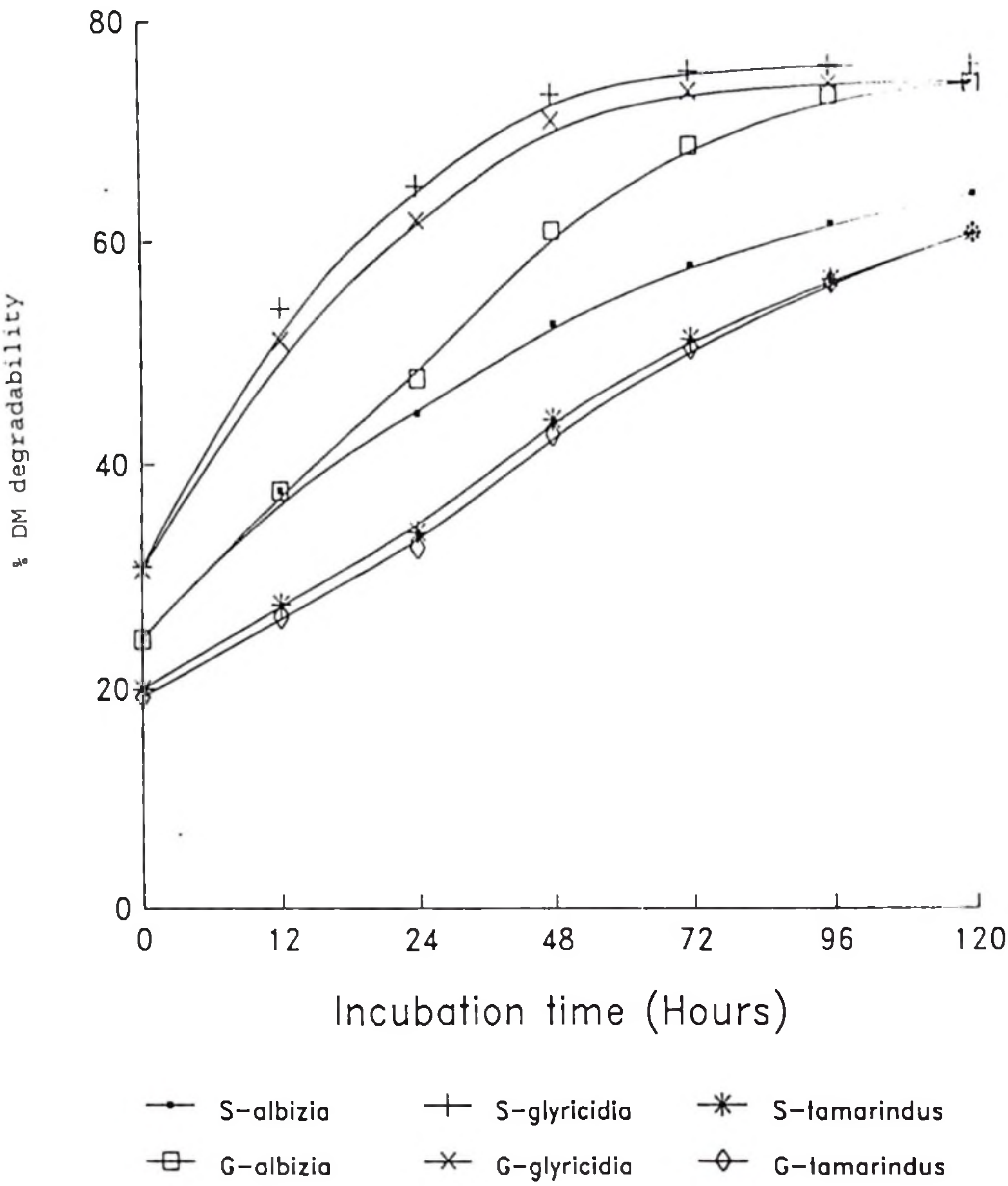

Figure 10 DM degradabilty of browses barks by sheep (S) and goats (G) fed standard diet.

