Replacement of Concentrate Mix With Vetch (*Vicia dasycarpa*) Hay on Feed Intake, Digestibility, Milk Yield and Composition of Lactating Crossbred Dairy Cows Fed Urea-Molasses Treated Wheat Straw

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Abstract: The experiment was conducted with the objective to assess the effect of replacing vetch for concentrate mix on feed intake and digestibility as well as milk production and composition in lactating crossbred (Boran x Friesian) cows kept on a basal feed of urea- molasses treated wheat straw (UMTWS). Eight crossbred cows of similar milk yield (8-10 kg d^{-1}), body weight (BW) and stage of lactation (early lactation), but differing in parities were arranged in 4 x 4 double Latin square design. The treatments included offering urea molasses treated wheat straw basal diet *ad libitum* and supplementation with concentrate mix (T_1), and replacement of the concentrate mix with vetch (*Vicia dasycarpa*) hay at the level of 25% (T_2), 50% (T_3) and 75% (T_4). The concentrate mix consisted of 74% wheat bran, 25% noug seed (*Guizotia abyssinica*) cake and 1% common salt. The CP content of UMTWS was 86.7 g/ kg dry matter (DM), whereas that of vetch hay and the concentrate mix were 199 and 225 g/ kg DM, respectively. The contrary was true for neutral detergent fiber (NDF) content which was 767 g/ kg DM in UMTWS, and 545 and 479 g/ kg DM in vetch hay and the concentrate mix respectively. *In sacco* degradability studies showed that the concentrate mix and vetch were similar in rumen degradability parameters, except that rate of degradation was relatively faster for vetch hay. Total DM intake was higher ($P < 0.05$) for cows in T_3 compared to cows in the other treatments. Nutrient intakes and apparent digestibility were found to be similar ($P > 0.05$) among treatments, except for cows in T_3 that had higher ($P < 0.05$) NDF and acid detergent fiber (ADF) intakes than cows in T_1 and T_2. Crude protein (CP) and ME intakes were sufficient to meet daily requirements for the observed mean daily milk yield of 6.5 kg. Cows in T_1 produced higher ($P < 0.05$) milk yield compared to cows in T_4. Body weight change and milk composition were similar ($P > 0.05$) for cows in the different treatments. It is concluded that vetch hay could substitute 50% of the concentrate mix without compromising feed intake and digestibility of nutrients as well as milk yield and composition of lactating Boran x Friesian cows.

Keywords: Concentrate Mix; Rumen Degradability; Urea Molasses Treatment; Wheat Straw; Vetch

1. Introduction

Wheat straw is one of the major cereal crop residues produced in the world. As an example, around 2.2 million tones of wheat straw are produced annually in Ethiopia (CSA, 2003). However, wheat straw utilization is highly constrained by low crude protein (CP) content (2.5%), poor organic matter digestibility (OMD) (37.8%) and high NDF (77.2%) content (EARO, 2004). Consequently, the use of urea treated wheat straw is becoming a common practice in some parts of the highlands of Ethiopia as a strategy to improve the nutritive value of wheat straw. Urea treatment of wheat straw under local conditions has raised its CP content by 5% and its *in vitro* OMD by 10% (Rehirahe and Ledin, 2004). Although such treatment resulted in improved intake and digestibility, reported improvements on urea-based diets alone did not go beyond meeting maintenance nutrient requirements of animals (Smith *et al.,* 1980). The major constraint to milk production of diets based on treated or untreated crop residues appear to be insufficient glycogenic compounds to provide the glucose for lactose synthesis and for oxidation to provide reduced nicotinamide adenine dinucleotide phosphate (NADPH) for synthesis of fatty acids (Preston and Leng, 1986). Thus, urea treated wheat straw requires strategic supplementation for improved animal performance. However, the practice of supplementation using purchased concentrates is unlikely under conditions of smallholder farmers due to high cost and/or unavailability/accessibility of the concentrate supplements. Moreover, from reported milk yield responses, concentrate supplementation of tropical low quality roughages for milk production may not be economical (Muinga *et al.,* 1992). Therefore, it is suggested that the use of improved forage legumes integrated into existing farming systems are valuable economic alternatives to purchased protein or energy rich concentrates as a practical on-farm solution for smallholder dairy production. One such forage legume is vetch (*Vicia dasycarpa*). The forage legume has acceptable dry matter (DM) yield (4-6 t /ha /year), CP content (19.9%) and *in vitro* OMD (68.7%) (Seyoum, 1995; Getinet, 1999). Moreover, it is adapted and widely used in the cool tropical highlands (Getinet, 1999). However, judicious use of vetch in the daily ration of lactating cows can only be justified when its level of inclusion is biologically justifiable. Therefore, the objective of this study was to determine the effect of replacement of a concentrate mix with vetch hay on feed intake, apparent digestibility of nutrients, milk yield and composition in lactating Boran x Friesian cows fed a basal diet of urea-molasses treated wheat straw (UMTWS).

