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SUPPLEMENTARY VALUE OF VETCH (*VICIA DASYCARPA*) HAY AS A REPLACEMENT TO CONCENTRATE MIX IN THE DIET OF LACTATING CROSSBRED COWS

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ABSTRACT: An experiment was conducted with the objective of replacing vetch for concentrate mix on feed intake and digestibility as well as milk production and composition in lactating F1 crossbred (Boran x Friesian) cows fed with a basal diet of urea-molasses-treated wheat straw. 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 (UMTWS) *ad libitum* and supplementation with concentrate mix (T_1), and replacement of the concentrate mix with vetch (*Vicia dasycarpa*) hay at a 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. *In sacco* degradability study 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 dry matter (DM) intake was significantly higher ($P<0.05$) for cows in T_3 compared to cows in the other treatments. Nutrient intakes and apparent digestibility were non-significant ($P>0.05$) among treatments, except for cows in T_3 that had higher ($P<0.05$) acid detergent fibre (ADF) intakes than cows on T_1 and T_2. Crude protein (CP) and metabolisable energy (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. Milk compositions were similar ($P>0.05$) for cows in the different treatments. It is concluded that vetch hay could substitute up to 50% of the concentrate mix without compromising feed intake and digestibility of nutrients as well as milk yield and compositions of lactating F1 Boran x Friesian cows.

Key words/phrases: Concentrate mix, rumen degradability, urea-molasses treatment, vetch, wheat straw

INTRODUCTION

Wheat straw is one of the major cereal crop residues produced in the world. As an example, around 2.5 million tons of wheat straw are produced annually in Ethiopia (CSA, 2010). However, wheat straw utilization is highly constrained by low contents of CP, poor organic matter digestibility (OMD) and high NDF content (Sharma *et al.*, 2004; Misra *et al.*, 2006). Consequently, urea treatment is becoming a common practice in Ethiopia as a strategy to improve its feed value. Urea treatment of wheat straw under local conditions raised CP content by 5% and *in vitro* OMD by 10% (Rehirahie Mesifen and Ledin, 2004). Post treatment intake and digestibility has only lead to a dramatic improvement of ruminant performance from sub maintenance to maintenance level (Smith, 2002). As far as lactating dairy cows are concerned, the major constraint to milk production on 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 the NDPH for synthesis of fatty acids. Thus, urea treated wheat straw requires strategic supplementation for improved animal performance.

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*). Vetch has high CP content (19.9%), *in vitro* organic matter digestibility (IVOMD) (68.7%) and DM yield (4–6 t/ha) (Seyoum Bediye, 1995; Getnet Assefa, 1999). Moreover, it is adapted and widely used in the cool tropical highlands (Getnet Assefa, 1999). However, judicious use of vetch in the daily ration of lactating cows can only be justified when its level of inclusion is biologically optimized. Thus, the objective of this study was to determine the effect of replacement of a concentrate mix with vetch hay on feed and nutrient intake and apparent digestibility, milk yield and composition in lactating F1 Boran x Friesian cows fed with urea-molasses-treated wheat straw.

MATERIALS AND METHODS

Study site and management of experimental animals

The study was conducted at Holetta Agricultural Research Centre, Ethiopia. The research centre is located at 9°3′N latitude and 38°30′E longitude at an altitude of 2400 masl. The mean annual rainfall is 1100 mm and the mean minimum and maximum temperatures are 6°C and 22°C, respectively. A total of eight lactating F1 crossbred cows (Boran x Friesian) with similar daily initial milk yield of 8–10 lt/head/day), same stage of lactation (early lactation), but differing in parties (one through four) were selected from the dairy herd of the research centre. 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.