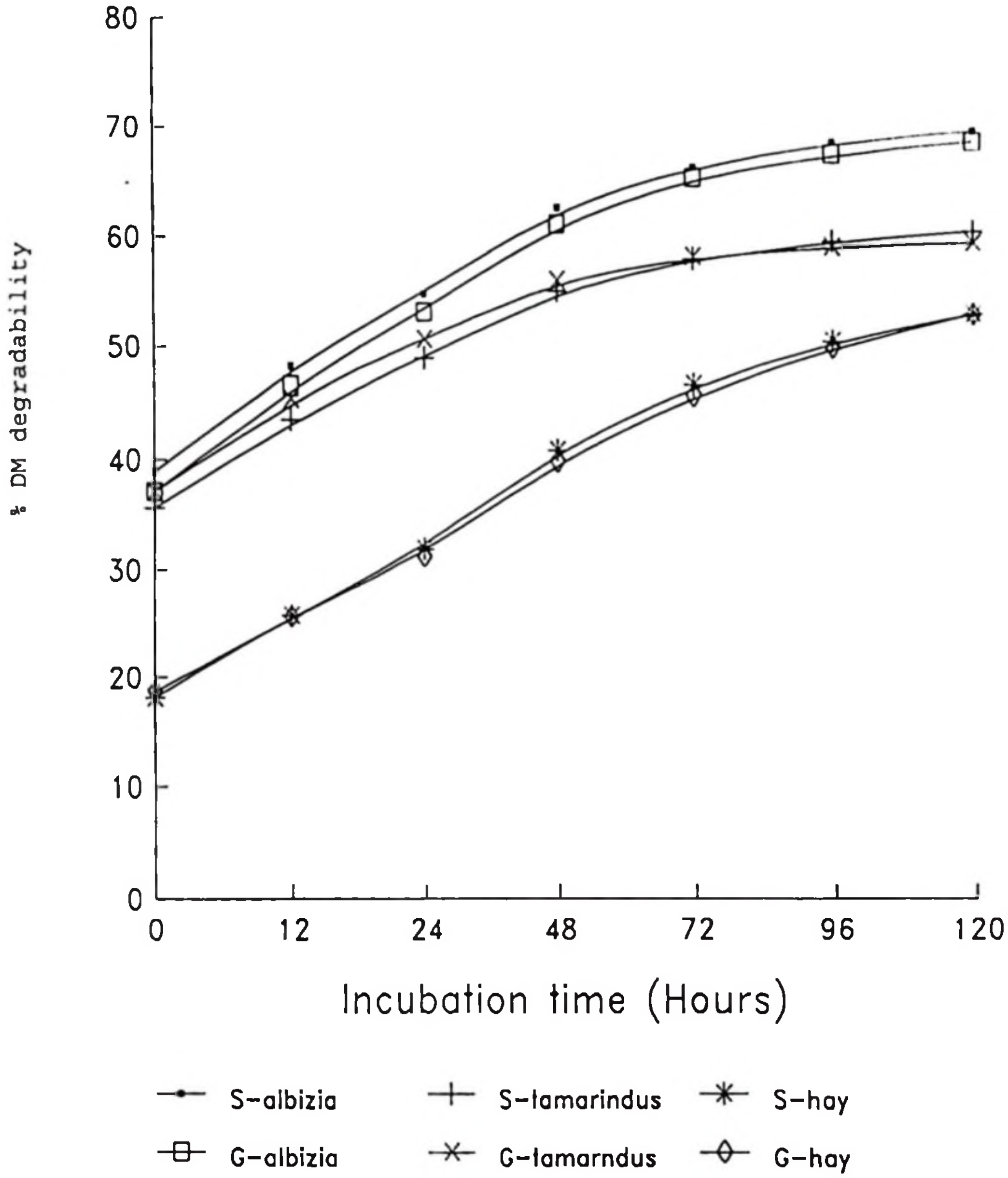

Figure 11 DM degradability of browses pods and hay by sheep (S) and goats (G) fed standard diet.

Leaves and pods had higher solubility values **(a)** for DM than barks and hay . Among the leaves that of *G. sepium* contained the highest water soluble component when compared to leaves of *A. lebbek* and *T. indica* . Slowly degradable fractions **(b)** for DM were lower in browse leaves and pods than in barks and hay except for *G. sepium* leaves and bark which showed higher fractions (Table 4.5). Potential degradable fractions **(a + b)** for DM varied significantly ($P < 0.05$) among the browse parts and hay (Table 4.5). They were highest in *G. sepium* leaves and bark of *A.lebbek*. Significant variations ($P<0.05$) of the DM degradation rate constants **(c)** were observed among the incubated browse parts and the hay. The (c) values were higher in all browse leaves and the *G. sepium* bark, ranging from 0.05 ± 0.01 to 0.08 ± 0.01 fraction per hour.