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2. Materials and Methods

2.1. Study Site and Management of Experimental Animals

The study was conducted at Holetta Research Center, Ethiopia. The research center is located at 9° 3" N latitude and 38° 30" E longitude at an altitude of 2400 masl. The mean annual rainfall is 1000 mm and the mean minimum and maximum temperatures are 6 °C and 22 °C, respectively. A total of eight lactating F_1 crossbred cows (Boran x Friesian) with similar daily initial milk yield of 8-10 l/ head), same stage of lactation (early lactation), but differing in parities (one through four) were selected from the dairy herd of the experiment station. All the cows were weighed and drenched with broad-spectrum anti-helminthes (Albendazole 500 mg) prior to the start of the experiment. The calves were separated from their dams five days after parturition.

2.2. Treatment Feeds

Vetch was harvested at 50% flowering, field cured, baled and stored in a shade. Representative samples were taken for laboratory analysis before the hay was baled. The straw of wheat variety (HAR-1899) was collected, baled and then stored in a shade. Treatment with urea-molasses was carried out every two weeks by applying 100 liter water, 5 kg urea, 10 liter molasses on 100 kg air dried straw (Sundstøl *et al*., 1978) and incubated in an above-ground silo (clamps) for 21 days. The concentrate mix was formulated using wheat bran, noug seed (*Guizotia abyssinica*) cake and salt at the ratio of 74, 25 and 1%, respectively. The DM content of the concentrate mix was 908.9 g kg^{-1}, and the CP and *in vitro* OMD contents were 225 g kg^{-1} DM and 752 g kg^{-1} DM, respectively. The ME content was 12 MJ kg^{-1} DM as estimated from *in vitro* OMD (DODM x 0.016) (McDonald *et al.,* 2002).

2.3. Experimental Design, Treatments and Measurements

Eight cows were randomly blocked in a switch over 4 x 4 double Latin square design composed of 15 days of adaptation and 15 days of treatment period. The experimental animals were then randomly allotted to one of the four dietary treatments given below.

T_1= UMTWS *ad libitum* + concentrate mix (control),

T_2= UMTWS *ad libitum* + 25% of the concentrate mix replaced by vetch hay,

T_3= UMTWS *ad libitum* + 50% of the concentrate mix replaced by vetch hay, and

T_4= UMTWS *ad libitum* + 75% of the concentrate mix replaced by vetch hay.

The amount of concentrate mix offer was at the rate of 0.5 kg/ liter of milk produced. The concentrate mix was offered in two equal portions at 0500 and 1700 h at morning and evening milking, respectively. Water and mineral block containing common salt, molasses, lime, copper sulphate, zinc sulphate, manganese sulphate, cobalt sulphate and ground bone meal were offered *ad libitum*. Vetch hay was offered every six hours. Feed offered and refused were measured and recorded daily for each cow to determine daily feed intake. Substitution of UMTWS with vetch was calculated as the difference in intakes of UMTWS between the control diet and the supplemented treatment expressed as a proportion of the quantity of vetch hay consumed in each treatment. Feed offer and refusal samples were taken daily per cow, bulked on a weekly basis and oven dried at 65 °C for 72 h. Samples were then ground in a laboratory mill to pass through a 1 mm sieve and kept at room temperature in sealed plastic bags until required for laboratory analysis.

2.4. Nylon Bag Degradability

Three rumen fistulated crossbred (Boran x Frisian) steers fed hay supplemented with 2 kg of concentrate mix were used in the experiment. The nylon bag degradability of OM, N and NDF at 0, 6, 12, 24, 48, 72 and 96 h were determined using exponential model of Ørskov and McDonald (1979) as:

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

where Y = the potential disappearance of DM at time t; a = the rapidly soluble fraction; b = the potentially, but slowly degradable fraction; and c = the rate of degradation of b. The potential degradability (PD) and effective degradability (ED) were determined as follows:

$$PD = (a + b)$$

$$ED = a + bc/\ (k + c)$$

where k = passage rate estimated at 3% h^{-1}.