Experimental feeds

Vetch was harvested at 50% flowering, field cured, baled and stored in a shade. Representative samples were taken for laboratory and degradability studies before the hay was baled. Wheat straw (HAR-1899) was collected, baled and then stored in a shade. Wheat straw was treated with urea molasses in batches every two weeks by impregnating 100 kg dried straw mass in a solution made up of 100 ℓ of water, 5 kg of urea, and 10 ℓ of molasses in an above-ground silo of dimension 2m×1m×1m for 21 days. Compaction was made with four people trampling over the wet straw mass several times and by loading heavy materials on top to keep the condition in the silo more air tight. The concentrate mix was formulated using wheat bran, noug seed cake (*Guizotia abyssinica*) and salt in the ratio of 74, 25 and 1%, respectively. The mix was prepared to meet nutrient requirements 866.5g CP d^{-1} and 97.6MJ, ME d^{-1} of F1 crossbred cows (Boran x Frisian) weighing 400 kg and with mean daily milk yields of 8–10 ℓ containing 4.5% butter fat (ARC, 1990). The concentrate mix contained DM (908.9 g kg^{-1}), CP (225 g kg^{-1} DM), and IVOMD (752 g kg^{-1} DM). The ME content was 12 MJ kg^{-1} DM as estimated from the equation DODM × 0.016 (McDonald *et al.*, 2002).

Experimental design, treatments and measurements

Eight cows were randomly blocked in a switch over 4 × 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 that include T_1 = Urea-Molasses Treated Wheat Straw (UMTWS) *ad libitum* + concentrate mix as 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. 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*. The concentrate mix at the rate of 0.5 kg/litre of milk was offered in two equal portions at 500 and 1700 hours at morning and evening milking, respectively. Vetch hay was offered at six hours time interval to maintain ideal microbial fermentation for UMTWS digestibility. Feed offer and refusals were measured and recorded daily for each cow to determine daily feed intake. Substitution rate UMTWS 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 for each cow, bulked on a weekly basis and oven dried at 65°C for 72 hours. Samples were then ground in a laboratory mill to pass through 2 and 1 mm sieve and kept at room temperature in sealed plastic bags until required for laboratory analysis. The daily milk yield of individual cows were recorded and about 100 ml of thoroughly mixed composite of morning and evening milk samples were used to determine percentage of fat, protein, lactose and total solids.

Nylon bag degradability

The kinetics of feed digestion for the basal and supplementary feeds in the rumen was studied in festulated F1 crossbred steers fed on a standard diet *ad libitum* natural pasture hay plus 2 kg concentrate composed of 55% wheat bran, 43% Noug cake and 2% salt. Organic matter, N and NDF degradability of the experimental feeds were determined using nylon bag technique developed by Ørskov and McDonald (1979). Feed samples grounded to pass 2 mm screen and weighing 3g on air-dry basis were transferred into each nylon bag. The bags were then incubated in duplicates for 6, 12, 24, 48, 72, and 96 hours in the rumen of each steer fed with the standard diet. After removal, the bags were washed manually under a running tap water until clear water appeared at the end. The zero hour bags (two bags per sample) were allowed to stay in a bucket containing clean water for about half an hour. After washing, the bags were dried in a forced-draught oven at 65°C for 72 hours, cooled and weighed. The residues were then pooled for each animal by incubation time and analyzed for determination of OM, N, and NDF degradability. Data from nylon bag disappearance were fitted to the model given below (Ørskov and McDonald, 1979):

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

Where,

Y = the potential disappearance of OM at time t;
a = the rapidly soluble fraction;
b = the potentially, but slowly degradable fraction;
c = the rate of degradation of b, and
t = time.

ED= effective degradability was calculated using Ørskov and McDonald (1979) exponential model below.

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

Where,

k = passage rate estimated at 3% h^{-1} (Ørskov and McDonald, 1979);
PD = (a+b), potential degradability.

Apparent digestibility

Apparent digestibility of treatment diets was determined by total collection of faeces for 6 consecutive days in each period. Contamination of faeces with urine was avoided by scooping the faeces into plastic buckets soon after defecation and frequent washing of the barn floor through out the day and night using stand-by personnel. Daily (24 hrs) faeces collection per animal was weighed, thoroughly mixed and about 1% of sample 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 hours to determine DM content. Another sample was oven dried at 65°C for 72 hours for further laboratory analysis. Apparent digestibility of DM or nutrients was determined using the formula developed by Osuji *et al.* (1993);

$$\text{Apparent digestibility} = \frac{\text{DM or nutrients intake - DM or nutirents in faeces}}{\text{DM or nutrients intake}}$$

Laboratory analysis

Samples of feed offer and refusals, nylon bag residues and faeces were analyzed for DM, OM and N (AOAC, 1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and permanganate lignin were determined by the methods of Van Soest and Robertson (1985). *In vitro* organic matter digestibility was determined using procedures outlined by Tilley and Terry (1963). NIR-Infrared milk product analyzer (user manual ver. 1.1, 2000) was used for milk fat, protein, lactose and total solids determinations.

