Tropical and Subtropical Agroecosystems

EFFECTS OF SUPPLEMENTING MAIZE STOVER WITH CLITORIA, GLIRICIDIA AND MUCUNA ON PERFORMANCE OF LACTATING JERSEY COWS IN COASTAL LOWLAND KENYA

[EFECTO DE LA SUPLEMENTACIÓN DE RASTROJO DE MAIZ CON CLITORIA, GLIRICIDIA Y MUCUNA EN EL COMPORTAMIENTO DE VACAS JERSEY LACTANTES EN KENIA]

H.K. Juma[1], S.A. Abdulrazak[1], R.W. Muinga[2*] and M.K. Ambula[1]

[1]Egerton University, P.O Box 536 Njoro, Kenya, E-mail: sabdulrazak@yahoo.com
[2]KARI, Mtwapa, P.O. Box 16 Mtwapa, 80109 Kenya, Fax: 041 5486207,
E-mail: karimtw@wananchi.com
**Corresponding address*

SUMMARY

A study was carried out at the Kenya Agricultural Research Institute's Mtwapa Centre to evaluate *Mucuna pruriens* (Mucuna) and *Clitoria ternatea* (Clitoria) as protein supplements based on the performance of lactating Jersey cows offered maize stover. Gliricidia, the recommended legume supplement to grass based diets for dairy feeding in coastal Kenya was used as the baseline for comparison. Twelve Jersey cows in their mid-lactation were divided into four groups balanced for initial live weight and milk yield. One group was fed the control diet, alone which consisted of maize stover *ad libitum* plus three kilograms of maize bran daily. The remaining three groups were fed the control diet supplemented with eight kilograms of fresh Clitoria, Gliricidia or Mucuna. Data was collected for seven weeks after a seven-day adaptation period. Maize stover had a lower crude protein concentration (5.2 %) than the minimum requirement (7 %) for optimal microbial activity in the rumen. Crude protein concentrations of Gliricidia and Clitoria were higher compared to that of Mucuna (23.2 and 21.8 vs. 18.0 %). Gliricidia had the highest concentration of tannins (2.23%) which was however lower than the critical level of 6 %. Nitrogen bound to neutral detergent fibre (3.5 %) was also highest in Gliricidia. Supplementing maize stover with any of the three legumes did not affect the intake of the basal diet. It however resulted in increased total dry and organic matter intakes. Apparent dry and organic matter digestibilities were improved by legume supplementation. Cows fed Clitoria, Gliricidia and Mucuna yielded 15, 20 and 15 % more milk than those fed the control diet alone. Milk yield, dry matter intake and apparent digestibility were similar between the legumes.

Key words: legume supplementation, feed intake, diet digestibility, milk yield, Jersey cows

RESUMEN

El trabajo se llevó a cabo en el Centro experimental Mtwapa del Instituto de Investigación Agrícola de Kenya (KARI) para evaluar *Mucuna pruriens* (Mucuna) y *Clitoria ternatea* (Clitoria) como suplementos proteínicos para vacas Jersey lactantes consumiendo rastrojo de maiz. Gliricidia es la leguminosa recomendada en Kenya para suplementar vacas lecheras alimentadas con dietas basadas en pastos y fue empleada como tramiento de línea base para comparación. Doce vacas Jersey a mitad de su lactancia fueron divididas en cuatro grupos balanceados por peso inicial y producción de leche. Un grupo fue alimentado con la dieta control: rastrojo de maíz *ad libitum* más tres kg de salvado de maíz. Los tres grupos restantes fueron alimentados con ocho kg base fresca de Clitoria, Gliricidia o Mucuna. Se colectó información por siete semanas, después de siete días de adaptación. El rastrojo de maíz tuvo una concentración de proteína cruda (5.2 %) menor a las necesidades mínimas para una actividad microbial óptima a nivel ruminal (7 %). Las concentraciones de proteína cruda de la Gliricidia y Clitoria fueron más altas que las de Mucuna (23.2 y 21.8 vs. 18.0 %). Gliricidia tuvo la mayor concentración de taninos (2.23%). El nitrógeno ligado a la fibra detergente neutra fue mayor en Gliricidia (3.5 %). La suplementación del rastrojo de maíz con las leguminosas no tuvo efecto sobre el consumo de la dieta basal. Sin embargo, resultó en un mayor consumo total de materia seca y materia orgánica. La digestibilidad aparente de la materia seca y materia orgánica fue mejorada por la suplementación con leguminosas. Las vacas alimentadas con Clitoria, Gliricidia y Mucuna tuvieron una producción de leche 15, 20 y 15 % mayor que aquellas alimentadas con la dieta control. La producción de leche, el consumo y digestibilidad de la material seca fueron similares para todos los tratamientos con leguminosas.