The effective DM degradability at 4 different passage rates and the 24 and 48 hours DM degradability of the various browse parts and hay are shown in Table 4.6. The effective DM degradability decreased as the passage rates increased from 1% to 4% per hour.

Table 4.6: LSMean for effective DM degradability at 4 different passage rates.

Feed	Effective degradability (% per time)				48h degradability (%)
	1	2	3	4	
A. lebbek leaves	63.33^{a}	60.10^{b}	57.43^{d}	55.28^{b}	65.72^{g}
G. sepium leaves	79.86^{b}	75.31^{f}	71.71^{c}	68.74^{c}	83.33^{c}
T. indica leaves	68.33^{c}	63.60^{d}	60.35^{a}	57.85^{b}	70.56^{a}
A. lebbek pods	61.75^{d}	56.82	53.62^{f}	51.33^{a}	58.46^{b}
T. indica pods	54.93^{d}	51.42^{e}	49.05^{b}	47.37^{d}	53.86^{d}
C. gayana hay	43.63^{f}	36.53^{g}	32.60^{e}	30.08^{a}	37.50^{f}
A. lebbek bark	61.30^{a}	53.07^{c}	48.20^{b}	44.93^{d}	56.04^{b}
G. sepium bark	68.57^{c}	63.60^{a}	59.77^{a}	56.70^{b}	71.04^{a}
T. indica bark	49.45^{e}	40.17^{e}	35.33^{e}	32.33^{e}	42.28^{e}
S.e.m (±)	0.72	0.64	0.68	0.69	1.02

Values within columns bearing the same superscript are not statistically different ($P > 0.05$)

5.0 DISCUSSION

5.1 Chemical composition

The lower values of CP and higher NDF contained in the hay than in the browse species (Tables 4.1a and 4.1b) indicates that the hay contained more fibres and less protein content than the browse. Such findings have been reported in Tanzania and elsewhere (Hartley and Jones,1977; Shoo,1986).

The CP contents of *A. lebbek* leaves and pods (22.2% and 22.9%) found in the present study were within the range of 18.1% to 22.2% reported in the literature (FAO,1980; Gupta,1981; Komwihangilo,1991) and lower than 29.2% reported by *Ganguli et al* (1964), cited by Skerman (1977). The CP content of *G. sepium* leaves (20.0%) falls within reported range of 18.0% to 25.4% (Carew, 1983; Kabaija,1985) but appeared to be lower than the value of 27.5% reported by Vearasilp (1981). The CP value for *G. sepium* bark in the present study appeared to be slightly lower than reported in other studies (Smith and Van Houtert, 1987). The CP contents was higher and lower for *T. indica* leaves and pods (12.3% and 8.7% respctively) than values(10.9% and 15.8% respectively) reported in other studies (NAS, 1979; Le Heuerou, 1980; FAO 1981; Komwihangilo,1991).

The calcium content of both leaves and bark of *G. sepium* in this study are higher than those obtained by other workers (Table 2.3). Published values were 0.19% and 1.3% for the leaves and bark in this order (Smith and Van Houtert,1987). *A. lebbek* leaves,bark and pods in the present study contained higher (1.5% to 2.7%) calcium values than those (0.52% to 2.02%) reported in other studies (Le Houerou,1980; FAO,1981; Komwihangilo,1991). The calcium levels (2.9% and 1.9%) for *T. indica* leaves and bark obtained in the present study are higher than the reported levels ranging from 0.25% to 2.86% (Le Houerou,1980; FAO,1981; Komwihangilo, 1991). However, calcium content (0.3%) of *T. indica* pods found in this study are lower than reported (0.7%) by Komwihangilo (1991).

Forage type, frequency of cutting and stage of regrowth have been reported to cause variation in nutritive value of most forage plants (Van Soest,1982). Such factors could lead to the observed differences in chemical composition reported by various workers in the literature and in this study.

5.2 Voluntary intake

The observation that sheep consumed more DM per day and per metabolic body weight than goats in this study is supported by other reports (Carew, 1983; Shoo, 1986).

