Effects of Substituting Sunflower Seed Cake with *Acacia tortilis* Pods as Protein Source in Supplementary Diets of Small East African Goats

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Abstract

A study was undertaken to evaluate the effects of substituting sunflower seed cake with Acacia tortilis pods as a protein source in supplementing Small East African goats fed a basal diet of Brachiaria brizantha hay. Twenty-four growing female goats with mean body weight of 9.71 ± 1.56 kg were used in a growth experiment. Twelve adult bucks were used in a digestibility experiment. In the growth experiment, the animals were divided into four groups, each with six animals, while for the digestibility experiment the animals were divided into four groups, each with three animals. These groups were randomly assigned to four supplementary diets containing different proportions of sunflower seed cake and Acacia tortilis pods. In treatments one (T_1), two (T_2), three (T_3) and four (T_4) sunflower seed cake was replaced with Acacia tortilis pods at levels of 0.0%, 33.3%, 66.7% and 100%, respectively. The intake of hay and total DM tended to increase with increasing levels of Acacia tortilis pods in the supplementary diet, the highest intake (430 g DM/day) was observed in goats offered supplementary diet T_4. The CP intake (49.1 to 58.9g/day) did not differ significantly ($P>0.05$) among the treatments. The intake of ME was significantly ($P<0.05$) lower (3.0 MJ) for animals in T_1 than those in T_4 (3.7 MJ). In the digestibility trial, no significant ($P>0.05$) effect on apparent digestibility of DM, OM, CP and NDF and on nitrogen utilisation was observed between treatments. In the growth trial, significant ($P<0.05$) lower growth rate was observed in animals under T_1 (20g/day) than those in T_3 (32g/day) and T_4 (32g/day). Similarly, the feed utilisation efficiency for animals in T_1 (FCR=18.5) was significantly ($P<0.05$) lower than those of the animals in T_3 (FCR=13.1) and T_4 (FCR=13.5). Replacement of sunflower seed cake with Acacia tortilis pods in the supplementary diets at the level of 66.7% and 100% gave the highest hay and total DM intake, daily live weight gain and feed utilisation efficiency. Therefore, Acacia tortilis pods may be used in place of high cost oil cakes in the feeding of goats.

Keywords: Sunflower seed cake, *Acacia tortilis pods*, DMI, protein, goats

Introduction

The goats kept by smallholder farmers usually search for their own food from natural grasslands throughout the year. However, as a major source of feed to livestock, natural pastures in the tropics are limited both in quatity and quality, particularly during the dry season. Consequently, animals reared based on natural pastures are unable to meet their maintenance and

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production requirements, especially for protein (Van Soest, 1994). To achieve higher levels of production, supplementary feeds are needed. Unfortunately supplies of conventional protein supplements such as oil cakes are limited in supply and or too expensive to be afforded by farmers in rural areas. Strategies for using other supplementary feeds, which are cheap and locally available in rural areas, are therefore needed. Leguminous tree leaves and their seeds seem to be appropriate alternative protein sources to traditionally used oil cakes in the rations for ruminants.

There are many tree species and shrubs in the tropics that can be used as cheap protein sources. Most of them have high CP, minerals and vitamin contents (Olsson and Welin-Berger, 1989). The use of supplements from trees and shrubs to ruminants has been reported to be an economical and sustainable way of improving the quality of poor roughages (Shayo and Udén, 1997) and enhancing rumen microbial activities (Ondiek *et al*., 2000). *Acacia tortilis* is one of the most widely spread browse trees in the semi-arid areas of central Tanzania and provides an important source of browse for both wild and domesticated ruminant animals. Leaves and young shoots are browsed by sheep and goats and are important feed resources towards the end of the dry season. The value of this species is especially in its pods. As they fall down, they are picked up and eaten by ruminant livestock. The nutritive value of *Acacia tortilis* pods as a potential protein supplement has been reported by various authors (Shayo, 1992; Shayo and Udén, 1997; Bwire, 2002). Pod production from *Acacia tortilis* trees in central Tanzania has been estimated at 9000 kg/ha per year (Shayo, 1992) and CP content ranges from 12 to 19% (Shayo, 1992; Ngwa *et al*., 2000). The pods are palatable to ruminants (Gwynne, 1969) and have high digestibility and degradability coefficients (Shayo, 1992, 1998). This shows that *Acacia tortilis* pods could be exploited as a cheap protein source in the rations for ruminants. The present study was undertaken to evaluate the effect of substituting sunflower seed cake with *Acacia tortilis* pods in concentrate mixture on feed intake, nutrient digestibility, nitrogen utilisation and growth performance of Small East African goats fed a basal diet of *Brachiaria brizantha* hay.