Statistical analysis

Analysis of variance of experimental data was run using the general linear model in SAS (2002). 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;
T_k = treatment effect;
E_{ijk} = random error.

The data set and the model (Ørskov and McDonald, 1979) for nylon bag degradability study were fed to SAS (2002) and the results were discussed using mean values for each parameter.

RESULTS

Chemical composition of experimental feeds

The DM and OM contents were almost similar for feeds used in the experiment (Table 1). The NDF was high in UMTWS followed by vetch and the concentrate mix, respectively. The same trend was observed for ADF contents of the treatment feeds. Lignin content in vetch and UMTWS was about 2.3 times greater than that in the concentrate mix. Crude protein (CP) 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.

Rumen degradability characteristics of experimental feeds

Urea-molasses-treated wheat straw (UMTWS) had higher slowly degradable fraction (*b*) and Potential Degradability (PD) of OM as well as higher water soluble (*a*) and rate constant (*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*, Effective Degradability (*ED*), and *c*, whereby higher *ED* and *c* were measured for vetch hay; *PD* of OM, N and NDF was higher for the concentrate mix.

Voluntary feed intake and apparent digestibility (DM and nutrient)

Treatments did not significantly (P>0.05) affect intake of UMTWS, total CP and ME (Table 3). 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. 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 proportion of vetch hay in the total diet was 9, 18, and 30% for T_2, T_3 and T_4, respectively. Neutral detergent fibre intake was higher (P<0.05) for cows supplemented with vetch at 50% (T_3) replacement compared to the control ones. Cows in T_3 also had higher (P<0.05) ADF intake compared to T_1 and T_2. Treatment diets were similar (P>0.05) in the apparent digestibility of DM and nutrients (Table 3) except for ME where cows on dietary T_3 appeared to have digested more of the ME than cows that received the control treatment.

Table 1. Chemical compositions of experimental feeds (g/kg DM).

Chemical compositions	Feed Type			
	TWS	UWS	Vetch	Concentrate
DM	931	933	927	922
OM	903	912	920	914
CP	86.7	24	199.0	225.0
IVOMD (%)	52.4	36	68.0	75.0
EME (MJ/kg DM)	8.47	6.08	10.97	12.04
NDF	767	792	545	479
ADF	576	482	377	203
Hemicelluloses	191	290	168	276
Lignin	108	82	108.8	48.0

EME= Estimated metabolisable energy (0.016*DOMDM); TWS = Treated wheat straw; UWS= Untreated wheat straw.

Table 2. Degradability characteristics of experimental feeds (g/kg DM).

Variable	Degradation Constant	TWS	Vetch	Concentrate
OM	a	111	241	242
	b	679	451	540
	c(g/h)	0.016	0.127	0.057
	PD	790	692	782
	ED	347	606	596
N	a	469	303	322
	b	251	580	638
	c(g/h)	0.092	0.130	0.050
	PD	720	883	960
	ED	658	774	721
NDF	a	18	50	67
	b	360	452	605
	c(g/h)	0.011	0.075	0.025
	PD	368	502	672
	ED	199	372	342

a= Soluble fraction; b = Potentially but slowly degradable fraction; c = Rate of degradation; PD = Potential degradability; ED = Effective degradability; TWS = Urea treated wheat Straw.

Table 3. Daily DM and nutrient intake and digestibility of experimental crossbred dairy cows.