2.5. Apparent Digestibility

Apparent digestibility of treatment diets was determined by total collection of feces for six consecutive days in each period. Contamination of feces with urine was avoided by scooping the feces into plastic buckets soon after defecation and frequent washing of the barn floor by farm personnel that were assigned around the clock to perform these activities. Daily feces collection per animal was weighed, thoroughly mixed and a sample of 1% was taken and stored in a deep freezer at - 4°C. At the end of the collection period, the samples were pooled, thawed and mixed thoroughly. A sub-sample was taken, oven dried at 105 °C for 24 h to determine DM content. Another sample was oven dried at 65 °C for 72 h for chemical analysis. Apparent digestibility of DM or nutrients was determined using the formula;

$$\text{Apparent digestibility of DM or nutrients} = \frac{\text{DM or nutrients intake} - \text{DM or nutrients in feces}}{\text{DM or nutrients intake}}$$

2.6. Laboratory Analysis

Samples of feed offer and refusals, nylon bag residues and feces were analyzed for DM, OM and N (AOAC, 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and permanganate lignin were determined by the methods of Van Soest and Robertson (1985). *In vitro* OMD was determined using procedures outlined by Tilley and Terry (1963). Gerber method (AOAC, 1990) was used for milk fat analysis, while the formaldehyde titration method (Payne, 1932) was used to analyze milk protein. Total solid in the milk was determined using the procedures outlined by Richardson (1985). NIR-Infrared milk product analyzer (user manual ver. 1.1, 2000) was used for lactose determination.

2.7. Statistical Analysis

Analysis of variance of experimental data was run using the general linear model in SAS (1999). Treatment means were separated using least significant difference test. The model used for the analysis of data was:

$$Y_{ijk} = \mu + C_i + P_j + T_k + E_{ijk}$$

where μ = overall mean, C_i = cow effect (parity), P_j = period effect, Tk = treatment effect, E_{ijk} = random error.

3. Results

3.1. Chemical Composition of Experimental Feeds

The DM and OM contents were almost similar for feeds used in the experiment (Table 1). The NDF was highest in UMTWS followed by vetch and the concentrate mix, respectively. The same trend like that of NDF was observed for ADF contents of the treatment feeds. Permanganate lignin content in vetch and UMTWS was about 2.3 times greater than that in the concentrate mix. Crude protein and ME concentration were found to be lower in UMTWS, which contained 2.3 and 2.6 times less CP and 2.5 and 3.6 times less ME as compared to vetch and the concentrate mix, respectively.

Table 1. Chemical compositions of experimental feeds.

Chemical composition	UMTWS		Vetch hay	Concentrate
	Offer	Refusal	Offer	Offer
DM ($g\ kg^{-1}$)	931.0	923.0	927.0	922.0
OM ($g\ kg^{-1}$ DM)	903.0	903.0	920.0	914.0
CP ($g\ kg^{-1}$ DM)	86.7	85.8	199.0	225.0
IVOMD (%)	52.4	51.6	68.0	75.0
EME[1] ($MJ\ kg^{-1}$ DM)	8.47	8.25	10.97	12.0
NDF ($g\ kg^{-1}$ DM)	767.0	777.0	545.0	479.0
ADF ($g\ kg^{-1}$ DM)	576.0	578.0	377.0	203.0
Hemicelluloses ($g\ kg^{-1}$ DM)	191.0	199.0	168.0	276.0
Permanganate lignin ($g\ kg^{-1}$ DM)	108.0	110.5	108.8	48.0

*ADF = Acid detergent fiber; CP = Crude protein; DM = Dry matter; EME = Estimated metabolisable energy (0.016*DOMD); IVOMD = In vitro organic matter digestibility; NDF = Neutral detergent fiber; UMTWS = Urea molasses treated wheat straw.*

3.2. Degradability Characteristics of Treatment Feeds

Urea molasses treated wheat straw had higher *b* fraction and *PD* of OM as well as higher *a* and *c* of N (Table 2) than vetch and the concentrate mix, which were similar for their *a* and *b* fractions of OM, N and NDF. However, substantial differences were noted in terms of their *PD*, *ED*, and *c*, whereby higher *ED* and *c* were measured for vetch hay, while *PD* of OM, N and NDF was higher for the concentrate mix.