Palabras clave: Suplementación, leguminosas, consume, digestibilidad, producción leche.

INTRODUCTION

There are commercial opportunities on marketing and consumption of dairy products in coastal lowland Kenya (Swallow, 1996). Unsatisfied demand calls for increased milk production (66 % deficit). However, feed quality and quantity are the major constraints to dairy production in the region (Muinga *et al.,* 1999). Most dairy farmers rely on natural pastures from the farm or cut and carried to the animals from roadsides and fallow land off-farm. These pastures are of variable quality and in cases of severe droughts may not be available (Abdulrazak, 1995).

The other available option farmers have is to feed their animals on crop residues. Maize stover is a common crop residue in coastal Kenya. It is characterised by low nitrogen (<3 % CP) and over 70 % NDF (Urio and Kategile, 1987). As a result of this, addition of a readily available source of nitrogen and/or energy is essential to benefit its use as animal feed (Abdulrazak, 1995). The commercial protein sources are expensive and alternatives such as leguminous forages are needed.

Clitoria ternatea (Clitoria) and *Mucuna pruriens* (Mucuna); two herbaceous legumes that have been recommended for soil fertility improvement in coastal Kenya (Saha *et al*., 1997); have a good potential as protein supplements considering their high crude protein content. This study was therefore conducted to evaluate the effects of supplementing maize stover with Clitoria and Mucuna in comparison with Gliricidia; the recommended legume supplement for roughage diets in dairy feeding; on feed intake, diet digestibility and milk yield of lactating Jersey cows.

MATERIAL AND METHODS

Experimental site and animals

This study was carried out at the Kenya Agricultural Research Institute's Mtwapa Centre, in coastal lowland Kenya. The area has an average annual rainfall of 1200 mm. Mean monthly minimum and maximum temperatures are 22^0C and 30^0C respectively. The relative humidity is high (>80%) Jaetzold and Schmidt, (1983).

Twelve lactating Jersey cows in their mid lactation (approximately 100 days in lactation) with an average age and live weight of 7.2 years (±4) and 260 kg (±45) respectively were selected from a dairy herd grazing natural pastures. Their average daily milk yield was 4.8 kg (±2.1). The animals were weighed and then grouped into four. The groups were balanced for initial milk yield (4.8 kg) and body weight (260 kg). They were housed in well-ventilated stalls with individual feeding facilities. They were also sprayed weekly with an acaricide against external parasites. All the animals were dewormed at the start of the experiment to control internal parasites. Blood samples were taken every week from the jugular vein to screen for East Coast fever (ECF) and trypanosomosis parasites.

Feeds and experimental diets

Maize stover was harvested from a coast composite maize crop established at the Centre, and stored at the beginning of the experiment. Gliricidia was cut back and the two months regrowth used to feed the animals. Clitoria and Mucuna were established at the onset of the long rains and harvested after attaining 50 - 60% flowering. Maize bran and mineral licks used in this experiment were purchased in bulk from a local supplier.

The control treatment comprised of maize stover fed *ad libitum*, plus 3 kg of maize bran and 70 g of dairy mineral lick. The other three treatments consisted of the control, plus 8 kg of fresh Clitoria, Gliricidia or Mucuna (equivalent to approximately 2 kg DM). Clean water was availed at all times.

Experimental procedures

Maize stover was chopped to about 40 mm before feeding to the animals. Clitoria and Mucuna were harvested at 10 cm from the ground and chopped to about 20 mm pieces using a machete before feeding to the animals. Leaves and tender twigs of approximately 5 mm diameter were separated from Gliricidia branches and fed to the animals. The basal diet was offered at 0800 h and added at 1400 h to ensure availability at all times. The respective legumes, maize bran and mineral lick were offered in two equal amounts of 4 kg, 1.5 kg and 35 g respectively in the morning and in the afternoon. The treatment diets were allocated randomly to the four groups of animals.