Feed/nutrient	T_1	T_2	T_3	T_4	Mean	Significance	SED	CV%
Intake (kg/day)								
Wheat straw	6.0^{a}	5.8^{a}	6.5^{a}	5.7^{a}	6.0	NS	0.3	14.5
Total DM	9.5^{ab}	9.2^{b}	10.2^{a}	9.5^{ab}	9.6	*	0.3	9.5
Total CP	1.3^{a}	1.2^{a}	1.4^{a}	1.3^{a}	1.3	NS	0.05	11.2
ME(MJ/day)	90.7^{a}	89.3^{a}	100.9^{a}	90.8^{a}	92.9	NS	4.58	13.9
NDF	5.9^{a}	6.0^{ab}	7.1^{a}	6.3^{ab}	6.31	*	0.39	17.3
ADF	3.8^{b}	4.1^{b}	5.0^{a}	4.5^{ab}	4.4	*	0.3	18.7
Apparent Digestibility (%)								
DM	59.1^{a}	58.4^{a}	63.9^{a}	61.4^{a}	60.7	NS	0.5	25.9
CP	68.4^{a}	66.6^{a}	69.1^{a}	67.5^{a}	67.9	NS	0.06	20.3
ME	90.6^{b}	91.0^{ab}	92.7^{a}	92.2^{ab}	91.6	*	4.42	14.7
NDF	58.7^{a}	61.2^{a}	64.3^{a}	63.2^{a}	61.8	NS	0.4	26.7
ADF	53.2^{a}	53.7^{a}	57.5^{a}	56.3^{a}	55.2	NS	0.3	13.2

^{abc} = Means with different superscripts within row are significantly different (P<0.05); NS = Not significant; * = Significant; SED = Standard error of difference; CV = Coefficient of variation.

Milk yield and compositions

Cows in T_1 produced higher (P<0.05) daily milk yield than those in T_4 (Table 4). But there was no significant difference among T_1, T_2 and T_3. Among the treatments with vetch inclusion, milk yield declined at the rate of 0.27 kg for each replacement in 1 kg of vetch in the diet of the lactating cows, although the differences were not significant (P>0.05). Treatment effects were also non-significant (P>0.05) for milk fat, milk protein, lactose and total solids. Among treatments with vetch replacement, slight increase in milk fat content 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 for about 2–4 weeks. Generally, cows on all dietary treatments were able to retain daily milk yield around the mean (6.5 kg d^{-1}) after peak lactation.

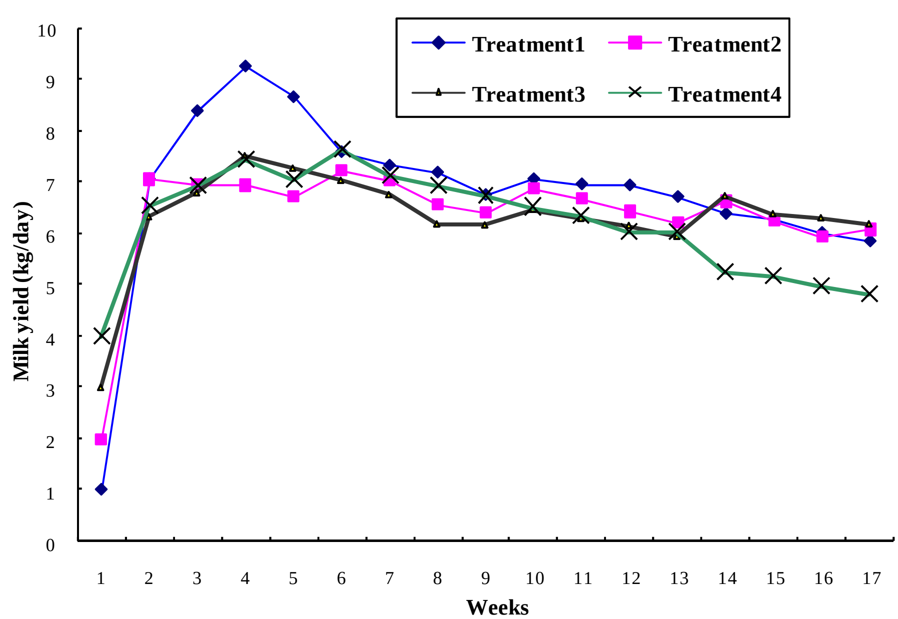

Fig. 1. Lactation curve of experimental cows fed on *ad libitum* urea treated wheat straw.

Table 4. Milk yield and composition of experimental crossbred dairy cows.