Materials and methods

Location and climate of the study area

The experiments were conducted at the Department of Animal Science and Production, Sokoine University of Agriculture (SUA), Morogoro, Tanzania. The area lies at an altitude of about 500 – 600 m above sea level and receives an average annual rainfall of 600 – 1000 mm. The area has four seasons namely, short rainy season (early October – mid January), short dry spell (late January – end of February), long rain season (early March – late May) and long dry season (June – September).

Experimental animals

Twenty-four (24) growing female goats of the Small East African breed (Dodoma strain) were used for feed intake and growth performance experiment. The goats were eight to nine months old and had mean body weight of 9.7 ± 1.6 kg at the start of the experiment. For digestibility experiment, twelve adult bucks also of the Small East African breed were used. Before commencement of the experiment, all animals were de-wormed using Levamisole hydrochloride at a dose rate of 1 ml/10 kg body weight and were also injected with 1 ml of a multi-vitamin mixture. The animals were sprayed with an acaricide (Dominex®) once every week. The goats were housed individually in pens in a wooden slatted floor house. For the digestibility trial, the goats were confined in individual cages specially designed to allow easy collection of faeces and urine. Water was provided *ad libitum* to all animals.

Experimental feeds

The feeds used in the experiment were *Brachiaria brizantha* hay (basal diet) concentrate. The concentrate in treatment one (T_1), treatment two (T_2), treatment three (T_3) and treatment four (T_4) were made up of sunflower seed cake, *Acacia tortilis* pods, hominy meal and mineral mix. Sunflower seed cake protein was substituted with *Acacia tortilis* pods as a source of protein at the level of 0.0%, 33.3%, 66.7% and 100% in T_1, T_2, T_3 and T_4, respectively. In order to obtain this substitution, the diets were compounded so as to contain sunflower seed cake at 35.6, 23.7, 11.9 and 0.0%, *Acacia tortilis*

pods at 0.0, 18.1, 36.2 and 54.4%, Hominy meal at 62.4, 56.2, 49.9 and 43.6% for T_1, T_2, T_3 and T_4, respectively. Mineral mix was included at 2% in all the treatments. The hay was harvested from a *Brachiaria brizantha* plot grown at Tungi area within Morogoro municipality (about 8 km from SUA). The grasses were cut at flowering stage in May, 2001. Before feeding, the hay was chopped using an electric forage chopper. Sunflower seed cake was purchased from Mpwapwa township in Central Tanzania, the same place from where *Acacia tortilis* pods were collected during the dry season of October – November, 2001 and brought to Morogoro for the study. Hominy meal was purchased from the local maize mills in Morogoro Municipality.

Feed intake and growth performance study

The 24 growing female goats were divided into four groups, each with six animals, and randomly allocated to the four treatments. All animals were given a preliminary period of 14 days to adapt them to the experimental conditions and diets. During this period the goats were given *Brachiaria brizantha* hay *ad libitum* and 200 g per animal per day of their treatment supplementary diets. Data collection period lasted for 90 days during which the animals were given their supplementary treatment diets at 0830 h at a rate of 20 g DM per kg body weight per day as recommended by Madsen *et al.* (1991) for local goats under Morogoro environment. The leftovers of the supplementary diets were collected and measured before the animals were provided with their ration in the following day. The animals were given hay in two equal portions (250 g per animal each time), one at 1000 h and another at 1530 h, to allow 5 – 10% hay refusal. Hay refusals for individual animals were collected and weighed the following morning (0700 h) before the next supplementary diet feeding. Daily feed offered and refusals were recorded separately for the supplementary diets and hay and their DM measured. The difference between the feed DM offered and refusals DM was taken as the amount of voluntary DM feed intake.

Chemical analysis and *In vitro* Digestibility

Samples of feeds offered and refusals were ground to pass in a 1 mm screen and representative sub-samples were subjected to proximate analysis following the AOAC (1990) procedure. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined using the method described by Goering and Van Soest (1970). *In vitro* dry matter digestibility (IVDMD) and *in vitro* organic matter digestibility (IVOMD) were determined according to Tilley and Terry (1963). The IVOMD values were used to estimate metabolisable energy (ME) according to MAFF (1975).

