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Research Article

Chemical Composition, in-vitro Digestibility and in-sacco Degradability of Natural Pasture Hay, Replacement of Concentrate with Lablab Purpureus Hay

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Abstract

The study was conducted to evaluate the chemical composition, in vitro dry matter digestibility (IVDMD) and insacco dry matter degradability of natural pasture hay, replacement of concentrate with Lablab Purpureus hay. The study treatments were natural pasture hay fed ad libitum to all treatments plus 100% CM/day (T1, control supplemented), 75%CM: 25%LP/day (T2), 50%CM: 50%LP/day (T3), 25%CM: 75%LP/day (T4), 100%LP/day (T5). The amount of other sole or mixture of supplements was calculated on isonitrogenous basis to the CM, from pre-determined nitrogen content of the dietary ingredients. Chemical composition of dry matter (DM), crude protein (CP), crude ash (CA), ether extract (EE), crude fibre (CF), neutral detergent fibre (NDF) was determined. In sacco rumen degradability was measured using three rumen fistulated Holstein Friesian and Borana cross steers at 0, 6, 12, 24, 48, 72 and 96 h. The DM and organic matter (OM) degradability data were fitted to the equation $Y = a + b(1 - e^{-ct})$. Variations were observed in chemical compositions. For instance, CP ranged from 74 to 311 g/kg for DM. The lowest CP was recorded for natural pasture hay while the highest CP was obtained from noug seed cake. The result of present study revealed that sole Lablab Purpureus (100% Lablab Purpureus) is a potential alternative supplementation with relatively high level of protein, nitrogen degradation and undegradable protein for sheep.

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Introduction

Livestock productivity in developing countries like Ethiopia is low mainly due to inadequate feed supply both in quantity and quality. most feed resources are characterized by inherent nutritional deficiencies are generally low in nitrogen, energy, vitamins and minerals [1], which affect microbial growth and fermentation in the rumen, resulting in low feed intake and digestibility, leading to reduced reproductive capacity, decline in growth rates and increased mortality rates. The bulky and fibrous nature of coarse feeds results in poor nutrient supply and reduced intake [2]. In general, the availability of feed resources in Ethiopia is insufficient both in terms of quality and quantity of nutrient supply. There are several complementary and alternative strategies that can be pursued in tropical regions with the objective of making low quality feeds more useful for production of meat and milk. Concentrate feed supplementation is one strategy, which can increase digestibility, nutrient supply and intake [3]. The crop-livestock farming systems in the Ethiopian highlands are under stress because of shrinking cultivated areas per household, land degradation reduced pasture land [4].

To solve this problem, there are options like supplementing animals with agro-industrial by-products such as different oil seed cakes and brans from edible oil and flour processing industries, respectively. However, they are costly and not readily available everywhere. As a result, production and feeding of herbaceous and fodder tree legumes through integration with food crops were suggested as one of the potential options to improve the nutrient supply to livestock [1]. Potential use of cultivated forages as supplementary diet options for livestock have been investigated in Ethiopia in earlier studies [5,6]. Supplementation with forage legumes (herbaceous and shrubby or tree legumes) can enhance the utilization of poor-quality roughages in smallholder mixed farming systems for better growth and carcass yield of sheep [7]. However, wider use of cultivated forages by livestock keepers in Ethiopia is not significant probably because of scarcity in information regarding the feeding value, lack of information regarding means of its efficient utilization, such as in combination with different non-grain and grain concentrates less adoption and wider cultivation practices of this feed. Chemical composition, in-vitro and in-sacco degradability characteristics are recognized to be a useful indicator of the nutritional value of livestock feed resources. Hence, the objective of this study was to evaluate the In-Vitro Dry Matter Digestibility (IVDMD, In-Vitro Organic Matter Digestibility (IVOMD) in-sacco DM degradability characteristics of Natural Pasture Hay, Replacement of Concentrate with Lablab Purpureus Hay.

Materials and Methods

Description of the study area

Natural pasture hay was purchased from Ejaji town, west shewa zone, Oromia region, on the all-weather high way between Addis

Ababa and nekemte, this town has a longitude 37.3^{0}E and latitude 8.99^{0}N. Ejaji is the administrative center of Elu gelan woreda. The mean annual rainfall was 1091 mm and the mean minimum and maximum daily temperatures of the area were 13^{0}C and 24 ^{0}C, respectively. Lablab Purpureus was planted at Guder campus, West shewa Zone, Oromia, Ethiopia. Campus was located 12km West of Ambo town. It was located between geographical coordinates of 8^{0}58'N to 9^0 67'N latitude and 37^0 46'E to 38^{0}67'E longitude with altitude average 2101 masl. The mean annual rainfall was 1068 mm and the mean minimum and maximum daily temperatures of the area were 14 and 28 ^{0}C, respectively. Noug seed cake (NSC), Maize grain and wheat bran (WB) were purchased from Guder food complex factories.