Treatment	Milk yield (kg/d)	Milk compositions (%)			
		Fat	Protein	Lactose	Total solids
T_1	6.68[a]	4.53[a]	3.60[a]	4.16[a]	14.01[a]
T_2	6.54[ab]	4.51[a]	3.64[a]	4.12[a]	13.91[a]
T_3	6.45[ab]	4.55[a]	3.62[a]	4.17[a]	14.08[a]
T_4	6.24[b]	4.62[a]	3.60[a]	4.16[a]	14.11[a]
Mean	6.48	4.55	3.62	4.15	14.03
Significance	*	NS	NS	NS	NS
SED	0.13	0.12	0.03	0.02	0.18
CV%	5.85	7.42	2.23	1.51	3.55

[abc] = within column, means with different superscripts are significantly different ($P<0.05$);
SED = standard error of difference; * = Significant; CV%= coefficient of variation; NS=Not significant.

DISCUSSION

Chemical composition of experimental feeds

The response of wheat straw to molasses urea treatment in this study was comparable to previous results (Sharma *et al.,* 2004; Misra *et al.,* 2006). The CP content of UMTWS (8.7%) was more than three times that of the untreated wheat straw (2.4%). However, the CP content of UMTWS observed in the current study was lower than 11–12% CP required for moderate levels of ruminant production; while it was still higher than the limiting levels (6–8%) below which appetite and digestibility are depressed (Preston and Leng, 1986). Urea treatment reduced NDF and hemicelluloses by 3.16% and 34.14%, respectively, while ADF and the lignin contents were increased by 16.32% and 24.07%, respectively, due to alkali induced "peeling" reactions, in which degradation of sugar moieties occur at the reducing end of hemi-cellulose chains rendering some of the hemi-cellulose soluble in neutral detergent solution (Misra *et al.,* 2006; Mesfin Dejene *et al.,* 2009). The decrease in the main fibre constituents has indeed resulted in improved IVOMD of the TWS (Table 1). Urea treatment improved IVOMD of UWS by around 16% units. This result is similar with an earlier report on maize residue (Oji *et al.,* 2007) and for teff straw (Mesfin Dejene *et al.,* 2009). Vetch and the concentrate mix had CP content of more than 15% usually required to support lactation and growth (Norton, 1982). Furthermore, their NDF and ADF contents are much lower with no negative effect on intake and digestibility.

Rumen degradability characteristics of experimental feeds

The degradation constants with the exception for water soluble fraction "*a*" were comparable to those reported for similar feedstuffs by Ørskov *et al.* (1988) and Seyoum Bediye (1995). However, this variation in "*a*" value according to a report by Ørskov *et al.* (1988) can be attributed to variability in the lack of standardized hand washing procedure. The relatively higher rate of degradation "*c*" of nutrients in the vetch hay implies rapid degradation in the rumen, limiting the quantities of rumen escape nutrients. This may compromise the value of the vetch hay in the diet of high performing lactating and growing animals. The slower rate at which the OM and NDF fractions of the UMTWS degraded suggests longer ruminal retention time which could lead to poor feed intake and digestibility. Compared to the concentrate mix and vetch hay the low degradability of UMTWS except for nitrogen was in agreement with similar results (Ørskov *et al.,* 1988) for low quality basal diets and this could be clearly attributed according to same authors to its dominant content of structural than soluble carbohydrates.

Voluntary feed DM and nutrient intake

The daily UMTWS intake and total DM intake obtained in the present study coincides with the 6.23 and 9.09 kg value reported by Mesfin Dejene *et al.* (2009) for lactating cows maintained on urea treated teff straw. The daily intake of UMTWS in this study also agrees with the value reported by Rehirahie Mesifen and Ledin (2004) for crossbred lactating cows fed with urea treated cereal straws supplemented with a concentrate mix and forage crops. Cows in the present study have also consumed comparable amount of total DM (2.6% of BW) to that reported by Misra *et al.* (2006) for urea ammoniated wheat straw and Wanapat *et al.* (2009) for urea treated rice straw. Substitution rates of 3.8, -8.53 and 4.52% for UMTWS in T_2, T_3, and T_4, respectively observed in the present study were much smaller than reported values by Khalilli *et al.* (1994) for low quality basal feeds supplemented with forage legumes. The results of the present study support the general contention that substitution usually occurs for forage legume supplementation, when the legume component contributes at least 30 to 40% of the total DM intake. In the present study, the maximum level of vetch included was 30% (T_4) of the total DM intake, and the replacement of the concentrate mix by up to 50% of vetch is considered to optimize both UMTWS and total DM intake compared to the control diet.