Feed intake varies with weight, physiological state, species and breed of an animal. As sheep and goats in this study were at comparable average weights(28.8 vs 27.3 kgLW), age(56 vs 58 months) and similar physiological state (all were dry mature ewes and does) these factors could not cause the observed difference in DMI between the two species. Shoo (1986) in a comparison study between sheep and goats supplemented different levels of *L. leucocephala* with hay based diet concluded that higher intakes by sheep could possibly be due to higher intake of crude protein which is known to increase intake of low quality roughage(i.e, hay) in ruminants. The difference in crude protein intake between sheep and goats was not determined in this study but might have caused the observed differences in DMI. NRC (1981) pointed out that the maintenance requirements of goats may be considerably higher when the animals are allowed more freedom of movement. In this study experimental animals were confined a factor which could probably lead to lower maintenance requirements of goats compared to sheep.

Highest intake for *G. sepium* may have been due to higher CP, IVOMD, %DMD and less CF of the leaves and bark of this browse specie compared to others (Tables 4.1a, 4.1b and 4.5). These factors are positively correlated to voluntary intake of forages (Van Soest,1982). The higher content of minerals (Table 4.1a) observed in *G. sepium* components could also have caused more intake of this browse than others in experiments 1 and 2 as minerals often stimulate appetite of animals (Underwood, 1977).

A. lebbek had higher CF contents , lower minerals and lower degradability constants (Tables 4.1a and 4.5) which may have contributed to the lowest feed intake among the three browses. The DM values found in the present study (exprssed as % liveweight) are higher than those reported for maintenance requirements of tropical sheep and goats at comparable age (Devendra and Mcleroy, 1982; Carew, 1983).

The higher DMI observed in leaves relative to corresponding values in barks is similar to observations by Komwihangilo (1991) and could be attributed to greater levels of CP, minerals, IVOMD and lower levels of cell wall contents contained in the leaves (Tables 4.1a and 4.1b). Besides high digestible nutrients, higher digestibility and degradability coefficients could also contribute to the increased DMI observed in leaves. Similar trends have been reported in voluntary intake studies with tropical forages (Hendricksen *et al*,. 1981; Poppi *et al*,.1981; Minson, 1982). These authors were of the opinion that higher voluntary intake of leaves than stems could be attributed to physical factors, a large surface area for bacterial attack and shorter retention time in the rumen.

More DM intake of leaves than bark could probably be caused by the higher proportion of the former than the latter in the offered browses as reported in the study by Komwihangilo (1991).

A rejection of *A. lebbek* and *T. indica* pods by sheep and goats was observed in this study. Similar observation have been reported by Komwihangilo (1991). Other results (Lowry, 1989; Ralph, 1989) on the other hand found sheep and goats to like *A. lebbek* pods in Australia contrary to the present observations. The rejection of the pods and *T. indica* bark could probably be caused by physical factors such as ease of eating and tough texture and antinutritional factors which need to be evaluated.

The higher DMI observed in sheep and goats when offered *Chloris gayana* in addition to browses compared to sole browses is supported by findings of Shoo (1986) who fed sheep and goats low quality hay supplemented with different levels of *L. leucocephala*. Digestible nutrients such as amino acids and glucose precusors are known to enhance DMI through activation of cellulolytic fermenting bacteria. Thus provision of the browse legumes along with hay may have improved the rate and extent of degradation of the low quality hay. In several studies, increased passage rate has been observed along with increased voluntary intake when cattle fed low quality diets were supplemented with protein (Guthrie and Wagner, 1988). Increased DMI in sheep and goats offered *adlibitum* forages (single or mixed) with hay have been reported elsewhere (Haryanto *et al.*, 1982; Meuret, 1988).

Results from this study show that there is great potential and likelihood of improving energy and nutrient status of sheep and goats by supplementing low quality hay with MPT browses. Such an improvement could be more pronounced in sheep than in goats (Table 4.3).

5.3 Preference ranking of browse species

The observation that *G. sepium* ranked least in relation to other browses (Table 4.4) comform to the results reported by Komwihangilo (1991) and Semenye *et al* (1986). Apparently the preference for or against the browse species was not in any way related to their nutritive quality as judged by the CP and the degradability values (Tables 4.1a and 4.5). Strong repulsive odours caused by alkaloids (Larbi *et al.*, 1993) and other antinutritional factors reported elsewhere (Jong *et al.*,1989) could possibly cause rejection of *G. sepium* when animals are given chance to select among many feeds.

The least preference of G. sepium by sheep and goats might mean that the browse can efficiently be utilized when offered as sole diet or in combination with hay.