Total daily faecal output per animal for the last two weeks of the experiment was collected as it was dropped and bulked in individual buckets before weighing and recording. Samples were taken daily for dry matter determination and ashing. These values were used in the determination of apparent *in vivo* dry and organic matter digestibilities as described by Abdulrazak, (1995).

In vitro gas production characteristics of the legumes were determined according to the method of Menke and Steingas (1988) as described by Abdulrazak and Fujihara (1999). Gas volume (ml) was recorded after 3, 6, 12, 24, 36, 48, 72 and 96 hours of incubation. The net gas volume was calculated by subtracting gas production in the syringes with rumen fluid plus buffer without sample from the gas volume recorded in tubes containing samples. The net gas volume data were fitted to the model $p = a+b\ (1-e^{-ct})$ (Orskov and McDonald, 1979).

The forages were sampled weekly throughout the experimental period. These samples were then sub-sampled for DM determination and chemical composition analysis. At the end of the experiment the samples were bulked per forage and a single sample taken. Every batch of maize bran purchased was sampled for DM and chemical composition determination. DM, ash, nitrogen (N), Neutral and acid detergent fibres (NDF and ADF), tannins and N bound to NDF (NDF-N) contents were measured according to procedures adapted by Abdulrazak and Fujihara (1999).

Data was collected for a period of seven weeks after a seven-day adaptation period and stored in Ms Excel files. It was subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedures of Statistical Analysis Systems (SAS, 1997) and means separated using least significant difference (LSD).

RESULTS

Animals remained healthy throughout the experimental period. Chemical composition of the feeds used in this experiment are presented in Table 1. Crude protein (CP) concentration of Gliricidia and Clitoria were higher compared to that of Mucuna (232 and 218 vs. 180 g kg^{-1} respectively). Clitoria and Mucuna had higher neutral and acid detergent fibres (NDF and ADF) levels compared to Gliricidia. The highest concentration of NDF-N and tannins were found in Gliricidia. Ash and organic matter (OM) levels were similar for the three legumes. Maize stover had a CP concentration of 52 g kg^{-1}, NDF of 784 g kg^{-} and ADF of 481 g kg^{-1}.

The results of net gas produced *in vitro* when samples of Clitoria, Gliricidia and Mucuna were incubated with rumen fluid are presented in Table 2. There were no differences in rate and total gas production between the three legumes.

Daily mean maize stover intake was on average 2.7 kg DM. Cows fed the control diet ate insignificantly more maize stover than those supplemented with the legumes (Table 3). Cows consumed significantly ($P<0.05$) less Mucuna than Gliricidia and Clitoria (1.8 vs. 2.1 kg). In effect cows fed on Gliricidia and Clitoria consumed more supplementary CP than those fed on Mucuna (0.49 and 0.45 vs. 0.32 kg respectively). Animals fed on Maize stover alone consumed 0.51 kg of CP, which was lower ($P<0.05$) than the 0.98, 0.93 and 0.79 kg of CP recorded for cows fed on Gliricidia, Clitoria and Mucuna respectively (Table 3). Cows consumed all the maize bran offered which was equivalent to 2.6 kg DM and supplied 0.35 kg of CP.

The mean total daily DMI per animal was approximately 6.8 kg DM. Animals in the control treatment consumed 5.7 kg DM, which was ($P<0.05$) lower than the 7.3 kg DM consumed by cows fed Clitoria and Gliricidia, and the 6.8 kg for cows fed Mucuna. The total DMI for the animals that were supplemented with a legume supplement were similar.

Legume supplementation increased ($P<0.05$) the diet DM digestibility from 493 (control diet) to 569, 538 and 536 g kg^{-1} for animals fed Clitoria, Gliricidia and Mucuna respectively. A similar trend was observed with diet OM digestibility. However, the digestibilities realised with Mucuna and Gliricidia were similar to those of animals fed the control diet only (Table 3).

