Trop Anim Health Prod (2016) 48:1463–1469
DOI 10.1007/s11250-016-1119-1

REGULAR ARTICLES

Milk yield response of cows supplemented with sorghum stover and *Tithonia diversifolia* leaf hay diets during the dry season in northern Uganda

Constantine Bakyusa Katongole[1] **· Jolly Mary Kabirizi**[2] **· William Ntege Nanyeenya**[2] **· John Kigongo**[2] **· Geofrey Nviiri**[3]

Received: 22 May 2016 / Accepted: 1 August 2016 / Published online: 12 August 2016

Abstract Five primiparous cows (Friesians crossed with undefined breeds and in early lactation) were used to assess the milk yield response of dairy cows offered a basal feed of *Panicum maximum* hay and supplemented with diets based on sorghum stover and *Tithonia diversifolia* leaf hay during the dry season. The cows were assigned to five experimental diets in a 5 × 5 Latin square design of 21-day experimental periods. The experimental diets consisted of a control (Panicum hay alone), and four experimental diets whereby Panicum hay was supplemented with diets based on sorghum stover, Tithonia leaf hay, maize bran, sunflower cake, and sugar cane molasses as follows: stover/Tithonia/bran/molasses (STBM), stover/Tithonia/bran (STB), stover/Tithonia/bran/cake (STBC), and stover/bran/cake (SBC). The supplements were formulated and offered to meet the crude protein and energy recommendations of a 350-kg cow producing about 10 kg milk/day. Average milk yield significantly increased ($P < 0.05$) from 6.49 kg/cow/day (control) to 7.25, 7.29, 7.50, and 7.52 kg/cow/day (SBC, STBM, STB, and STBC, respectively). There was no significant difference ($P > 0.05$) in the amounts consumed across the supplements. A similar trend was observed for milk returned/kg supplement consumed. On average, each kilogram of STB, STBC, STBM, and SBC returned 0.48, 0.37, 0.29, and 0.29 kg milk/day, respectively. Thus, the results of the present study revealed that supplements based on sorghum stover and Tithonia leaf hay are a viable option as dry season feed supplements for dairy cows. However, only two supplements, namely STB and STBC, had positive net financial benefits.

Keywords Dry season · Milk yield response · Smallholder dairy farming · Sorghum stover · *Tithonia diversifolia*

✉ Constantine Bakyusa Katongole
tbakyuka@caes.mak.ac.ug

[1] Department of Agricultural Production, Makerere University, P.O. Box 7062, Kampala, Uganda

[2] National Livestock Resources Institute (NaLIRRI), P.O. Box 96, Tororo, Uganda

[3] Ngetta Zonal Agricultural Research and Development Institute, P.O. Box 52, Lira, Uganda

Introduction

Smallholder dairy farming plays a significant role in the rural livelihoods of tropical developing countries. However, the severe unavailability of forage resources during the dry season is a crucial constraint. The smallholder farmers rely heavily on natural forage resources during both the wet and dry seasons. Often, as is the case for many tropical areas (northern Uganda inclusive), there is a severe decrease in the quantity and quality of natural forage resources during the dry season, making it difficult for the cows to satisfy their feed requirements for milk production.

The use of crop residues is one of the well-known alternatives for addressing the pasture unavailability constraint during the dry season. Unfortunately, the full potential of many crop residues for dry season feeding has largely remained unrealized. According to UBOS and MAAIF (2011), over 55 % of all agricultural households in northern Uganda produce sorghum, implying that sorghum stover is widely available in the region. However, much of the stover is either burnt or left to rot in the field after the removal of grains. Use of sorghum stover would be an important strategy for coping with the feed unavailability constraint during the dry season. Although the feeding value of sorghum stover is low because of its high fiber and low N contents (Bello and Tsado 2013), studies (Bals et al. 2010; Yousuf et al. 2014) have shown that full benefits can be obtained from sorghum stover for livestock feeding through chemical treatments. However, the chemical reagents are either dangerous to handle or difficult to obtain, and hence, are not feasible for rural smallholders.