3.4. Feed Intake and Digestibility

Treatments did not affect ($P > 0.05$) intake of UMTWS (Table 3). However, cows in T_3 (50% vetch replacement) daily consumed 0.51, 0.74 and 0.78 kg more UMTWS than those maintained on T_1, T_2 and T_4, respectively. Total DM intake across all dietary treatments followed the same trend, however cows in T_3 had higher ($P < 0.05$) total DM intake than those in T_2. The intake of UMTWS was 1.7, 1.6, 1.8 and 1.6% of BW and total DM intake was 2.6, 2.6, 2.8 and 2.6% of BW for cows in T_1, T_2, T_3 and T_4, respectively. The proportion of vetch hay in the total diet was 9, 18, and 30% for T_2, T_3 and T_4, respectively. Numerically higher CP intake was recorded for cows maintained on T_3. Metabolisable energy intake was similar ($P > 0.05$) between dietary treatments. Neutral detergent fibre intake was higher ($P < 0.05$) for cows supplemented with vetch at 50% replacement compared to the control ones. Cows in T_3 had higher ($P < 0.05$) ADF intake compared to T_1 and T_2. Treatment diets were similar in the digestibility of DM and nutrients (Table 4), though T_3 appeared to promote numerically higher DM and nutrient digestibility than the other treatments.

3.5. Milk Yield, Composition and Body Weight Change

Cows in T_1 produced higher ($P < 0.05$) daily milk yield than those in T_4 (Table 5). Among the treatments with vetch inclusion, milk yield declined at the rate of 0.27 kg for each 1 kg increase of vetch in the diet of the lactating cows, although the differences were non- significant ($P > 0.05$). Treatment effects were also non-significant for milk fat ($P > 0.05$), milk protein ($P > 0.05$), lactose ($P > 0.05$) and total solids ($P > 0.05$). Among treatments with vetch replacement, numerical increase in milk fat concentration was observed with increase in the level of vetch in the total diet, while a declining trend was observed for milk protein. The lactation curve in Figure 1 represents the milk yield for a lactation period of 120 days. Cows on all dietary treatments reached peak milk yield during the first four weeks, but retained that peak lactation very briefly. Generally, cows on all dietary treatments were able to retain daily milk yield around the mean (6.5 kg/ d) after peak lactation (Figure 1). No difference ($P > 0.05$) in BW loss was observed among cows in the different treatments (Table 5). The pattern of BW changes over the 120 days of lactation is given in Figure 2. Loss of BW during the first period of lactation declined in the second phase and resulted in further improvement in the last period of lactation.