Treatments, Sampling of feeds and their preparation

Experimental feeds were composed of natural grass hay and replacement of concentrate mix with Lablab Purpureus (LP) legume forage. The natural pasture hay was bought from hay producer and stored in hay shade till the feeding was started. A seed of Lablab Purpureus of 90% viability was sown at the recommended rate of 15-20 kg/ha in Ambo University campus farm site. The LP was sown in a plot with 40 cm within rows and 100 cm between rows. The legume received 50 kg/ha phosphate fertilizer at sowing time. Hand weeding and hoeing were conducted until the forage reach harvest stage. Lablab Purpureus hay was prepared by cutting or harvesting at growth stage of 50% flowering and stored in hay shade. The hay was dried until it is crispy by frequently turning in order to maintain its green color. Mechanical chopping was done approximately to 4-7cm length and chopped materials were dried under shade until use for feeding. The concentrate mixtures consist of 55% wheat bran, 30% noug seed cake and 15% maize grain. The Lablab Purpureus replaced the concentrate mixture at proportions of 0%, 25%, 50%, 75% and 100%. The Lablab Purpureus and the concentrate were provided as a mixed ration according to the treatment. Concentrate was supplemented for control group at a rate of 400 gm/head/day and treatment groups were supplemented with four levels of Lablab Purpureus and concentrate mix as outlined below. Horro sheep breed expected to consume 830g DM daily. The amount of grass hay to be included in the mixture was then obtained by subtracting the 400g DM CM from total daily DM intake and was 430g DM of grass hay.

Treatments diets were

T1=430g of grass hay+100%CM or 400g CM; T2=430g+75%CM+25%LP; T3=430g+50%CM+50%LP; T4=430g+25%CM+75%LP; T5=430g+100%LP or 400g LP.

For each of the above treatment diets, enough amounts of samples were prepared for in-vitro and in-sacco degradability.

Chemical analysis

Samples of dietary ingredients and treatment diets were dried at 60^{0}C for 72 hours in a forced draft oven. Part of the dried samples were ground in a Willey mill to pass through 1 mm sieve for chemical analysis and in-vitro DM digestibility while the other part was ground to pass through 2 mm sieve for in-sacco degradability. Dietary ingredient samples were analysed for DM, OM, ash, nitrogen (N) according to the AOAC [8]. Crude protein content was calculated as N x 6.25. The NDF, ADF and ADL contents were analyzed using the detergent extraction method [9]. The metabolizable energy (ME) was estimated ME (MJ/Kg DM) = 0.016 X DOMD, Where DOMD = is gram digestible organic matter per kilogram dry matter, where DOMD is digestible organic matter in dry matter taken from invitro DM digestibility values. Organic matter (OM) content was calculated as: % OM =100 - ash percentage.

In vitro organic matter digestibility

In-vitro DM digestibility and IVOMD was determined following the two stage fermentation procedure of Tilley and Terry [10]. Samples were incubated for 48 hours with rumen fluid and buffer followed by another 48 hour digestion with pepsin and HCl. Rumen liquor was collected from three ruminally fistulated Boran x Holstein Friesian steers in the morning before animals were offered feed. These animals were under maintenance level of feeding on ad libitum hay (7% CP) and 2kg of concentrate mixture comprising of 74, 25 and 1% wheat bran, noug seed cake and salt, respectively. The residue after incubation was ashed in a muffle furnace at 550 ^{0}C for 5 hours to determine IVOMD.

In sacco Dry Matter Degradability

Ruminal in-sacco DM degradability characteristics was determined by incubating 3 g samples of feed in nylon bags having (41 µm pore size and 6.5 x 14 cm dimension), in three ruminally fistulated Boran x Holstein Friesian steers for 0, 6, 12, 24, 48, 72 and 96 hours [11,12]. The steers were kept under maintenance ration as described in the previous section and had free access to water and common salt. Sample containing nylon bags were inserted at different times and removed at the same time. Upon the removal of nylon bags at the end of the incubation hours, all bags were hand washed under a running tap water and oven dried at 105^{0}C for 24 hours. Zero hour solubility was also estimated by hand washing the samples contained in nylon bags in the same way as the incubated samples. The degradability of DM (DMD) was determined for each incubation time as DMD (g/kg DM) = 1000 x (DM in feed sample-DM in residue)/DM in feed. The DMD parameters were fitted to the equation described by Ørskov and McDonald [11,12] using the Neway Excel programme [13].