Cows that were fed the control diet alone produced 3.9 kg of milk per cow per day. Legume supplementation ($P<0.05$) increased milk yield to 4.5, 4.7 and 4.5 kg for cows fed Clitoria, Gliricidia and Mucuna respectively. Milk yield was similar between the cows fed a legume supplement. There were no differences ($P>0.05$) in live weight changes between the treatments. On average all the cows gained approximately 4 kg live weight by the end of the experiment.

Table 1**.** Nutrient composition of the feeds (g kg^{-1}DM except where stated)

	Stover	Clitoria	Gliricidia	Mucuna	Maize bran
Dry matter (g kg^{-1})	642	210	250	220	867
Organic matter	936	913	911	899	922
Crude protein	52	218	232	180	135
Neutral detergent fibre	784	605	506	596	783
Nitrogen bound to NDF	4.0	13.0	35.0	19.0	55.6
Acid detergent fibre	481	474	303	428	-
Calcium	2.0	1.5	4.0	6.3	0.1
Phosphorus	0.2	0.3	0.2	0.4	0.6
Tannins	-	17.1	22.3	18.0	-

Table 2. *In vitro* gas production (ml) and *in vitro* OMD of Clitoria, Gliricidia and Mucuna

	Legumes		
Incubation time (h)	Clitoria	Gliricidia	Mucuna
12	14.4	17.4	15.4
24	26.4	28.3	27.4
48	35.8	36.5	33.3
72	38.4	39.8	37.9
96	39.1	40.2	39.1
constants*			
a + b	41.9	43.5	42.4
c	0.05	0.05	0.05
RSD	6.286	5.429	6.605
%IVOMD 48 h	52.8	53.5	50.3

*constants in the model $p = a + b\,(1-e^{-ct})$ (Menke and Steingass, (1988), where p = volume of gas produced with time t; a = intercept of gas production curve; b =asymptote of exponential $b(1-e^{-ct})$; a + b = potential extent of gas production, c = rate of gas production. %IVOMD 48 h - *In vitro* OM digestibility calculated from the equation: %IVOMD =18.53 + 0.9239 gas production (at 48 h) + 0.054 CP (Menke and Steingass, 1988)

Table 3. Mean daily intakes (kg), milk yield (kg) apparent OMD and DMD for dairy cows fed Maize stover *ad libitum*, with or without a legume supplement.

	Treatments				
	Control	Clitoria	Gliricidia	Mucuna	SEM
DM intake					
Legume	0^{c}	2.1^{a}	2.1^{a}	1.8^{b}	0.06
Stover	3.1^{a}	2.6^{a}	2.6^{a}	2.4^{a}	0.30
Maize bran	2.6	2.6	2.6	2.6	-
Total	5.7^{b}	7.3^{a}	7.3^{a}	6.8^{a}	0.42
OM intake					
Legume	0^{c}	1.9^{a}	1.9^{a}	1.6^{b}	0.05
Stover	2.8^{a}	2.4^{a}	2.5^{a}	2.2^{a}	0.29
Maize bran	2.4	2.4	2.4	2.4	-
Total	5.2^{b}	6.7^{a}	6.8^{a}	6.2^{a}	0.32
CP intake					
Legume	0^{d}	0.45^{b}	0.49^{a}	0.32^{c}	0.01
Stover	0.16^{a}	0.13^{a}	0.14^{a}	0.12^{a}	0.02
Maize bran	0.35	0.35	0.35	0.35	-
Total	0.51^{c}	0.93^{a}	0.98^{a}	0.79^{b}	0.03
DMD (g kg^{-1})	493^{b}	569^{a}	538^{a}	536^{a}	17.3
OMD (g kg^{-1})	488^{b}	589^{a}	542^{ab}	544^{ab}	34.7
Milk yield (M.Y)	3.9^{b}	4.5^{a}	4.7^{a}	4.5^{a}	0.21
% increase in M.Y	-	15	20	15	nd
Liveweight change (kg)	+4	+4.8	+5.1	+5	nd

Means in the same row with similar letter superscript are not different at alfa = 5%; Figures on liveweight change are as at the end of the experimental period.