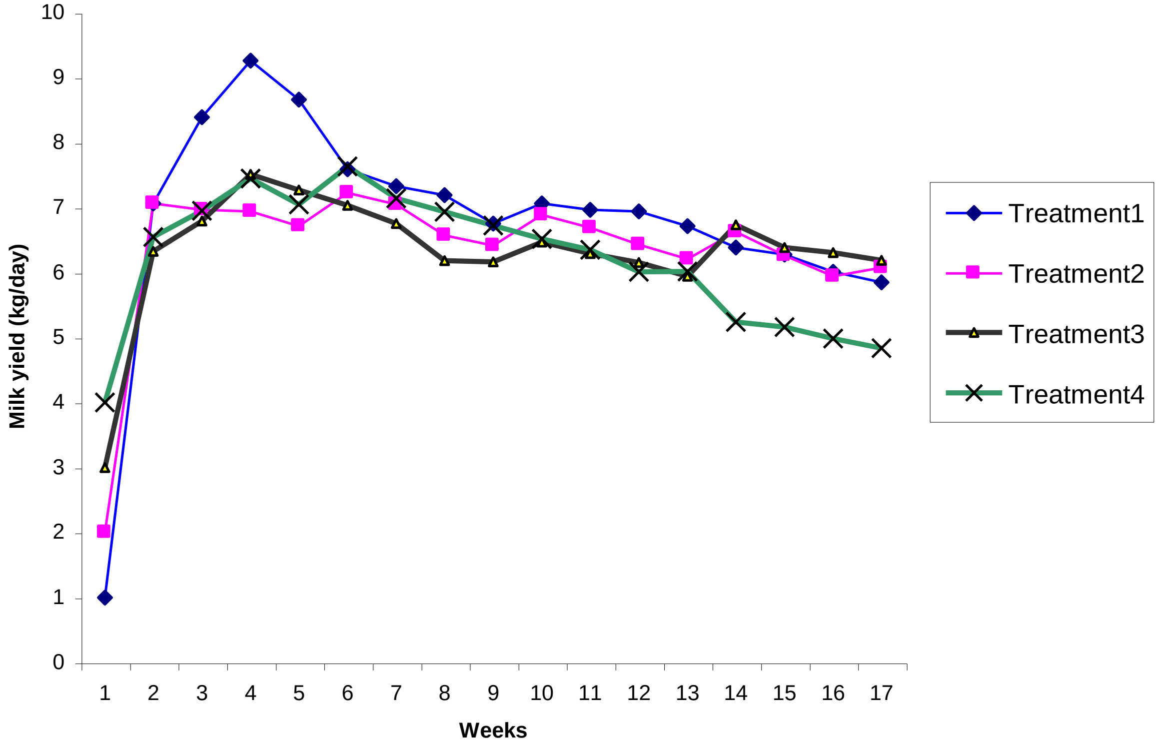

Figure 1. Lactation curve of lactating cows fed on *ad libitum* urea treated wheat straw supplemented with different proportions of vetch hay as partial replacement to concentrate mix.

Table 2. Degradation constants of organic matter, nitrogen and neutral detergent fibre of treatment feeds.

Variable	Degradation constants	UMTWS ($g\ kg^{-1}$ DM)	Vetch ($g\ kg^{-1}$ DM)	Concentrate mix ($g\ kg^{-1}$ DM)
OM	*a*	111	241	242
	b	679	451	540
	c ($g\ h^{-1}$)	0.02	0.13	0.06
	PD	790	692	782
	ED	347	606	596
N	*a*	469	303	322
	b	251	580	638
	c ($g\ h^{-1}$)	0.09	0.13	0.05
	PD	720	883	960
	ED	658	774	721
NDF	*a*	18	50	67
	b	360	452	605
	c ($g\ h^{-1}$)	0.01	0.07	0.03
	PD	368	502	672
	ED	199	372	342

a = Soluble fraction; b = Slowly, but potentially degradable fraction; c = Rate of degradation; ED = Effective degradability; N = Nitrogen; NDF = Neutral detergent fibre; OM = Organic matter; PD = Potential degradability; UMTWS = Urea molasses treated wheat straw

Table 3. Effect of replacement of concentrate mix with different proportions of vetch on daily feed intake of lactating crossbred cows fed molasses urea treated wheat straw.

Feed intake (kg /d)	T_1	T_2	T_3	T_4	SL	SED
UMTWS DM intake	6.0^{a}	5.8^{a}	6.5^{a}	5.7^{a}	ns	0.31
Total DM intake	9.5^{ab}	9.2^{b}	10.2^{a}	9.5^{ab}	*	0.32
CP intake	1.3^{a}	1.2^{a}	1.4^{a}	1.3^{a}	ns	0.05
NDF intake	5.9^{b}	6.0^{ab}	7.1^{a}	6.3^{ab}	*	0.39
ADF intake	3.8^{b}	4.1^{b}	5.0^{a}	4.5^{ab}	*	0.3
ME intake (MJ /d)	90.7^{a}	89.3^{a}	100.9^{a}	90.8^{a}	ns	4.58
Substitution rate		0.26	-0.29	0.09		

[abc] means with different superscripts within row are significantly different (P < 0.05); ADF = Acid detergent fiber; CP = Crude protein; DM= Dry matter; ME = Metabolisable energy; NDF = Neutral detergent fiber; NS = Not significant; SED = Standard error of difference. UMTWS = Urea molasses treated wheat straw.