All animals were weighed for three consecutive days at the beginning of the experiment, taking the means as initial weights. The same weighing procedure was employed at the end of the experiment for final weights. In between, the animals were weighed once per week. Weighing was done at 7.30 h in the morning prior to feeding using an electrical digital weighing balance. Daily weight gain was derived as the difference between the initial and final body weights divided by the number of days in experiment.

Digestibility experiment

The male goats were used in this experiment to determine *in vivo* digestibility and nitrogen utilisation of the four supplementary diets described above. Three animals were randomly allocated to each treatment. The animals were confined in individual digestibility cages. The cages were fitted with wire mesh and a plastic sheet underneath to allow separate collection of faeces and urine. The goats were given a preliminary period of 14 days to adapt to the cages and feeds. This was followed by seven days of data collection. On each of all 21 days every animal was given hay at 0830 h and 1530 h, offered in amounts to allow 5 – 10% refusals. The goats were also given their respective supplementary diets at 1030 h at a rate of 15 g DM/kg body weight, based on experiences in the growth experiment, and had free access to clean water all the time. The amounts of hay and supplementary diets offered and leftovers for each animal were recorded daily and representative samples taken for DM determination. The faeces and urine produced by each animal were collected and measured daily at 0730 h. Soon after weighing, the faeces were thoroughly mixed and 20% stored in a deep freezer at –5°C. At the end of the collection period the samples were bulked and a

sub-sample taken for chemical analysis. Chemical analyses of feed offered, refusals and faeces were made for DM, ash, OM, CP and NDF as described above. Of the day's excreted urine from each animal 10% was preserved in airtight bottle by adding 20 ml of dilute sulphuric acid in the collection bucket. The animal's urine samples were bulked at the end of the collection period and a sub-sample taken for analyses. The urine, faeces, hay and supplementary diets were analysed for nitrogen content by Kjeldahl method.

Statistical analysis

The effects of treatment on feed intake, digestibility and growth rate were analysed using the General Linear Model (GLM) procedure of SAS version 6.12 (SAS, 1998). In the analysis of growth rate, initial body weights of the animals were used as covariate.

Results

Feed intake and growth experiment

Chemical composition of feed ingredients and treatment supplementary diets fed to goats are given in Table 1. Sunflower seed cake had a higher DM, OM, CP, NDF and ME content than *Acacia tortilis* pods, which had higher ash content, IVDMD and IVOMD than sunflower seed cake. Among the supplementary diets, T1 had the highest content of DM, OM, CP and NDF. It also showed the highest IVDMD and IVOMD. The ME contents of the supplementary diets were similar.

Table 1: Chemical composition of the feed ingredients and supplementary diets (treatments)

	Hay	Sunflower seed cake	*Acacia tortilis* pods	Hominy meal	Supplementary diets			
Feed ingredient					T1	T2	T3	T4
DM(g/kg)	862	904	869	876	905	894	889	874
OM (g.kg DM)	868	956	932	929	934	933	921	917
Ash (g/kg DM)	132	44	68	71	66	67	79	83
CP(g/kg DM)	114	239	164	120	176	170	165	165
NDF (g/kg DM)	752	465	390	220	495	391	411	403
ADF (g/kg DM)	-	-	-	-	328	295	324	301
IVDMD (%)	56.8	43.5	50.9	77.9	67.3	64.7	62.1	65.4
IVOMD(%)	57.9	46.1	51.2	78.4	68.2	66.9	65.4	66.9
ME (MJ/kg DM)	7.7	12.6	11.0	13.3	11.4	12.4	11.8	11.9

Dry matter intake (DMI) of basal diet and supplements and intake of CP and ME by goats in different treatments are presented in Table 2. The DMI of the supplementary diets did not differ significantly (P>0.05) among the treatments. Hay intake was significantly (P≤0.01) lower for T_1 than for the other treatments (T_2, T_3, and T_4) while total feed intake was significantly (P≤0.05) lower for T_1 than T_4 while there was no significant difference between the other treatments.

tively. The CP intake did not differ significantly (P>0.05) among treatments, though it was lowest for T_1 (49 g/day) and highest for T_4 (59 g/day). The intake of ME ranged from 3.0 to 3.7 MJ/ day and was significantly (P≤0.05) different only between T_1 and T_4.. Growth performance and feed conversion ratio of the goats in

Table 2: Mean DM intake of hay, supplementary diets and intake of CP and ME by goats under different treatments

Parameter	Treatments					
	T_1	T_2	T_3	T_4	Se	Signif.
Hay (gDM/dat	145.7^b	203.3^a	211.7^a	236.5^a	15.1	**
Supplementary diet (g DM/day)	185.0	197.1	192.9	193.6	12.5	NS
Total feed intake (gDM/day)	330.6^b	400.5^{ab}	404.6^{ab}	430.1^a	25.6	*
Feed intake, g/kg $W^{0.75}$	37.9^b	41.9^a	43.2^a	44.6^a	1.1	**
CP intake (g/day)	49.1	56.6	55.9	58.9	3.5	NS
ME intake (MJ)	3.0^b	3.6^{ab}	3.5^{ab}	3.7^a	0.2	*

Means in the same row with different superscript differ significantly

*=P<0.05, **= P<0.01, NS=Non-significant.