DISCUSSION

The CP concentration in the maize stover reported in this study was higher than that reported by Abdulrazak *et al.* (1996) at the same site and elsewhere by Kimambo *et al.* (1992) and Urio and Kategile (1987). The maize stover used in this experiment was cut immediately after cobs were harvested, as a result had high moisture content compared to that used in Abdulrazak's study (358 g kg^{-1} of moisture compared to 137 g kg^{-1} of moisture), which was cut and stored at the beginning of the experiment; an indication that the stover used in Abdulrazak's study may have been at a later stage of growth. Crowder and Chedda (1982) indicated that advanced maturity is accompanied by an increase in cell wall and a decrease in cell contents.

This causes dilution of mineral contents in proportion to the increase in bulk and results in lower CP, P and K percentages. The fibre concentration can be classified as high and was likely to depress its digestibility and hence intake.

The CP concentration of Gliricidia was within the range of 210 to 260 g kg^{-1} reported by Kaitho *et al.* (1997). Mucuna had similar CP concentration to the 173 g kg^{-1} reported by Muinga *et al.* (2002). This value was also within the expected range of 150 g kg^{-1} to 340 g kg^{-1} documented in the legume-screening database (Mureithi and Gitahi 2004). Humphreys and Partridge (1995) reported the CP range of Clitoria to be between 105 and 255 g kg^{-1}. The mean CP concentration of Clitoria used in this experiment was 218 g kg^{-1}. The range reported in the Legume screening database (Mureithi and Gitahi, 2004) was between 190 g kg^{-1} and 240 g kg^{-1}. The three legumes had higher CP concentrations than dairy meal (160 g kg^{-1}), which is the most popular commercial protein concentrate. The tannin levels for the three legumes reported in this experiment were below the critical level of 6 % as a result were unlikely to have had any detrimental effects on digestion. However Gliricidia had high tannin concentration than Clitoria and Mucuna.

Compared to Gliricidia; Mucuna and Clitoria had higher concentrations of NDF (506 vs. 596 and 605 g kg^{-1} DM respectively). This trend was similar for ADF whose values were 303 vs. 428 and 474 g kg^{-1} DM for Gliricidia, Mucuna and Clitoria respectively. The high fibre content in Mucuna and Clitoria can be explained by the harvesting height, which was approximately 10 cm from the ground level. In effect stemmy parts of these legumes were included in the ration hence increasing the fibrous proportion of the feed. On the other hand, only leaves and tender/succulent twigs (less than 5 mm diameter) of Gliricidia were used to feed the animals thus resulting in the lower fibre content of Gliricidia. This fact also explains the higher DM intake of Gliricidia compared to Clitoria and Mucuna and consequently the higher supplementary CP supplied by Gliricidia. However the NDF concentration of the three legumes can be classified as medium and were unlikely to have any negative effects on their digestibility (Luinmuller, 1991).

Total gas production was similar between the three legumes (Table 2), which was also reflected in the OMD measured *in vitro* (IVOMD). The 528, 535 and 503 g kg^{-1} IVOMD of Clitoria, Gliricidia and Mucuna respectively, show that the three legumes have the potential to supply metabolisable energy adding their value as nitrogen supplements.

The CP content of maize stover was however lower than 7 % required for optimal rumen microbial activity (McDonald *et al.,* 1991). As a result legume supplementation had effect on intake, digestibility and milk yield. In this study legume supplementation depressed ($P>0.05$) the intake of maize stover probably due to substitution effect. Minson and Milford (1967) reported an increase in the intake of Pangola grass owing to the elimination of CP deficiency. However this is not always the case. Studies elsewhere have reported substitution of the basal diet by legume supplementation (Getachew *et al.* 1994; Smith *et al.* 1990; Mosi and Butterworth 1985). Minson and Milford (1967) indicated that legume forage supplements have a stimulating effect on intake due to their content of N and give rise to substitution due to their 'bulk effect'. Animals readily consumed all the Gliricidia and Clitoria offered as opposed to Mucuna. Mucuna tended to lose its green colour and turn black after chopping. This might have led to its refusal by the animals. Forbes, (1986) indicated that the overall impression of the feed given by the animals' senses plays a vital role in selection of feed by animals. On average the legumes substituted for approximately 0.6 kg of the basal diet. Even with substitution effect, legume supplementation still increased ($P<0.05$) total dry matter intake, the reason being that animals consumed approximately 2 kg of the legumes, which was more than the amount substituted for in the basal diet.