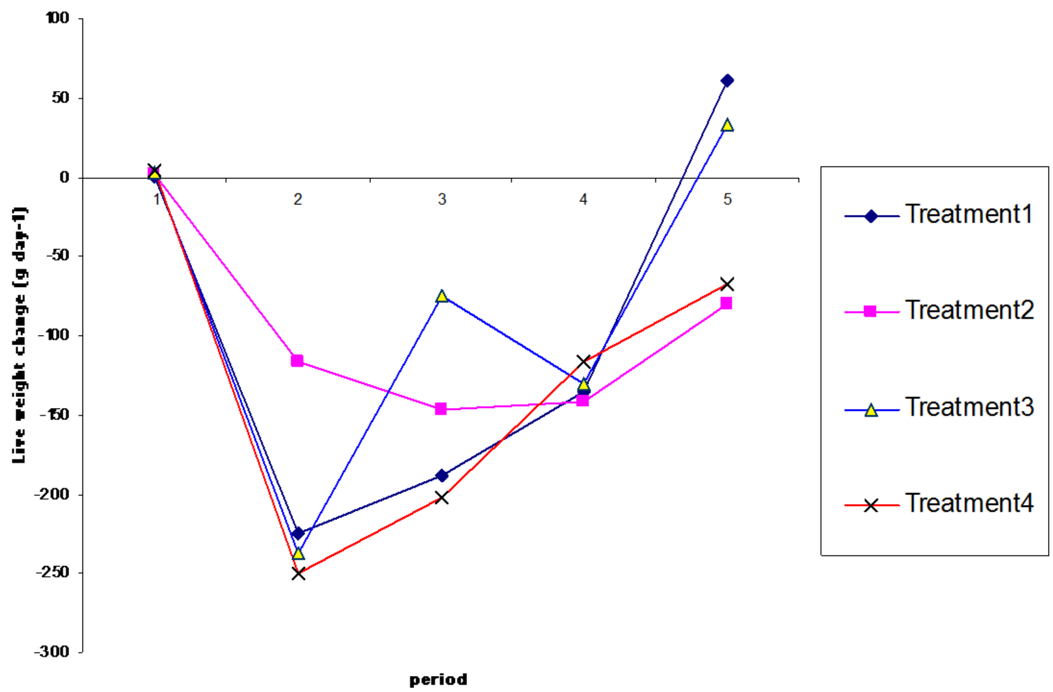

Figure 2. Periodic live weight change of lactating crossbred cows fed *ad libitum* urea molasses treated wheat straw and supplemented with vetch hay as a partial replacement to concentrate mix.

4. Discussion

4.1. Chemical Composition of Experimental Feeds

The response of wheat straw to molasses urea treatment in this study was comparable to the results of Mason *et al.* (1988). The CP content of UMTWS was three times (8.7%) more than that of untreated wheat straw (2.5%) reported by EARO (2004). The CP content of the UMTWS in this study was lower than 11-12% CP required for moderate levels of ruminant production (ARC, 1980), while it was still higher than the limiting levels (6-8%) below which appetite and digestibility are depressed (Forbs, 1995). The NDF content (77%) of UMTWS was much higher than 55%, which is suggested to limit feed intake (Van Soest, 1994). The lignin content (10.8%) of UMTWS was also higher than that reported for untreated wheat straw (7.9%) by EARO (2004). Mason *et al.,* (1988) also reported similar increase in lignin content due to urea treatment. The *in vitro* OMD (52.4%) was improved by around 14 percentage units when compared to that of untreated wheat straw (38%) reported by EARO (2004). Vetch and the concentrate mix had CP content of more than 15%, the level of CP usually required to support lactation and growth (McDonald *et al.,* 2002). Furthermore, their NDF contents are lower than 55% reported by Van Soest (1994) to limit appetite and digestibility.

4.2. Rumen Degradation Characteristics of Experimental Feeds

The degradation parameters with the exception for *a* value were comparable to those reported for similar feedstuffs by Ørskov *et al.* (1980) and Seyoum (1995). The variation in the estimation of *a* value could be attributed to lack of standardised hand washing procedure. The relatively higher *c* of nutrients in the vetch hay implies rapid degradation in the rumen, limiting the quantities of rumen escape nutrients (McDonald *et al.,* 2002). This may compromise the value of vetch hay in the diet of lactating and growing cattle. The slower rate at which the OM and NDF fractions of the UMTWS degraded suggest longer rumen retention time which could lead to poor feed intake and digestibility. Such phenomenon can also lead to wastage through urinary excretion of rumen degraded nitrogen from UMTWS due to lack of parallel degradation of OM and nitrogen. The low degradability of UMTWS except for nitrogen was in agreement with similar results (Ørskov *et al.,* 1980) for low quality basal diets and this could be clearly attributed to the higher content of structural over soluble carbohydrates.

Table 4. Effect of replacement of concentrate mix with different proportions of vetch on diet apparent digestibility in lactating crossbred cows fed urea molasses treated wheat straw.

Apparent digestibility (%)	T_1	T_2	T_3	T_4	SL	SED
DM	59.1[a]	58.4[a]	63.9[a]	61.4[a]	ns	0.5
CP	68.4[a]	66.6[a]	69.1[a]	67.5[a]	ns	0.06
NDF	58.7[a]	61.2[a]	64.3[a]	63.2[a]	ns	0.4
ADF	53.2[a]	53.7[a]	57.5[a]	56.3[a]	ns	0.3

[abc] means with different superscripts with in row are significantly different ($P < 0.05$); ADF = Acid detergent fiber; CP = Crude protein; DM = Dry matter; NDF = Neutral detergent fiber; ns = Not significant; SED = Standard error of difference.

Table 5. Effect of replacement of concentrate mix with different proportions of vetch on body weight change, milk yield and composition in lactating crossbred cows fed urea molasses treated wheat straw.