Previous reports (Sarnklong et al. 2010; Bello and Tsado 2013; Malisetty et al. 2014) have suggested supplementation as an effective way of enhancing the utilization of crop residues, thus sustaining animal performance during periods of pasture unavailability. However, in many developing countries, the use of conventional concentrate supplements is not feasible because of the high cost and inaccessibility (Teferedegne 2000; Katongole et al. 2012). Previous studies (Ondiek et al. 2013; Hossain et al. 2015) have demonstrated that supplementation of low quality roughages with leguminous forages is a sustainable practice for smallholder farming systems. Even though *Tithonia diversfolia* (Wild Sunflower) is not a leguminous plant, its leaves have been reported to be relatively high in N concentration (Wambui et al. 2006; Osuga et al. 2012), which makes it a possible option for improving the feeding quality of sorghum stover. Besides, *Tithonia diversfolia* is widely available in northern Uganda as a weed on uncultivated farmlands and along roadsides. Therefore, in the present study, the milk yield response of dairy cows offered a basal feed of Panicum hay and supplemented with diets based on sorghum stover and Tithonia leaf hay was assessed.

Materials and methods

Experimental site

The experiment was conducted at the Ngetta Zonal Agricultural Research and Development Institute (Ngetta ZARDI) in Lira District, northern Uganda, 02° 18′ N, 32°55′ E and altitude 1090 m. The area has bimodal rainfall, with April–May and August–November as the first and second rainy seasons, respectively. Average annual rainfall is 1300–1660 mm, mean daily maximum temperature is 24–33 °C, and minimum temperature is 10–15 °C.

Experimental animals and their management

Five lactating cows (Friesians crossed with undefined breeds, in early lactation at 88 ± 18 days in milk) were selected from the milking herd at Ngetta ZARDI. The cows had an average daily milk yield of 5–6 kg/cow. The cows were group fed on Panicum hay as the basal feed and milked twice daily (0700 and 1700 h). The cows had free access to clean drinking water and mineral block licks.

Experimental diets and design

Five experimental diets were compared during the dry season (January–April) using five cows in a 5 × 5 Latin square design that had five periods. Each period lasted 21 days (first 7 days were for adaptation). The feedstuffs used were Panicum hay, sorghum stover (S), Tithonia leaf hay (T), maize bran (B), sunflower cake (C), and sugarcane molasses (M). The experimental diets were Control (Panicum hay alone) and the four diets (STBM, STB, STBC, and SBC) where Panicum hay was supplemented (Table 1).

The supplements were formulated to meet the crude protein (CP) and metabolizable energy (ME) recommendations (about 120 g/kg DM and 9.3 MJ/kg DM) of a 350-kg cow producing about 10 kg milk/day (Chamberlain 1993). The formulation also considered the intake from the Panicum hay. Each day, the supplements were offered individually after milking (0700 and 1700 h) in two equal portions. All the four supplements were offered to the cows at a level of 1 kg of supplement/kg milk above the yield of 4 kg.

Without considering sorghum varieties, stover (previous grain harvest) was collected from within and around the experimental site. Tithonia leaves (together with tender shoots/stems) were harvested from naturally growing stands in and around the experimental site. The stover and Tithonia were sun-dried and ground using a motorized hammer mill (through 5- and 12-mm screens, respectively), and thereafter thoroughly hand-mixed with the other feedstuffs (Table 1). The other feedstuffs (maize bran, sunflower cake, and sugar cane molasses) were purchased from local suppliers. The chemical composition and ME of the feedstuffs and the five experimental diets are summarized in Table 2.

Supplement intake and milk yield

To determine the intake of the supplements by each cow, the amounts of the supplements offered to each cow and the amounts refused were recorded daily. The milk yield of each cow was recorded daily. The marginal returns of milk to the supplements (extra milk produced/kg of supplement consumed) as well as the amount of additional g CP/kg of extra milk produced (additional CP utilization efficiency) were then computed.