The improved CP intake with vetch-supplemented treatments could be attributed to the combining effect of vetch with the concentrate mix, both of which were higher in their CP contents. 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). Compared to the CP requirement of 866.5 g d^{-1} there were extra allowances of CP of 423.5, 363.5, 503.5 and 393.5 g d^{-1} for T_1, T_2, T_3 and T_4, respectively. On the contrary, the estimated ME requirement of 97.6 MJ, ME d^{-1} has not been met except in T_3. Therefore, energy balance from this trial showed a deficit of –6.9, -8.31 and –6.8 MJ d^{-1} for T_1, T_2 and T_4, respectively; while a positive energy balance of 3.32MJ d^{-1} was recorded for T_3. The mean daily CP and ME intakes can fairly be compared to earlier values reported by Prasad *et al.* (1998) for cross bred lactating cows but slightly lower than that reported by Doan *et al.* (1999) for pure lactating Friesian cows maintained on urea treated rice straw owning to the difference in the straw used for urea treatment and type of breed. Vetch replacement of concentrate improved plant fibre intakes and digestibility coefficients (Table 3). More over the concentrated alkaline agents as a result of urea treatment can chemically break the ester bonds between lignin, hemi-cellulose and cellulose and physically make structural fibre swollen. These effects enable rumen microbes to attach the structural carbohydrate more easily hence higher degradability and intake could be obtained (Wanapat and Cherdthong, 2009).

Feed DM and apparent nutrient digestibility

DM digestibility of experimental diets observed in this study was relatively higher than DM digestibility of 54.3% in crossbred calves fed with wheat straw, supplemented with concentrate (Misra *et al.*, 2006), and DM digestibility of 48.6% in cows fed with 3% urea treated wheat straw, supplemented with a concentrate mix and forage legume (Pathak, 2005). The observed differences could have arisen due to the variation in the quality of wheat straw, 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 by modulating rumen microbial population, pH and consequently rumen fermentation. However, it is in agreement with the 60.5% and 63.7% values that were reported for dairy cows maintained on urea treated rice straw by Wanapat *et al.* (2009) and Prasad *et al.* (1998).

On the other hand, absence of variation between dietary treatments containing vetch and the control diet in CP digestibility is an excellent reflection of the possibility of partial replacement of the concentrate mix with vetch in the present study. The CP digestibility observed in the present study is comparable to that reported by Prasad *et al.* (1998) for crossbred cows fed with urea treated rice straw, but larger than the CP digestibility reported earlier (Pathak 2005; Misra *et al.*, 2006; Wanapat *et al.*, 2009) for similar feed types. The combining effect of a forage legume (vetch hay) with a concentrate mix at the rate of 50% replacement displayed substantial effect in terms of optimizing digestibility of the available CP and metabolisable energy. It is an implication for the existence of a more ideal ruminal environment which can further be evidenced from a rather larger ($P<0.05$) intakes (TDMI; ADFI) and numerical increments ($P>0.05$) for some other intakes like TWS, CP, ME and NDF.

On average, 61.83% of the total NDF and 55.17% of the ADF consumed have been digested for vetch supplemented groups. The mean value of apparent NDF and ADF digestibility from this study (61.83%, 55.2%) can fairly be compared with the value reported for both cell wall constituents (61.7%, 58.2%) earlier by Prasad *et al.* (1998) for urea treated rice straw fed crossbred cows but still larger than the value (55.3%, 49.2%) reported for same feed by Wanapat *et al.* (2009) for dairy cows and the values (56.4%, 46.7%) reported for crossbred calves fed on urea treated wheat straw by Misra *et al.* (2006) the in the daily ration of lactating crossbred cows. Ndlovu (1992) attributed the reason for the increased digestibility of cell wall constituents after being supplemented with forage legumes to higher degradations associated to high N content, buffering capacity and fragility of their cell walls although legumes are known to have more lignin in the cell walls. The reason for the marked but slight increment (P>0.05) in apparent NDF ADF digestibilities in the current trial was attributed according to Zorilla-Rios *et al.* (1989) to the small amount of readily available carbohydrate stimulating bacterial digestion of straw by enhancing bacterial attachment to particulate matter. However, compared to NDF, both intake and digestibility were lower for the ADF constituent. The difference in the digestibility coefficients between NDF and ADF fractions can be explained by the presence of the partially available hemicelluloses fraction in the NDF residue and the higher concentration of the indigestible lignin fraction in the ADF as compared to NDF residue. In this experiment too, higher levels of cell wall (NDF and ADF) intakes and digestibility were optimized when the basal material was supplemented with a moderate level of (50%) concentrate replacement.