Treatment	Body weight change (g/ day)	Milk yield (kg/ d)	Milk composition (%)			
			Fat	Protein	Lactose	Total solids
T1	-119.1[a]	6.68[a]	4.53[a]	3.60[a]	4.16[a]	14.01[a]
T2	-121.4[a]	6.54[ab]	4.51[a]	3.64[a]	4.12[a]	13.91[a]
T3	-102.1[a]	6.45[ab]	4.55[a]	3.62[a]	4.17[a]	14.08[a]
T4	-133.2[a]	6.24[b]	4.62[a]	3.60[a]	4.16[a]	14.11[a]
SL	ns	*	ns	ns	ns	ns
SED	13.89	0.13	0.12	0.03	0.02	0.18

[abc]means with different superscripts within column are significantly different ($P < 0.05$); T_1 = 0.5 kg concentrate + ad libitum UMTWS; T_2 = 25% of concentrate mix replaced by vetch hay + ad libitum UMTWS; T_3 = 50% of concentrate mix replaced by vetch hay + ad libitum UMTWS; T_4 = 75% of concentrate mix replaced by vetch hay + ad libitum UMTWS; SED = Standard error of difference; NS = Not significant; UMTWS = Urea molasses treated wheat straw.

4.3. Feed Intake

The daily UMTWS DM intake and DM intake as percent of BW (2.6%) in this study agrees with that reported by Rehirahe and Ledin (2004) in lactating crossbred cows offered urea treated cereal straws supplemented with concentrate mix and forage crops. Observed substitution rates of UMTWS with vetch hay were 3.8, -8.53 and 4.52% for T_2, T_3 and T_4, respectively in this study that were much smaller than that reported by Khalilli *et al.* (1994) for low quality basal feeds supplemented with forage legumes. The results of the present study tended to support the general contention that substitution usually occurs for forage legume supplementation, when the legume component contributes at least 30 -40% of the total DM intake (Topps, 1997). The maximum level of vetch hay included in the present study was 30% (T_4) of the total DM intake, and the replacement of the concentrate mix by up to 50% of vetch hay is found to optimize both UMTWS and total DM intake compared to the control diet.

The CP intake of cows in this trial satisfied the estimated CP requirements for maintenance and 8-10 l milk production containing 4.5% butterfat (ARC, 1990). The nitrogen requirement for microbial protein synthesis is roughly estimated to be 145 g CP/ kg OM fermented. With 8.7% CP content and 52% OMD, UMTWS supplied 167.3 g CP/ kg OM fermented. This implies that, all dietary treatments were able to satisfy CP intake for normal rumen microbial fermentation. Higher CP intake through increased forage legume supplementation could replace part of the basal feed intake, which is related to physical limitation of the digestive tract to handle larger amount of DM. Since feeding vetch at 75% replacement did not increase basal feed intake, it appears that 50% vetch replacement is the optimal level in the current study.

Protein requirements for maintenance and the observed daily mean milk yield (6.5 kg/ d) of cows used in this trial were met at all levels of vetch hay supplementation, but the estimated ME intake requirement (97.6MJ/ d) according to ARC (1990) for maintenance and milk production of the cows was not met except in T_3. Therefore, energy intake from this trial showed a deficit of –6.9, -8.31 and –6.8 MJ/ d for T_1, T_2 and T_4, respectively; while excess energy intake of 3.32 MJ/ d was recorded for T_3. The finding in this trial clearly supports the idea suggested by Preston and Leng (1986) that molasses or alkali treated straw based diets are more digestible, but they support little improvement in animal productivity unless they are supplemented with by-pass nutrients. Milk production cannot be supported on fermentative digestion alone, it is thus, important to supply adequate amount of energy to the level that the extra protein is utilized to curtail the observed BW losses, and thereby increase milk yield. Generally speaking, the result of the present study is in agreement with other studies (Ørskov *et al*,. 1988; Rehirahe and Ledin, 2004), where both the milk yield and BW loss of cows fed good quality straw treated with ammonia were similar to that expected from feeding good quality silage or hay.