$Y = a + b (1-e^{-ct})$, where Y = the potential disappearance of DM at time t

a = rapidly degradable fraction

b = potentially but slowly degradable fraction

c = the rate of degradation of b

e = the natural logarithm

t = time

The potential degradability (PD) was estimated as the sum of rapidly degradable fraction and the potentially but slowly degradable fraction (PD = a+b). Effective degradability (ED) was calculated following the method of Ørskov and McDonald [11,12] assuming a passage rate of 4%/h, as ED = a + [b*c)/(c+k)]; where k = passage rate (rumen out flow rate).

Statistical analysis

Data was subjected to analysis of variance (ANOVA) using the GLM (General Linear Model) procedure of statistical analysis system [14]. When analysis of variance (ANOVA) declare significant difference among treatment means, mean separation was carried out by the least significant difference (LSD).

Results and Discussion

Chemical Composition

The chemical composition of the experimental feeds used in the current study was presented in (Table 1). Variations were observed in chemical compositions. For instance, CP ranged from 74 to 311. The lowest CP was recorded for natural pasture hay while the highest CP was obtained from noug seed cake. The DM content of natural pasture hay offered to the experimental animals was comparable to the values of 906 and 912 reported by Dereje [15] and Jalel [16], respectively, but lower than the value of 96% reported by Worknesh and higher than value of 723 reported by Abera and Yoseph [17]. Leaf of Lablab Purpureus has CP content that ranges 21-38%, but it varies depending on the plant part composition [18]. Lablab Purpureus hay has high NDF and ADF when compared with the other feedstuffs used in the current study, other than the basal diet hay. The current OM value for Lablab Purpureus was comparable to the value of 891 reported by Worknesh.

The value of CP in the maize grain was comparable to the value of 84 and 85 reported by Tesfaye [19] and Tesfaye, respectively. Similarly, OM content of maize grain was comparable to the value of 983 reported by the former author. The CP content of WB is not usually consistent, mainly due to variation in variety and extraction rate [11]. Fine wheat for instance, contains CP that ranges from 16 to 21% and coarse wheat or bran contains 10-15% CP content. The CP content of NSC in the current study was lower than the value of 325 and 328 reported by Abera and Yoseph [17] and Dereje [15], respectively. But it was comparable to the value of 318 and 316 reported by Anteneh [20] and Worknesh, respectively. The difference in the CP content of NSC used in the present study and other studies might be due to the method of processing and variety of the noug seed used [21].

Ingredients	Chemical composition (g/kg for DM and g/kg for others)						
	DM	OM	Ash	CP	NDF	ADF	ADL
Grass hay	909	878	122	74	724	445	83
Lablab Purpureus	918	881	119	210	513	463	117
Wheat bran	905	941	59	187	490	157	62
Noug cake	890	907	93	311	388	283	94
Maize grain	902	981	19	82	58	27	11

Table 1: Chemical Composition of natural pasture hay, Lablab Purpureus hay, wheat bran, noug cake and maize grain.

DM= Dry matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; ADL=Acid detergent lignin; OM= Organic matter

In-vitro dry matter and organic matter digestibility and metabolizable energy content

In-vitro dry matter and organic matter digestibility and metabolizable energy content of dietary ingredients and treatment diets was given in (Table 2).

Ingredients and treatment diets	IVDMD (g/kg DM)	IVOMD (g/kg DM)	ME (MJ/kg DM)
Ingredients			
Grass hay	424^{e}	392.3^{d}	6.27^{e}
Lablab Purpureus	613.6^{d}	571^{c}	9.13^{d}
Noug seed cake	780.6^{b}	706.3^{b}	11.3^{b}
Wheat bran	823^{a}	769^{a}	12.3^{a}
Maize grain	727.6^{c}	675.6^{b}	10.76^{c}
SEM	4.77	6.68	0.105
SL	***	***	***
Treatment diets			
T1	682.3^{a}	647.6^{a}	10.36^{a}
T2	656.3^{b}	616.6^{a}	9.86^{a}
T3	618^{c}	557.3^{b}	8.9^{b}
T4	594.6^{d}	529.6^{bc}	8.46^{bc}
T5	576^{e}	496.6^{c}	7.9^{c}
SEM	2.77	9.16	0.15
SL	***	***	***