Chemical analysis

Representative samples of the feedstuffs and the five experimental diets were taken, weighed, and oven dried at 60 °C. Thereafter, the samples were weighed and ground through a 1-mm screen. The samples were analyzed for dry matter (DM), crude protein (CP), calcium (Ca),

Table 1 Feedstuff composition of experimental diets

	Experimental diet				
	Control	STBM	STB	STBC	SBC
Panicum hay	Ad libitum	Ad libitum	Ad libitum	Ad libitum	Ad libitum
Supplements (%, as fed basis)					
Sorghum stover (S)	–	9.1	18.0	32.4	51.5
Tithonia leaf hay (T)	–	31.1	41.0	27.3	–
Maize bran (B)	–	11.9	41.0	26.0	5.9
Sunflower cake (C)	–	–	–	14.3	42.6
Sugarcane molasses (M)	–	47.9	–	–	–

Control, Panicum hay fed alone; *STBM* stover/Tithonia/bran/molasses, *STB* stover/Tithonia/bran, *STBC* stover/Tithonia/bran/cake, *SBC* stover/bran/cake

phosphorus (P), and ash according to AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined by the method of Van Soest and Robertson (1985).

Statistical analysis

Diet effects were analyzed using the PROC GLM procedure of SAS (2003) using the model: $Y_{ijkl} = \mu + C_i + P_j + D_k + e_{ijkl}$, where μ was the overall mean effect, C_i the cow effect, P_j the experimental period effect, D_k the experimental diet effect, and e_{ijkl} the random error. The daily milk increments (extra milk due to the supplements) were subjected to single degree of freedom comparisons by the following pair-wise orthogonal contrasts: (1) contrast I = supplements with Tithonia as the sole protein source versus supplements with sunflower cake (STB and STBM versus STBC and SBC) and (2) contrast II = supplements with sugar cane molasses versus supplements without sugar cane molasses (STBM versus STB, STBC, and SBC).

Economic analysis

The profitability of the supplements was assessed using partial budget analysis. Changes in the costs and returns resulting from each supplement were calculated. Financial benefits were calculated using the equation: net financial benefit = (added returns + reduced costs)−(added costs + reduced returns). Increase in milk production resulting from the supplements was the sole variable considered for the calculation of added returns. The variables considered for the added costs included the costs for the feedstuffs, transport, and extra labor involved. The prices used to compute the added returns and added costs were based on the local market situation.

Table 2 Chemical composition and ME of sorghum stover, Tithonia leaf hay, maize bran, sunflower cake, and the experimental diets (means ± standard deviation)

	DM g/kg	CP g/kg DM	NDF	ADF	ADL	Ash	Ca	*P*	ME[a] MJ/kg DM
Sorghum stover	743 ± 23.9	33 ± 12.1	658 ± 40.7	426 ± 32.5	93 ± 9.5	53 ± 8.8	8 ± 1.2	0.70 ± 0.5	4.1
Tithonia leaf hay	909 ± 14.6	166 ± 15.2	367 ± 20.2	321 ± 28.7	82 ± 2.6	105 ± 14.3	23 ± 3.0	2.2 ± 0.3	6.0
Maize bran	889 ± 0.3	92 ± 0.7	354 ± 2.4	87 ± 9.5	22 ± 5.1	43 ± 3.2	0.42 ± 0.1	0.34 ± 0.1	11.7
Sunflower cake	91.8 ± 0.5	26.5 ± 0.3	39.4 ± 1.7	31.0 ± 4.8	9.7 ± 3.0	67 ± 5.9	0.63 ± 0.3	1.02 ± 0.2	11.2
Experimental diets									
Control	933 ± 4.2	63 ± 2.6	768 ± 4.2	354 ± 2.7	64 ± 0.2	62 ± 0.8	14 ± 0.7	1.5 ± 0.4	5.0
STBM	626 ± 11.4	114 ± 4.4	480 ± 13.9	259 ± 3.3	65 ± 0.8	78 ± 0.5	16 ± 0.5	4.3 ± 1.2	7.8
STB	862 ± 12.6	120 ± 0.7	499 ± 3.7	268 ± 4.0	62 ± 0.8	64 ± 3.6	13 ± 0.6	4.0 ± 0.6	8.0
STBC	901 ± 6.0	109 ± 4.2	455 ± 19.5	239 ± 10.5	62 ± 0.9	79 ± 1.9	16 ± 1.9	4.0 ± 0.2	7.6
SBC	926 ± 4.9	142 ± 1.4	630 ± 8.0	386 ± 9.1	105 ± 1.3	42 ± 0.7	8.8 ± 0.6	3.4 ± 0.5	7.6