The highest DMI observed (Table 4.4) when all the three browses were simultaneously offered with hay (Experiment 3) to sheep and goats compared to those in experiments 1 and 2 is probably due to a better nutrient balance. It is also possible that when offered in combination , there were little chances for the animals to consume excessive quantities of any single antinutritional components in the forages . Mixed browses in this study might have prevented animal's detoxication mechanism from having to cope with a large dose of a single toxin as observed by Moss (1991), cited by Becker and Lohrmann (1992). The observed DMI could also be partly attributed to the increased opportunity for feed selection given to the animals in such a feeding system. Such an opportunity is known to cause higher voluntary intake of forages and shrubs (Devendra and Mclroy, 1982; Becker and Lohrmann, 1992).

5.4 Degradation characteristics

Different DM degradability constants **a**, **b**, **a+b** and **c** observed for various components of browses and hay in this study agree with the findings of Weisbjerg *et al* (1990) for different temperate grasses and legumes.

Similar variation in degradability constants has been reported for tropical forages and legumes (Mgheni,D.M personal communication,1993).

DM losses at 24 hours of incubation for leaves and bark of *G. sepium* (Table 4.5) are not in agreement with those reported by Van Houtert cited in Smith and Van Houtert (1987). Kabaija (1985) obtained rumen dry matter degradability values of 75.7% and 70.4% for glyricidia leaves at an age of six and 12 weeks respectively. In another study, Jong *et al* (1989) found lower (75.4% vs 84.53%) DM degradability values than those observed in this study for glyricidia leaves at 48 hours incubation period.

For the *A. lebbek* leaves the present findings are in disagreement to those (52.6% and 58.7%) of Jong *et al* (1989) at 24 hours of incubation for oven and freeze dried samples respectively. In this study only oven dried samples were used and DM degradability of 62.4% and 66.58% at 24 and 48 hours respectively were noted.

Oven drying of the samples before incubation, nutrient composition of the feeds, high levels of phenolic compounds and stage of growth and forage species have been reported as possible factors which can cause variation in DM degradability (Orskov *et al.,1980;*

Reed,1986; Mahyuddin *et al.*, 1988). The higher values of DM degradability shown in this study could have possibly been due to the practical problems associated with the nylon bag technique. It was noted that some amount of residues remaining after incubation could not be properly extracted from the bags. This may have exagerated the amount of DM that was actually degraded.

The observed low proportions of indigestible residues(**100-(a+b)**) and the highest degradation constants found in the leaves of all browse species (Table 4.5) and the bark of *G. sepium* suggest that the potentially degradable materials will pass across the rumen faster and hence create a space for more feed intake by the animal (Ørskov and Ryle, 1990). The same authors stated that the potential extent of digestion in the rumen determines the minimal proportion which persist as an indigestible residue which takes up space while it is retained in the stomach.

The effective DM degradability of different browse parts and the hay derived at a passage rate of 1% per hour using the 48 hour DM degradability values was found to be suitable for the assessment of their *in vivo* digestibility (Table 4.6) as proposed by Aerts *et al* (1977) and Xu and Sundstol (1991).

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A study was carried out to determine voluntary intake, nutritive value and selectivity of three browse species offered to sheep and goats.

In experiment 1 where animals were offered browses as sole diets, the DMI of *G. sepium* was highest followed by *T. indica* whereas that of *A. lebbek* was the least in both sheep and goats. There was a significant difference ($P<0.05$) in DMI of *A. lebbek* and *G. sepium* between sheep and goats whereas there was none for *T. indica* ($P>0.05$). The consumption of leaves was higher than that of bark in both sheep and goats.

In experiment 2 where *C. gayana* hay was offered in addition to browses DMI of *A. lebbek* increased and that of *G. sepium* and *T. indica* declined in relation to the values obtained in experiment 1. In goats DMI of the respective browses declined. Total DMI was higher ($P<0.05$) than that of experiment 1 in sheep and goats.

In experiment 3 when all the browses and hay were simultaneously offered to sheep and goats highest DMI were attained in relation to values obtained in experiment 1 and 2. Sheep had higher total DMI than goats although the difference was not significant ($P > 0.05$). *A. lebbek* ranked first and *T. indica* second in sheep whereas *T. indica* and *A. lebbek* ranked first and second respectively in goats. *G. sepium* ranked last in sheep and goats.