The intake of hay and total feed intake tended to increase with increasing levels of *Acacia tortilis*. pods in the supplementary diet, the highest intake of both hay and total feed was shown by goats under supplementary diet T_4. Feed intake in terms of g/kg $W^{0.75}$ was significantly (P≤0.01) lower for T_1 than for the other treatments (T_2, T_3, and T_4). The highest and lowest values were observed in T_4 (44.6 g/kg $W^{0.75}$) and T_1 (37.9 g/kg $W^{0.75}$) respec-

different treatments are shown in Table 3. The animals had similar weights at the start of the experiment. Significant (P≤0.05) differences were observed in growth rate between the animals in T_1 and those in T_3 and T_4. The growth rate of the animals in T_3 was the highest

Table 3: Growth performance and feed conversion ratio of goats under different treatments

Parameter	Treatments				SEM	Signif.
	T_1	T_2	T_3	T_4		
Mean intial weight (kg)	9.4	9.9	9.6	9.7	0.7	NS
Mean final weight (kg)	11.2	12.4	12.5	12.6	0.8	NS
Total weight gain (kg)	1.8^{b}	2.4^{ab}	2.9^{a}	2.9^{a}	0.3	*
Growth rate (g/day)	19.5^{b}	26.6^{ab}	32.0^{a}	31.8^{a}	3.0	*
Feed conversion ratio (FCR)	18.5^{a}	15.6^{ab}	13.1^{b}	13.5^{b}	1.3	*

*=P<0.05, NS= Non-significant.

(32.0 g/day) while that of the animals in T_1 was the lowest (19.5 g/day). Animals in T_1 needed significantly (P<0.05) more feed per kg gain than animals in T_3 and T_4. Hence, the feed conversion ratio for animals in T_1 was higher (P≤0.05) than that of the animals in T_3 and T_4. The feed conversion ratio decreased with the increasing level of *Acacia tortilis* pods in the supplementary diets.

Table 4: *In vivo* digestibility and nitrogen utilisation by goats under different treatments

Parameter	Treatments				SE	Signif.
	T_1	T_2	T_3	T_4		
Degestibility coefficients (%)						
DM	63.5	64.3	66.4	68.0	2.1	NS
OM	68.0	68.4	70.5	72.2	2.0	NS
CP	63.2	60.3	62.6	64.3	2.5	NS
NDF	67.2	65.4	64.6	67.7	1.9	NS
Nitrogen utilisation						
N-intake (g/day)	12.2	11.6	13.2	14.6	1.3	NS
N-excretion (g/day)						
Faecal - N	4.6	4.2	5.1	5.3	0.6	NS
Urinary - N	6.8	6.2	6.5	6.5	0.7	NS
Total N excretion	11.4	10.4	11.6	11.8	1.3	NS
N-absorbed (g/day)	7.6	7.4	8.1	9.3	0.7	NS
N-retained (g/day)	0.8	1.2	1.6	2.8	0.6	

NS=Non-significant

Digestibility experiment

In the digestibility trial, substitution of sunflower seed cake with *Acacia tortilis* pods at different levels had no significant ($P>0.05$) effect on apparent digestibility of DM, OM, CP, NDF and nitrogen utilisation (Table 4). However, animals under T_1 showed the lowest digestibility coefficients for DM (63.5%) and OM (68.0%) while animals under T_4 showed the highest digestibility coefficients for all the nutrients. The amount of N absorbed ranged from 7.4 to 9.3 g/day while N balance ranged from 0.8 to 2.8 g/day. The animals under T_1 had the lowest amount of N retained while those under T_4 had the highest.