Control, Panicum hay alone; *STBM* stover/Tithonia/bran/molasses, *STB* stover/Tithonia/bran, *STBC* stover/Tithonia/bran/cake, *SBC* stover/bran/cake

[a] ME values of the experimental diets were calculated based on the ME values (from Mgheni et al. 2013) of their constituent feedstuffs

Reduced costs and reduced revenue were assumed to be negligible for all the supplements.

Results

Chemical composition of feeds

The chemical composition and ME of the feeds offered to the cows are summarized in Table 2. Sorghum stover had a low CP content (33 g/kg DM) but high NDF, ADF, and ADL contents. Tithonia leaf hay contained medium level CP (166 g/kg DM), NDF (367 g/kg DM), and ADF (321 g/kg DM) but relatively high ash (105 g/kg DM) and ADL (82 g/kg DM). The NDF concentration of the supplements was of medium level, except for SBC (630 g/kg DM).

Milk yield response

The control diet (Panicum hay alone) recorded the lowest ($P < 0.05$) average daily milk yield (Table 3). The daily milk yield was similar ($P > 0.05$) across the four supplements. The average daily milk increment due to STB and STBM (where Tithonia was the sole protein source) was not significantly different (contrast I) from the increment due to STBC and SBC (where sunflower cake was included). It was also observed that the average daily milk increment due to STBM (where sugar cane molasses was added) was not significantly different (contrast II) from the increment due to STB, STBC, and SBC (where no sugar cane molasses was added).

Table 3 Milk yield of Friesian-cross cows fed a basal diet of Panicum hay with or without supplements based on sorghum stover and Tithonia leaf hay

	Milk yield (kg/cow/day)	Milk increment (kg/cow/day)
Control	6.39[b]	–
STBM	7.29[a]	0.90
STB	7.50[a]	1.11
STBC	7.52[a]	1.13
SBC	7.25[a]	0.86
SEM	0.18	0.17
CV	6.1	43.7
Significance level	*	NS
Orthogonal contrasts (significance level)		
Contrast I (STB and STBM versus STBC and SBC)		NS
Contrast II (STBM versus STB, STBC, and SBC)		NS

Control, Panicum hay alone; *STBM* stover/Tithonia/bran/molasses, *STB* stover/Tithonia/bran, *STBC* stover/Tithonia/bran/cake, *SBC* stover/bran/cake

[ab] Means within the same column with different superscripts are significantly different ($P < 0.05$)

NS not significant, *SEM* standard error of the mean, *CV* coefficient of variation

*$P < 0.05$

Supplement intakes, marginal returns of milk, and efficiency of utilization of additional CP

There was no significant difference ($P > 0.05$) in the amounts consumed across the supplements (Table 4). A similar trend was observed for milk returned/kg supplement consumed. On average, each kg of STB, STBC, STBM, and SBC returned 0.48, 0.37, 0.29, and 0.29 kg milk, respectively. The amount of additional CP consumed/kg milk was also not significantly different ($P > 0.05$) across the four supplements. The CP utilization efficiencies of STBM and SBC (828 and 514 g CP/kg milk, respectively) were numerically higher, though not significantly ($P > 0.05$) different from those of STB and STBC (365 and 358 g CP/kg milk, respectively).