Milk yield and compositions

The mean daily milk yield obtained from the present trial was comparable to values 6.1 kg d^{-1} reported for urea ammoniated rice straw based diets offered to crossbred lactating cows (Prasad *et al.*, 1998). Moreover, Mesfin Dejene *et al.* (2009) reported slightly higher but comparable milk yield (7 ℓ/day) for crossbred cows fed with urea treated teff straw, supplemented with a concentrate mix that is fortified with escape nitrogen source. Owing to the difference in the feeding management and breed type, however, milk yields as high as 11 kg d^{-1} (Wanapat *et al.*, 2009) and 20 kg d^{-1} (Doan *et al.*, 1999) have also been reported for urea ammoniated cereal straws. The observed lack of difference for both parameters (milk yield and composition) between the control and vetch-supplemented treatments concurs with the findings of the present study where vetch can partially replace a concentrate mix without any significant reduction in milk yield and quality. However, the decline in milk yield of cows on T_4 as compared to those on the control diet could be explained by the reduction in the amount of energy intake below the requirement as a result of high vetch intake which actually was relatively lower for its energy value (Table 3). Milk yields for all dietary treatments were in general smaller than expected (*i.e.*, 8–10 ℓ d^{-1}) owing to the smaller ME intake often below requirements which actually resulted from inefficient utilization of the extra protein supplied from almost all dietary treatments. A report by Oldham (1980) has demonstrated an increasing response in DM intake and milk yield to be induced by increasing the protein to energy ratio (P/E) in the absorbed products. According to Oldham (1980), higher levels of milk production can not only be supported from fermentative digestion alone. The results of the present study showed that there was a more or less stable profile and strong persistency in terms of daily milk yield among the cows receiving the different dietary treatments except for those cows maintained on T_4 (75% vetch replacement), indicating that the lactation curve from the present study (Fig. 1) was normal and assumed the lactation curve of cows described by Wood (1969).

The higher level of milk fat reported in this study is comparable to values reported by Prasad *et al.* (1998) and Wanapat *et al.* (2009). The reason behind comparable values for fat concentration between the vetch supplemented and the control group can be explained by higher and better utilization of dietary fibre leading to more precursors for mammary lipid synthesis (Susmel *et al.*, 1995). Moreover, it can also be linked to the extensive use of body reserves to support lactation (during early lactation) as lipids from body fats are incorporated directly into milk fat as compared to dietary fats. Similarly, the milk protein content observed (3.62%) in the current study is in agreement with earlier values (3.3%) reported by Wanapat *et al.* (2009). However, the higher level of CP intake did not significantly affect the concentration of milk protein in the current trial which agrees with the conclusion made by Hill and Leaver (1999) for ammoniated whole crop wheat straw fed to lactating cows that showed milk protein concentration to be affected by the level of concentrate rather than the level of dietary CP intake. The mean value of lactose (4.15%) observed in the preset study, on the other hand, is consistent with the respective value of 4.10%; however, total solids (14.03%) from the present study slightly contrasts with the value (12.5%) reported earlier by Wanapat *et al.* (2009). This difference could be associated with the relatively higher fat concentration, the breeds of cows and feed type used in the two experiments. The milk yield and composition data from the current study did not show any beneficial advantage in increasing the level of vetch beyond 50% replacement.

CONCLUSIONS

The chemical compositions as well as the rumen degradation characteristics of vetch and the concentrate mix used in this study were comparable. Based on this observation and the feed intake and digestibility response of the experimental animals, it can be concluded that vetch hay can replace the concentrate mix used in the current study most appropriately at the rate of 50% replacement. This has an important practical implication for smallholder dairy farmers where utilization of concentrate feed ingredients are constrained by availability, accessibility and fluctuating market prices and where legumes could be used instead as feed supplement when planted in crop rotation or as relay crop.

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