In experiment 4 leaves and pods of the browses contained higher soluble **(a)** and potential degradable components **(a+b)** than the bark and hay. Leaves had also highest degradation rate constants **(c)** compared to the rest of browse parts and hay. Slowly degradable materials **(b)** were higher in bark and hay than in leaves (except for *G. sepium*) and pods.

The increased DMI in sheep and goats when *Chloris gayana* hay was offered with the browses may suggest that animal performance which declines during the dry season can be improved by supplementing the available poor quality pasture with the browses.

The highest DMI revealed in sheep and goats exposed to all browses and hay could possibly mean that confined animals given chance to choose among various browse species can improve their performance through increased DMI.

The least preference of *G. sepium* shown in sheep and goats might mean that under cut and carry system where there is less labour and a tendency to avoid browse wastage, this browse specie should be offered first followed by *A. lebbek* and *T. indica* which seemed to be the most palatable in both sheep and goats. However, with availability of enough labour and browses an offer of more than one browse specie would be an appropriate approach if high levels of DMI and possibly improvement in performance are to be attained.

6.2 Recommendations

Since the types and levels of toxic and antinutritional substances of the studied browses were not evaluated in this study, there is a need to establish them as they are known to influence voluntary intake of the browses. Rumen degradability of protein in the browses has to be established.

There is a need to evaluate the effects of the browses on growth, reproductive and productive performances of sheep and goats when offered in dried or fresh forms at various levels.

More browse species should be included in preference studies to create more chance for selection by confined sheep and goats.

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8.0 APPENDICES

Appendix 1: Individual initial liveweights (kg) and ages (months) of experimental animals.

Sheep			Goats		
Animal	Age month	Initial weight (kg)	Animal No.	Age (moths)	Initial weight (kg)
05	35.0	32.0	321	30.0	27.6
121	34.0	30.4	0126	31.0	27.4
300	65.0	33.2	322	33.0	28.0
38	21.0	26.4	7167	36.0	24.8
03	22.0	24.4	7174	36.0	27.9
287	25.0	28.8	218	77.2	24.8
150	34.0	27.2	320	86.0	29.2
0049	37.0	29.2	224	44.0	26.2
77	90.0	29.4	7095	77.0	24.8
06	21.0	26.8	217	58.0	28.0
051	22.0	32.0	219	79.0	25.6
280	37.0	25.8	222	62.0	30.2

Appendix 2: Individual initial, final and mean liveweights for sheep and goats during the voluntary intake study.

(a) Experiment 1

Sheep				Goats			
Animal No.	Initial weight (kg)	Final weight (kg)	mean weight (kg)	Animal No.	Initial weight (kg)	Final weight (kg)	Mean weight (kg)
05	32.0	31.4	31.7	321	27.6	26.1	26.9
21	30.4	29.7	30.1	0126	27.4	26.8	27.1
300	33.2	32.7	33.0	322	28.0	27.0	27.5
38	26.4	25.2	25.8	7167	24.8	23.7	24.5
03	24.4	23.8	24.4				
287	28.8	28.0	28.4	218	24.8	24.3	24.6
150	27.2	26.7	27.0	320	29.2	28.6	28.9
0049	29.2	28.2	28.7	224	26.2	25.0	25.6
77	29.4	28.5	29.0	9095	24.8	23.8	24.3
06	26.8	26.3	26.6	217	28.0	27.7	27.9
051	32.0	31.6	31.8	219	25.6	24.2	24.9
280	25.8	25.1	25.5	222	30.2	29.2	29.7

Appendix 2 continued

(b) Experiment 2

Seep				Goats			
Animal No.	Initial weight (kg)	Final weight kg)	Mean weight (kg)	Animal No.	Initial weight (kg)	Final weight (kg)	Mean weight (kg)
05	31.4	28.0	29.7	321	26.1	26.4	26.3
121	29.7	31.0	30.4	0126	26.8	28.6	27.7
300	32.7	35.8	34.3	322	27.0	26.6	26.8
38	25.2	25.6	25.4	7167	23.7	24.0	23.9
03	23.8	24.2	24	7074	26.8	27.0	26.9
87	28.0	28.6	28.3	218	24.3	25.0	24.7
150	26.7	26.8	26.8	320	28.6	28.7	28.7
0049	28.2	28.0	28.1	224	25.0	23.4	24.2
77	28.5	29.6	29.1	9095	23.8	22.2	23.0
06	26.3	23.8	25.1	217	27.7	25.0	26.4
051	31.6	28.0	29.8	219	24.2	21.4	22.8
280	25.1	23.0	24.1	222	29.2	28.0	28.6