The elimination of N deficiency in the rumen due to legume supplementation resulted in improved rumen environment. Rumen microbial activity was bound to be optimal in effect resulting in increased diet digestibility. Similar results were reported elsewhere by Pathirana *et al.* (1992), Premaratne *et al*. 1992 and Mosi and Butterworth, (1985) who reported improved overall diet digestibility with legume supplementation. The improved diet digestibility led to reduced ingesta retention time in the reticulo-rumen in effect feed intake was increased.

Owing to the intake of supplementary CP and the overall increase in TDMI, cows supplemented with Clitoria, Gliricidia and Mucuna yielded 15, 20 and 15 % more milk than the unsupplemented ones. Muinga (1992) noted that the nutritional factors likely to limit milk production are protein and energy. All cows were fed 2.6 kg DM of maize bran as an energy source so as to eliminate energy deficiencies, it was therefore assumed that energy was not limiting in all the treatment diets. The increase in TDMI due to legume supplementation also increased the intake of energy in the legume-supplemented diet as observed by McDonald *et al.* (1991). Calcium, Mg and P were also assumed to be not limiting since all the animals were offered 70 g of mineral lick. Milk yield was therefore likely to be limited by CP intake. All the treatments were adequate in terms of CP intake for maintenance (0.318 kg/d for animals weighing up to 400 kg) (NRC, 1994). The increase in milk yield observed in the legume-supplemented diets is attributed to the intake of supplementary CP. Even though cows fed the control diet alone were expected to lose weight, they gained approximately 4 kg by the end of the experiment compared to 5 kg gained by animals supplemented with a legume. The lack of weight loss in the unsupplemented animals might be as a result of the intake of maize bran, which in addition to supplying energy also supplied 0.35 kg of CP per kilogram. This was likely to mask any negative effects of CP deficiency in the diet. The reason animals gained weight is that they were past mid lactation and were in the process of replacing body tissues that were mobilised during early lactation for milk production.

CONCLUSIONS

It can be concluded from this study that Mucuna and Clitoria gave similar lactation performance to Gliricidia as protein supplements to maize stover basal diet. Farmers can use Clitoria and Mucuna as protein supplements at 2 kg DM for increased milk production.

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REFERENCES

Abdulrazak, S.A. and Fujihara, T. 1999. Animal Nutrition. A laboratory manual. Kashiwagi Printing Company, Matsue-shi, Japan.

Abdulrazak, S.A. 1995. The effects of supplementing roughage diets with leguminous tree forages on intake, digestion and performance of crossbred cattle in coastal lowland Kenya. Phd thesis, University of Aberdeen. U.K.

Abdulrazak, S.A., Muinga, R.W., Thorpe, W. and Ørskov, R. 1996. The effects of supplementation with Gliricidia or Leucaena forage on intake, digestion and live weight gains of *Bos Taurus X Bos indicus* steers offered Napier grass. Journal of Animal. Science 63: 381-388.

Crowder, L. V. and Chedda, H.L. 1982. Herbage quality and nutritive value. In: Tropical grasslands husbandry. Longman.

Forbes, J.M., 1986. The voluntary feed intake of farm animals. Butterworth Publishers limited. U.K.

Getachew, G., Said, A.N. and Sundstol, F. 1994. The effects of legume supplementation on digestibility and body weight gain by sheep fed basal diet of maize stover. Animal Feed Science and Technology, 46: 97-108.

Humphreys, L.R. and Partridge, I..J. 1995. A Guide to Better Pastures for the Tropics and Subtropics' (revised 5th Edition) published by NSW Agriculture, Australia.

Jaetzold, R. and Schmidt, H. 1983. The farm management handbook of Kenya Volume II/C, East Kenya, Ministry of Agriculture, Kenya and the German Agency for Technical Co-operation (GTZ).

Kaitho, R.J., Williams, B.A., Umnna N.N., Tamminga, S. and Bruchem, J. van. 1997. Relationship between rumen degradability, gas production and chemical composition of browses. Agroforestry Systems 38: 129-144.