Economic analysis

Results from the partial budget (Table 5) showed that supplements STB and STBC realized profitable effects, while STBM and SBC resulted in returns of net losses. Supplements STB and STBC would attract more revenue to the enterprise (Uganda Shillings 747 and 529/day, respectively), whereas supplements STBM and SBC would cause financial losses to the enterprise (Uganda Shillings −1403 and −218/day, respectively).

Discussion

Chemical composition of feeds

The CP content of Tithonia leaf hay observed in this study was lower (by over 40 %) than the values reported by Wambui et al. 2006 and Osuga et al. 2012. The lower CP was probably due to differences in the maturity stage and proportion of stems in the samples analyzed. Presumably for the same reason, the NDF content was over 30 % higher than what was reported by the same authors. Supplement NDF increased with sorghum stover inclusion, which was not surprising since sorghum stover is generally fibrous (Bello and Tsado 2013). The NDF content of SBC was just slightly above 600 g/kg DM, which is usually considered as the threshold likely to significantly affect intake in

Table 4 Supplement intake, marginal returns of milk to supplement intake, and additional CP utilization efficiency of Friesian-cross cows fed a basal diet of Panicum hay with supplements based on sorghum stover and Tithonia leaf hay

	Supplement intake (kg/cow/day)	Marginal returns of milk to each kg supplement[a] (kg milk/kg supplement)	Additional CP utilization efficiency[b] (g CP/kg milk)
STBM	2.94	0.29	828
STB	2.74	0.48	365
STBC	3.02	0.37	358
SBC	2.99	0.29	514
SEM	0.29	0.05	220
CV	21.1	35.3	75.0
Significance level	NS	NS	NS

STBM stover/Tithonia/bran/molasses, *STB* stover/Tithonia/bran, *STBC* stover/Tithonia/bran/cake, *SBC* stover/bran/cake

[a] Calculated as the extra milk produced (milk increment) from each kilogram of supplement eaten

[b] Calculated as the amount of additional CP (g) required to produce each kilogram of extra milk

NS not significant, *SEM* standard error of the mean, *CV* coefficient of variation

ruminants (Zewdu 2005). The high CP content of SBC compared to the other supplements could not easily be explained.

Milk yield response

The supplements significantly improved ($P < 0.05$) milk yield, which is indicative of inadequate DM intake and consequently low nutrient intake from the control diet. Where inadequate nutrients are supplied by the basal feed, supplementary feeding can subsequently improve DM intake. Maximizing DM intake is a major concern in dairy cows, particularly those in early lactation (Agenäs et al. 2003). The supplements increased the daily milk yield by 13–18 %. Although the milk yield increase was not numerically very large, there are other benefits of biological significance associated with the supplementation. For instance, the extra DM offered to the cows, particularly during the dry season when there is feed scarcity, helps the cows to maintain body condition in preparation for the rainy season when forage availability improves.

Supplement intakes, marginal returns of milk, and the efficiency of use of the additional CP

The intake of the supplements was generally low (45–50 % of the amounts offered), which was probably due to the way the stover and Tithonia leaf hay were prepared. In this study, stover and Tithonia leaf hay were ground through 5- and 12-mm screens. Cattle requires forage fiber in coarse form for increased rumen pH, chewing activity, rumination, and eating time, ultimately influencing intake (Kononoff and Heinrichs 2003). However, excessive amounts of long, coarse fiber may also limit intake (Allen 2000).

Milk yield/unit of DM consumed provides a measure of dairy efficiency. This measure has relevance to

Table 5 Partial budget for assessing the profitability of Tithonia-sorghum stover supplements

		Milk yield (kg/cow/day)			Uganda Shillings (thousands)*		
	Intake (kg)	Control	Supplement	Increment	Added returns + reduced costs	Added costs + reduced returns	Net financial benefit
STBM	2.94	6.39	7.29	0.90	1.17	2.57	−1.40
STB	2.74	6.39	7.50	1.11	1.44	0.70	0.75
STBC	3.02	6.39	7.52	1.13	1.47	0.94	0.53
SBC	2.99	6.39	7.25	0.86	1.12	1.34	−0.22