Discussion

The chemical composition and the IVDMD and IVOMD of the *Acacia tortilis* pods found in the present study are in agreement with the values reported by Shayo (1998) and Bwire (2002). Shayo (1998) determined the chemical composition and digestibility of different parts of *Acacia tortilis* and found the CP content to be 12.7, 16.6, and 30.9% of the DM and IVDMD to be 72.2, 68.0 and 83.6 % for empty pods, whole pods, and seeds, respectively. Bwire (2002) reported the CP and ME contents in *Acacia tortilis* pods to range from 14.8 to 19.6% and 11.1 to 11.8 MJ/kg DM, respectively. The CP and ME contents for all the supplementary diets were higher than the 12% CP and 8.4 MJ/kg DM contents of the diet, considered to be ideal for a goat diet (Devendra and Burns, 1983). The lack of significant difference in terms of CP and ME contents and IVDMD and IVOMD between the treatments is an indication that *Acacia tortilis* pods can be used in place of sunflower seed cake in the concentrate mixture without affecting the concentration of nutrients and the digestibility of the ration.

Hay intake and total dry matter intake increased with increasing inclusion levels of *Acacia tortilis* pods in the supplementary diets. The high feed intake shown by goats, which were supplemented with a concentrate containing *Acacia tortilis* pods as the sole source of protein is an indication that *Acacia tortilis* pods are more palatable than the sunflower seed cake. Gwynne (1969) reported that the palatability of *Acacia tortilis* pods is due to a strong smell that attracts ungulates to eat them. The increased total DMI could also be attributed to the higher degestibility of the *Acacia tortilis* pods compared to sunflower seed cake (Table 1). An increase in apparent digestibility of DM and OM with increasing level of *Acacia tortilis* pods in the supplementary diets is consistent with the findings of Bitende (1994) who observed increased digestibility of DM and OM in sheep supplemented with *Acacia tortilis* and *Sesbania* leaves. The author reported that browse trees contain high amount of protein, minerals and vitamins. which are essential forthe growth of rumen microbes. Thus. supplementation of low quality roughages with browse tree leaves/seeds improves rumen microbial activity and fermentation pattern and consequently increases the dry matter intake and digestibility. This is supported by Nherera *et al.* (1998) who reported that supplementation of poor quality roughages with high N containing multipurpose trees increases feed intake and digestibility in ruminants due to elimination of the effect of N deficiency. The increase in the amount of N absorbed with increasing levels of *Acacia tortilis* pods observed in the present study may be an indication that the efficiency of utilising N taken improved with the increasing level of *Acacia tortilis* pods in the supplementary diet. It may also be due to the presence of condensed tannins in the pods which have a tendency of binding proteins to form complexes. reducing their degradability in the rumen and thus becoming by-pass protein. Some of the complexes formed in the rumen dissociate at low pH in the abomasums and make the protein available for digestion in the small intestine. thus providing additional source of amino acids to the animal (Miller, 1994). This is supported by proportionally lower N excreted in the urine in animals fed high levels of *Acacia tortilis* compared to those fed high sunflower seed cake.

Total and average daily weight gain observed in this study indicates that substitution of sunflower seed cake with *Acacia tortilis* pods improved the growth performance of the goats. The growth rates of the animals increased with the level of replacement of sunflower seed cake with *Acacia tortilis* pods in the supplementary diets. This response can be attributed to the high total DMI and CP intake in animals given supplementary diets with large proportions of *Acacia*

tortilis pods. This is in agreement with the findings of Ndlovu and Sibanda (1996) who reported a high growth rate (67 g/day) of kids supplemented with 300 – 400 g/day of *Acacia tortilis* pods and concluded that *Acacia tortilis* pods are suitable protein supplements for growing goats. The significant improvement in the live-weight gain of growing goats resulted from a more efficient feed utilization with increasing levels of *Acacia tortilis* pods in the supplementary diet, something which suggests that replacement of sunflower seed cake with *Acacia tortilis* pods improved nitrogen utilization of the diet and consequently resulted in increased consumption of total dry matter with a corresponding increase in live-weight gain and feed conversion efficiency. Goats given the supplementary diet containing *Acacia tortilis* pods as sole source of protein had higher feed conversion efficiency and required only 13.5 g DM of feed to produce one g of weight gain per day compared to 18.5 g DM of feed for the supplementary diet containing sunflower seed cake as the sole source of protein.

Conclusion

Substitution of locally produced sunflower seed cake with *Acacia tortilis* pods in a concentrate mixture had significant effects on the intake of hay and total DMI. The high level of total DM intake resulted in improved growth rate and feed conversion efficiency, which increased with the level of replacement of locally produced sunflower seed cake with *Acacia tortilis* pods in the supplementary diets. Replacement of sunflower seed cake with *Acacia tortilis* pods in the supplementary diets at the level of 66.7% and 100% gave the highest daily live weight gain and feed utilisation efficiency. Therefore, it can be concluded that *Acacia tortilis* pods are a potential protein supplement that may be used to replace high cost oil cakes in the feeding systems of goats with good growth performance results.