(c) Experiment 3

Sheep				Goat			
Animal No.	Initial weight (kg)	Final weight (kg)	Mean weight (kg)	Animal No.	Initial weight (kg)	Final weight (kg)	Mean weight (kg)
05	27.0	28.4	27.7	219	20.2	22.4	21.3
121	28.0	29.0	28.5	217	21.4	23.0	22.2
300	35.4	38.0	36.7	A7167	21.8	23.0	22.4
150	28.0	27.6	27.8	0	23.0	24.2	23.6
015	29.4	36.0	32.7	27693	31.2	33.6	32.4
3	25.0	24.8	24.9	5276	33.8	34.1	34.0

Appendix 3: Mean DM intake of individual sheep and goats in the voluntary intake study

(a) Experiment 1

			DM intake (g/day)		
Feed type	Species	Animal No.	Leaves	Bark	Total
A. lebbek	Sheep	03	307.1	225.1	532.2
		287	302.1	304.1	606.2
		150	317.6	260.7	578.3
		0049	319.2	249.1	568.3
	Goats	-	-	-	-
		218	258.6	152.2	410.8
		320	313.2	147.3	460.8
		224	313.3	260.7	573.0
G. sepium	Sheep	05	311.8	364.1	675.9
		121	431.1	28.1	718.2
		300	426.9	410.1	837.0
		38	461.2	325.0	786.2
	Goats	321	325.0	206.0	531.0
		0126	246.8	180.0	426.8
		322	325.1	111.7	436.8
		7167	300.1	295.1	595.2
T. indica	Sheep	77	529.8	-	529.8
		06	593.8	-	593.8
		051	601.9	-	601.9
		280	584.0	-	584.0
	Goats	9095	585.5	-	585.5
		217	586.5	-	586.5
		219	566.4	-	566.4
		222	593.7	-	593.7

Appendix 3 continued

(b) Experiment 2

Feed type	Species	Animal No.	DM intake (g/day)			
			Leaves	Bark	Hay	Total
A. lebbek	Sheep	03	370.9	172.0	412.5	955.4
		287	419.5	301.5	451.3	1172.3
		150	382.5	83.0	349.4	814.9
		0049	378.7	94.3	270.9	743.9
	Goats	7174	62.0	68.0	388.7	518.7
		218	153.8	42.5	413.7	610.0
		320	255.5	111.7	421.4	788.6
		224	397.1	175.2	311.4	883.7
G. sepium	Sheep	05	345.7	190.0	414.8	950.5
		121	336.5	190.0	307.9	834.4
		300	383.6	202.4	403.5	989.5
		38	382.9	214	306.5	903.4
	Goats	321	345.4	126.5	320.5	792.4
		0126	334.1	130.0	335.1	799.2
		322	342.7	84	340.3	767.0
		7167	339.6	160.5	330.9	831.0
T. indica	Sheep	77	316.5	-	73.5	389.5
		06	290.7	-	409.9	700.6
		051	326.6	-	504.0	830.6
		280	329.8	-	378.0	707.8
	Goats	9095	294.0	-	425.4	719.4
		217	349.6	-	377.3	726.9
		219	286.7	-	486.8	773.5
		222	299.0	-	344.3	643.3

Appendix 3 continued

(c) Experiment 3

		DM intake (g/day)						
Species	Animal No.	Albizia leaves	Glyricidia leaves	Tamarindus leaves	Albizia bark	Glyricidia bark	Hay	Total
Sheep	05	227.0	58.7	471.3	150.2	55.2	232.1	1294.5
	121	249.0	178.9	351.1	157.7	60.8	396.9	1394.4
	300	364.1	265.2	448.1	106.7	81.2	345.3	1610.6
	150	377.2	228.3	402.6	92.1	94.8	291.7	1446.7
	215	345.1	208.6	425.1	26.7	8.3	179.7	1193.5
	38	373.8	231.6	429.2	50.4	31.5	220	1336.5
Goats	219	301.3	101.3	402.2	29.5	25.4	252.3	1112.0
	217	133.7	250.3	433.1	65.2	59.2	378.1	1319.6
	A7167	85.4	256.5	442.4	54.6	64.0	345.0	1247.9
	0	315.5	236.1	470.0	69.2	82.8	341.7	1515.3
	27693	381.8	239.4	467.6	111	30.5	184.6	1414.9
	S276	378.9	225.9	452.8	70.3	96.2	172.1	1396.2

Appendix 4: Analyses of variance on the mean effects of species and forage on the voluntary dry matter intake of sheep and goats.