The numerically higher DM digestibility in T_3 and T_4 compared to T_1 and T_2 is similar to DM digestibility observed in buffaloes fed urea treated wheat straw with low levels of concentrate supplementation (Rai *et al*., 1989). The DM digestibility of the treatment feeds observed in this study are relatively higher than DM digestibility of 55.3% in crossbred cows fed ammoniated wheat straw supplemented with concentrate (Singh *et al*., 1992). The observed differences in DM digestibility could be attributed to the quantity of urea used for straw treatment and the breeds of cows used. Moreover, the level of concentrate in the total diet may have also contributed to the differences observed in digestibility by modulating rumen microbial population, pH and consequently rumen fermentation. The lack of differences between dietary treatments containing vetch hay and the control diet in CP digestibility signifies that vetch hay could partially replace the concentrate mix used in the present study. The CP digestibility observed in the present study is comparable to that reported by Mpairwe (1998) for crossbred cows fed low quality basal diet supplemented with graded levels of lablab hay and wheat bran, but larger than the CP digestibility reported by Singh *et al*. (1992) for similar types of feeds used in this study.

4.4. Milk Yield, Composition and Body Weight Change

The daily milk yield obtained from the present trial was comparable to 6.2 and 5.6 kg/ d for similar diets offered to crossbred lactating cows (Rehirahe and Ledin, 2004). Moreover, Varvikko and Khalilli (1993) noticed similar results for crossbred cows fed poor quality native hay supplemented with graded levels of tagasaste replacing a concentrate mix by up to 33%. The observed lack of difference for both parameters (milk yield and quality) between the control and vetch hay containing treatments concurs with the objective of this study that vetch hay can partially replace the concentrate mix without any significant reduction in milk yield and quality.

The low milk production in this study is similar to the results of Hill and Leaver (1999) in lactating dairy cows offered urea treated whole-crop wheat as a sole forage, whereby high feed and digestible OM intakes resulted only in moderate levels of milk production, which they attributed to a low efficiency of utilisation of the digested energy from urea treated whole-crop wheat.

The results of this study showed that there was a more or less stable profile and strong persistency in terms of daily milk yield among the cows that received the different dietary treatments except for those cows maintained on T_4 (75% vetch replacement), indicating that the lactation curve from the present study was normal and assumed the lactation curve of cows described by Wood (1969). The higher level of milk fat reported in this study compared well to similar studies (Khalilli *et al*., 1994; Mpairwe, 1998) and could probably be associated with better utilization of dietary fibre leading to more precursors for mammary lipid synthesis (Susmel *et al*., 1995). Moreover, elevation in milk fat is observed when body reserves are used extensively to support lactation as lipids from body fats are incorporated directly into milk fat as compared to dietary fats (Ørskov and Ryle, 1990). Thus, the increased milk fat concentration observed in the present study could also be explained by the BW loss of the experimental cows.

Similarly, the high milk protein content observed (3.62 %) in the current study compared well with other similar studies (Khalilli *et al*., 1994; Mpairwe, 1998) and could be attributed to the high CP intakes of the cows which has been reported to increase milk yield and milk protein concentration (Phipps, 1994). The milk yield and composition data from the current study show no beneficial advantage of increasing the level of vetch hay beyond 50% replacement of the concentrate mix.

Lose in BW despite the increased CP intake above the requirement in this study suggests that energy was the most limiting nutrient. Indeed, acetate is the predominant rumen fermentation end product in urea treated straw based diet (Leng, 1982). This limits the molar proportion of propionic acid leading to inadequacy of glucose for milk synthesis. The BW lose of cows during early lactation (60-90 days after calving) was not surprising and has been reported in a similar study (Muinga *et al*., 1992) with BW loss for the entire lactation period ranging between 20- 90 kg for lactating crossbred cows fed *ad libitum* Napier grass and supplemented with 0.4 or 8 kg/ d of fresh leucaena forage from day 15- 112 of lactation. Garnsworthy (1997) noted that cows in early lactation and those of higher genetic merits partition energy for milk production at the expense of body fat reserve and noted that cows usually lose 0.5-1.0 kg of BW each day for the first eight weeks of lactation and this is mostly body fat. Therefore, increased energy intakes at this stage of lactation is expected to result in further increases in milk yield, if the cow's genetic potential has not been attained and/or a reduction in body fat mobilization. Improvements in BW of cows for all dietary treatments during the last period of the lactation can be attributed to the use of more dietary energy for tissue retention owing to the decreased milk yield during this period (Figure 1).

5. Conclusions

The chemical composition as well as the rumen degradation characteristics of vetch hay and the concentrate mix used in this study were comparable. Based on this and the feed intake and digestibility response of the experimental animals, it is concluded that vetch hay can replace the concentrate mix used in the current study most appropriately at the 50% inclusion, which has an important impact in small scale milk production schemes, where the supply of concentrate feed ingredients are limited and where on-farm produced legumes could be used in crop rotation or as a relay crops.

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