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References

AOAC, 1990. Official Methods of Analysis, 15th edn. Association of Official Analytical Chemists (AOAC), Washington D.C. pp 69-88.

Bitende S.N., 1994. The potential of *Acacia tortilis* fruits and *Sesbania sesban* leaves as livestock feeds in smallholder farming systems. M.Sc. dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden. pp 1-10.

Bwire J.M.N., 2002. Feeding strategies for dual-purpose cattle in semi-arid areas of Tanzania. PhD thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden. pp 1-12.

Devendra C. and Burns M., 1983. Goat production in the tropics, 2nd edn. Commonwealth Agricultural Bureau, Slough, UK. pp 183.

Goering H.K. and Van Soest P.J., 1970. Forage fibre analysis, USDA handbook No. 379, pp 1 - 20.

Gwynne M.D., 1969. The nutritive value of Acacia pods in relation to Acacia seed distribution by ungulates. E. Afri. Wildlife J. 7: 176 – 178.

Madsen, A., Mtenga, L.A. and Muhikambele, V.R.M. 1991. Protein not a limiting factor. Spores 34: 12.

MAFF, 1975. Ministry of Agriculture, Fisheries and Food. Energy allowances and feeding systems for ruminants. Technical bulletin, Ministry of Agriculture, Fisheries and Food, No. 62, pp 62 – 67.

Miller S.M., 1994. The role of *Acacia aneura* in animal production. In: Gutterridge R.C. and Shelton H.M. (Eds), Forage tree legumes in tropical agriculture. CAB International, UK., pp. 245 – 254.

Ndlovu L.R. and Sibanda L.M., 1996. Potential of *Lablab purpureus* and *Acacia tortilis* pods in smallholder goat kid feeding systems in semi-arid areas of South Africa. Small Rumin. Res. 21: 273 – 276.

Ngwa A.T., Nsahlai I.V. and Bonsi M.L.K., 2000. The potential of legume pods as supplements to low quality roughages. S. Afri. J. Anim. Sci. 30: 107 – 108.

Nherera F.V., Ndlovu L.R. and Dzowela B.H., 1998. Utilisation of *Leucaena diversifolia*, *Leucaena esculenta*, *Leucaena palida* and *Calliandra calothyrsus* as nitrogen supplements for growing goats fed maize stover. Anim. Feed Sci. and Technol. 74: 15 – 28.

Olsson A. and Welin-Berger S., 1989. The potential of

local shrubs as feed for livestock and mineral content of some soil licks in central Tanzania. Working paper No. 125, Swedish University of Agricultural Sciences, Uppsala, Sweden, 24 pp.

Ondiek J.O., Tuitoek J.K., Abdulrazak S.A., Bareeba F.B. and Fujihara T., 2000. Use of *Leucaena leucocephala* and *Gliricidia sepium* as nitrogen sources in supplementary concentrates for dairy goats offered Rhodes grass hay. Asian-Australasian J. Anim. Sci. 13: 1249 – 1254.

SAS, 1998. Statistical Analysis System, SAS/STAT user,s guide. Statistical Analysis Institute, Inc., Cary, NC, USA.

Shayo C.M., 1992. Evaluation of water melon as source of water, and water melon seeds and Acacia pods as protein supplements for dairy cows in central Tanzania. M.Sc. dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden. pp 4-89.

Shayo C.M., 1998. Browse leaves and pods as ruminant feed in central Tanzania. PhD thesis. Swedish University of Agricultural Sciences. Uppsala, Sweden. pp 25.

Shayo C.M. and Udén P., 1997. Comparison of water melon (*Citrus vulgaris*) seed meal, *Acacia tortilis* pods and sunflower seed cake supplements in central Tanzania: The effect on hay intake and milk yield and composition of Mpwapwa cows. Trop. Grassl. 31: 130 –134.

Tilley J.M.A. and Terry R.A., 1963. A two-stage technique for *in vitro* digestion of forage crops. J. Brit. Grassl. Soc., 18: 104 – 111.

Van Soest P.J., 1994. Nutritional ecology of the ruminants, 2nd edn. Comstock publishing associates, Cornell University Press, Ithaca, London, pp.476.