Control, Panicum hay alone; *STBM* stover/Tithonia/bran/molasses, *STB* stover/Tithonia/bran, *STBC* stover/Tithonia/bran/cake, *SBC* stover/bran/cake

*US$ 1 = Uganda Shillings 3340

conversion of inputs to saleable products. If a consumed nutrient is not converted to milk, meat, or calf, it will be excreted (Britt et al. 2003). In the present study, the dairy efficiency of the supplements was generally low. On average, 1 kg of STB, STBC, STBM, and SBC returned 0.48, 0.37, 0.29, and 0.29 kg milk, respectively. The additional CP utilization efficiency of the supplements was low (358–828 g CP/kg milk), which was partly attributed to the high fiber intake. In the present study, the NDF content of the supplements ranged from 455 to 630 g/kg DM. Britt et al. (2003) observed a negative relationship between dairy efficiency and dietary fiber. The increased dietary fiber reflects the effect of decreased dietary digestibility; hence, the low ability of the cows to convert the supplements to milk.

Economic analysis

Based on the financial assessment results (Table 5), adopting supplements STBM and SBC would ultimately make the enterprise lose revenue (Uganda Shillings −1403 and −218/day, respectively). The resultant effect is attributable to the inclusion levels of molasses (STBM) and sunflower cake (SCB) on the economic returns. The unit price of sunflower cake was higher than the prices of the rest of the ingredients by over 100 %. Similarly, the unit price of molasses was higher than the prices of the rest of the ingredients by over 300 %. This implies that the inclusion of molasses in STBM and sunflower cake in SBC elevated the value of the supplements beyond the value of the extra milk due to the supplements. Sensitivity analysis showed that STBM would still lead to a daily loss of Uganda Shillings 1002 (about US$ 0.30) even with a 25 % drop in the price of molasses.

Conclusions

Supplements based on sorghum stover and Tithonia leaf hay are a viable option as dry season feed supplements to dairy cows. The supplements increased the daily milk yield of cows offered a basal feed of Panicum hay by 13–18 %. However, despite the milk yield increase, only two supplements, namely STB and STBC had positive net financial benefits. Generally, the intakes of the supplements were lower than anticipated, which may probably be due to the way the stover and Tithonia leaf hay were prepared; hence, the need for further studies to determine the best treatment of sorghum stover and Tithonia leaf hay for maximum intake by cows.

Acknowledgments The authors acknowledge the staff of NaLIRRI (National Livestock Resources Research Institute), Makerere University, Ngetta ZARDI and farmers in Lira and Soroti districts for their participation. The financial support from NARO (National Agricultural Research Organization) under the Agricultural Technology and Agribusiness Advisory Services (ATAAS) project funded by the World Bank is also acknowledged.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Agenäs, S., Burstedt, E., Holtenius, K., 2003. Effects of feeding intensity during the dry period. 1. Feed intake, body weight, and milk production. Journal of Dairy Science, 86(3), 870-882.

Allen, M.S., 2000. Effects of diet on short-term regulation of feed intake by lactating dairy cattle. Journal of Dairy Science, 83(7), 1598-1624.

AOAC., 1990. Official Methods of Analytical Chemists Inc., Arlington, Virginia, USA.

Bals, B., Murnen, H., Allen, M., Dale, B., 2010. Ammonia fiber expansion (AFEX) treatment of eleven different forages: Improvements to fiber digestibility *in vitro*. Animal Feed Science and Technology, 155(2), 147-155.

Bello, A.A., Tsado, D.N., 2013. Feed intake and nutrient digestibility of growing Yankasa rams fed sorghum stover supplemented with graded levels of dried poultry droppings based diet. Asian Journal of Animal Sciences, 7(2), 56-63.

Britt, J.S., Thomas, R.C., Speer, N.C., Hall, M.B., 2003. Efficiency of converting nutrient dry matter to milk in Holstein herds. Journal of Dairy Science, 86(11), 3796-3801.

Chamberlain, A., 1993. Milk production in the tropics. Intermediate Tropical Agricultural Series, Longman Scientific and Technical, England, UK.