Kimambo, A.E., Makiri, A.M and Shem, M.N. 1992. The use of *Leucaena leucocephala* supplementation to improve the utilization of maize stover by sheep. In: Stares, J.E.S. and Said, A.N. (Eds) Complementary of feed resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Botswana, 1991. pp: 430.

Luinmuller, E., Steingas, H. and Karl-Heinz, M. 1991. Tannins in ruminants' feedstuffs. Animal Research and Development 28: 9-52.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. 1991. Animal Nutrition. Longman, Wiley and Sons, 4th Edition.

Menke, K. H. and Steingass, H. 1988. Estimation of the energetic feed value obtained from the chemical analysis and *in vitro* gas production using rumen fluid. Animal Research and Development 28: 7-55.

Minson, D.J. and Milford, R. 1967. The voluntary intake and digestibility of diets containing different proportions of legumes and mature pangola grass (*Digitaria decumbens).* Australian journal of Experimental Agriculture and animal husbandry 7: 546 - 551.

Mosi, A.K and Butterworths, M. H. 1985. The voluntary intake and digestibility of combination of cereal crop residue and legume hay for sheep. Animal Feed Science and Technology 12: 240 - 251.

Muinga, R.W. 1992. Nutrition and performance of dairy cows in coastal lowlands Kenya in relation to utilisation of local feed resources. Ph.D. Thesis, Department of Agriculture, University of Aberdeen, U.K.

Muinga, R.W., Bimbuzi, S. and Mambo, L.C., 1999. Nutrient composition of locally available feedstuffs in coastal lowland Kenya. In: Proceedings of the 6th Biennial KARI Scientific Conference, Nairobi, Kenya, 8 - 13 November 1998. pp: 287 - 293.

Muinga, R.W., Saha, H.M. and Mureithi, J.G. 2002. The effect of Mucuna (*Mucuna pruriens*) forage on the performance of lactating cows. In: Eilittä, M., Muinga, R., Mureithi, J., Sandoval Castro, C., Szabo, N. (eds). Increasing mucuna's potential as a food and feed crop. Tropical and Subtropical Agroecosystems, 1: pp: 87-91.

Mureithi, J. G. and Gitahi, F.M. 2004. Kenya Agricultural Research Institute, Legume Research Network Project; Legume Screening Database.

NRC. 1994. Nutrient requirements of Dairy cattle. National Academy of Sciences, Washington, D.C.

Ørskov, E.R., and McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighed according to rate of passage. Journal of Agricultural Science, Cambridge 92: 499-503.

Pathirana, K.K., Mangalita, U.L.P and Gunaratne, S.S.N. 1992. Straw based supplementation of low output system for zebu heifers. In: International Atomic Energy, Technical Document – 691 IAEA, Viena, Austria.

Premaratne, S., Perera, H.G.D and Van Bruchem, J. 1992. Effect of type and level of forage supplementation on voluntary intake and digestibility of rice straw in sheep. In: Livestock and Feed development in the tropics. Proceedings of the International seminar held at Brawijaya University, Indonesia October, 1991.

Saha, H.M., Njunie, M.N. and Tsanje, N.M. 1997. Legume screening for soil fertility improvement in coastal lowland Kenya. 1st annual conference of the Soil management and Legume Research Network Project (LRNP) workshop held in Mombasa, Kenya. March 24-26. pp: 87-100.

Smith, T., Manyuchi, B and Mikairi, S. 1990. Legume supplementation of maize stover. In: Dzowela, B.H., Said, A.N., Wendem – Agenehu, A. and Kategile, J.A. (eds) Utilization of research on forage and Agricultural by-product materials as animal feed resources in Africa. ILCA, Addis Ababa, Ethiopia pp: 303 – 320.

Statistical Analysis Systems Institute, (SAS), 1997. Guide for personal Computer version 6th Edition. Statistical Analysis Systems Institute Inc., Cary, NC.

Swallow, K.A. 1996. Economic Development, Institutions and Technique Change: Intensification of cattle feeding techniques by the Giriama of Kenya's Coast Province. PhD thesis, University of Wisconsin-Madison.

Urio, N.A and Kategile, J.A., 1987. Maize stover and cobs as feed resource for ruminants in Tanzania. In: The utilization of agricultural by products as livestock feed in Africa. ARNAB workshop held in Malawi, September. 1986. pp: 37-44.

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