Variable	Source	DF	Mean square	Fvalue	Significant level
Experiment 1					
Leaves	Species	1	263116.65	17.20	*
	Forage	2	2923172.22	191.04	**
	Species x forage	2	198859.49	13.00	*
Bark	Species	1	503376.91	31.31	*
	Forage	2	5859325.79	364.44	**
	Species x forage	2	23575.68	14.65	*
Total DMI	Species	1	1478954.30	48.71	*
	Forage	2	3741343.50	123.22	**
	Species x forage	2	825228.81	27.18	*
Experiment 2					
Leave	Species	1	479797.99	21.13	*
	Forage	2	97524.70	4.30	*
	Species x forage	2	383221.52	16.88	*
Bark	Species	1	614969.01	70.01	*
	Forage	2	3354879.51	381.96	**
	Species x forage	2	192561.78	21.92	*
Hay	Species	1	154485.69	2.96	NS
	Forage	2	59494.85	1.14	NS
	Species x forage	2	171769.99	3.29	*
Total DMI	Species	1	1174681.91	10.85	*
	Forage	2	3065839.85	28.31	*
	Species x forage	2	1703182.83	15.72	*

* Significant ($P<0.05$)
** Highly significant ($P<0.05$)
NS Not significant ($P>0.05$)

Appendix 4 continued

Experiment 3					
Variable	Source	DF	Mean Square	F-value	Significance level
Leaves	Species	1	247.23	2.32	*
	Forage	2	16938.41	158.66	**
	Species x Forage	2	1380.01	12.93	*
Bark	Species	1	185.65	4.93	*
	Forage	2	3448.71	91.51	**
	Species x Forage	2	665.98	17.67	*
Leaves + Bark	Species	1	4.42	0.03	NS
	Forage	2	9729.21	57.61	**
	Species x Forage	2	3724.32	22.05	*
Hay	Species	1	811.36	3.82	NS
	Forage	2	-	-	-
	Species x Forage	2	-	-	-
Total DMI	Species	1	696.47	2.11	NS
	Forage	2	9730.06	29.46	**
	Forage x Species	2	3724.47	11.28	*

Appendix 5: Fitted values for feeds incubated in the rumen of sheep and goats fed standard diet

Feed/Animal	Time of incubation (hours)						
	0	12	24	48	72	96	120
G. sepium leaves							
Sheep	38.84	65.12	76.37	83.26	84.54	84.78	84.82
Goat	38.38	66.32	77.67	83.90	84.53	86.21	86.29
A. Lebbek leaves							
Sheep	32.26	52.20	61.00	66.58	67.66	67.87	67.92
Goat	32.06	54.37	62.40	66.39	66.39	67.01	67.02
T. indica leaves							
Sheep	36.65	54.00	63.00	70.18	72.22	72.50	73.00
Goat	32.59	54.56	63.81	71.23	73.39	74.06	74.27
A. lebbek pods							
Sheep	38.89	48.19	54.71	62.55	66.15	68.47	69.49
Goat	37.09	46.47	53.09	61.11	65.23	67.38	68.54
T. indica pods							
Sheep	35.55	43.57	48.87	54.92	57.90	59.51	60.46
Goat	37.08	45.38	50.58	55.92	58.10	59.01	59.41
C. gayana hay							
Sheep	18.12	25.69	31.80	40.72	46.55	50.38	52.90
Goat	18.69	25.58	31.23	39.72	45.62	49.85	52.84
G. sepium bark							
Sheep	30.84	53.97	65.17	73.44	75.58	76.17	76.34
Goat	30.55	51.03	61.98	71.06	73.72	74.51	74.96
T. indica bark							
Sheep	19.95	27.41	33.88	43.94	51.24	56.64	61.05
Goat	19.23	26.30	32.47	42.60	50.39	56.40	61.05
A. lebbek bark							
Sheep	24.48	37.60	44.47	52.54	57.90	61.81	64.71
Goat	24.40	37.61	47.64	61.06	68.90	73.53	74.62