Hossain, M.S., Miah, M.Y., Khandaker, Z.H., Islam, F., 2015. Effect of different levels of matikalai (*Vigna mungo*) hay supplementation to straw-based diets on feed intake, digestibility and growth rate of indigenous cattle. Livestock Research for Rural Development, 27(2).

Katongole, C.B., Nambi-Kasozi, J., Lumu, R., Bareeba, F., Presto, M., Ivarsson, E., Lindberg, J.E., 2012. Strategies for coping with feed scarcity among urban and peri-urban livestock farmers in Kampala, Uganda. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 113(2), 165-174.

Kononoff, P.J., Heinrichs, A.J., 2003. The effect of reducing alfalfa haylage particle size on cows in early lactation. Journal of Dairy Science, 86(4), 1445-1457.

Malisetty, V., Yerradoddi, R.R., Devanaboina, N., Mallam, M., Mitta, P., 2014. Effect of feeding sorghum straw based complete rations with different roughage to concentrate ratio on dry matter intake, nutrient utilization, and nitrogen balance in Nellore ram lambs. Tropical Animal Health and Production, 46(5), 759-764.

Mgheni, D.M., Laswai, G.H., Mtenga, L.A., Ndikumana, J., Zziwa, E., 2013. Chemical composition and nutritional values of feed resources for ruminants: Eastern and Central Africa (ECA) feedstuff table for ruminants. ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa), Entebbe. http://asareca.org/~asareca/sites/default/files/publications/Eastern%20and%20

Central%20Africa%20%28ECA%29%20feedstuff%20table%20for%20ruminants%202013.pdf.

Ondiek, J.O., Ogore, P.B., Shakala, E.K., Kaburu, G.M., 2013. Feed intake, digestibility and performance of growing small East African goats offered maize (*Zea mays*) stover supplemented with *Balanites aegyptiaca* and *Acacia tortilis* leaf forages. Basic Research Journal of Agricultural Science and Review, 2(1), 21-26.

Osuga, I.M., Abdulrazak, S.A., Muleke, C.I., Fujihara, T., 2012. Potential nutritive value of various parts of wild sunflower (*Tithonia diversifolia*) as source of feed for ruminants in Kenya. Journal of Food, Agriculture & Environment, 10(2), 632-635.

Sarnklong, C., Cone, J.W., Pellikaan, W., Hendriks, W.H., 2010. Utilization of rice straw and different treatments to improve its feed value for ruminants: a review. Asian-Australasian Journal of Animal Sciences, 23(5), 680-692.

SAS., 2003. User's Guide Version 9.1. SAS Institute Inc., Cary, N.C. (USA)

Teferedegne, B., 2000. New perspectives on the use of tropical plants to improve ruminant nutrition. Proceedings of the Nutrition Society, 59, 209-214

UBOS, MAAIF, 2011. Uganda Census of Agriculture (UCA) 2008/2009 at a glance. Uganda Bureau of Statistics in collaboration with Ministry of Agriculture, Animal Industry and Fisheries. Kampala, Uganda. http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20documents/UCAGlance.pdf.

Van Soest, P.J., Robertson, J.B., 1985. Analysis of forage and fibrous foods. A laboratory manual for animal science 613. Cornell University Press, Ithaca, New York, U.S.

Wambui, C.C., Abdulrazak, S.A., Noordin, Q., 2006. The effect of supplementing urea treated maize stover with Tithonia, Calliandra and Sesbania to growing goats. Livestock Research for Rural Development, 18(5).

Yousuf, A.B., Dismuke, A., Kering, M., Atalay, A., 2014. Effects of treatment of sorghum stover residue with Ammonium Hydroxide on cell wall composition and *in vitro* digestibility. Journal of Agricultural Science, 6(9), 21-28.

Zewdu, T., 2005. Variation in growth, yield, chemical composition and in vitro dry matter digestibility of Napier grass accessions (*Pennisetum purpureum*). Tropical Science, 45(2), 67-73.