Table 2: In-vitro dry matter and organic matter digestibility and metabolizable energy content of dietary ingredients and treatment diets.

a-e= means within a row not bearing a common superscript are significantly different; p<0.01=**, p<0.001=***; ns=non-significant; SL=significance level; SEM= Standard error of the mean; DM = Dry matter; MJ = Mega joule; IVDMD= in-vitro dry matter digestibility; IVOMD= In-vitro organic matter digestibility;ME = Metabolizable energy; T1=430g of grass hay+100%CM or 400g CM; T2=430g+75%CM+25%LP; T3=430g+50%CM+50%LP T4=430g+25%CM+75%LP; T5=430g+100%LP or 400g LP.

In-sacco dry matter degradability characteristics

In-sacco dry matter degradability characteristics in (Table 3).

Ingredients and treatment diets	Incubation hours					
	6	12	24	48	72	96
Ingredients						
Grass hay	97.3^{d}	159^{e}	222.3^{e}	291^{e}	371.3^{e}	428.6^{e}
Lablab Purpureus	206.3^{c}	282.3^{d}	355.6^{d}	468.3^{d}	549.6^{d}	583.3^{d}
Noug seed cake	412.6^{b}	544^{b}	642.3^{b}	701.6^{b}	778.3^{b}	810.6^{b}
Wheat bran	510.3^{a}	646^{a}	735.6^{a}	784.3^{a}	840.6^{a}	858^{a}
Maize grain	393.3^{b}	514^{c}	609^{c}	676.3^{c}	747.6^{c}	774^{c}
SEM	4.38	4.9	4.12	3.33	5.56	3.7
SL	***	***	***	***	***	***
Treatment diets						
T1	324.6^{a}	401^{a}	475^{a}	579.6^{a}	572^{a}	635.6^{a}
T2	292.3^{b}	363.6^{b}	442.6^{b}	544.3^{b}	539.6^{b}	592.6^{b}
T3	253.3^{c}	349^{b}	410.3^{c}	491^{c}	489.6^{c}	538.6^{c}
T4	217.3^{d}	306.3^{c}	378.6^{d}	428.6^{d}	448.3^{d}	487.3^{d}
T5	194.3^{e}	271.6^{d}	322.3^{e}	389^{e}	487.6^{e}	456.6^{e}
SEM	0.95	3.25	4.99	4.93	5.87	6.0
SL	***	***	***	***	***	***

Table 3: In-sacco dry matter degradability (g/kg DM) of dietary ingredients and treatment diets.

a-e= means within a row not bearing a common superscript are significantly different; p<0.01=**, p<0.001=***; ns=non-significant; SL=significance level; SEM= Standard error of the mean; DM = Dry matter; T1=430g of grass hay+100%CM or 400g CM;T2=430g+75%CM+25%LP;T3=430g+50%CM+50%LP T4=430g+25%CM+75%LP; T5=430g+100%LP or 400g LP.

The in-sacco DM degradation parameters of the dietary ingredients and treatment diets are presented in (Table 4). The degradation

parameters (a, b, c, ED and PD) for DM varied significantly among all treatments and dietary ingredients. The rapidly degradable DM fraction of the dietary ingredients ranged from 78g/kg DM in pasture hay to 345g/kg DM in wheat bran and treatment diets ranged from 176g/kg DM in T4 to 256g/kg DM in T1. The slowly degradable DM fraction of the dietary ingredients ranged from 462g/kg DM in pasture hay to 586g/kg DM in noug seed cake and treatment diets ranged from 497g/kg DM in T1 to 523g/kg DM in T4. The rate of DM degradation of dietary ingredients ranged from 0.023%/h in pasture hay to 0.072%/h in Lablab Purpureus and treatment diet ranged from 0.044%/h in T1 to 0.072%/h in T5 while potential degradability of DM of dietary ingredients ranged from 540g/kg DM in pasture hay to 866g/kg DM in wheat bran and treatment diet ranged from 691g/kg DM in T3 to 753g/kg DM in T1. The highest effective degradability of DM (631.8g/kg DM) in dietary ingredients was recorded in wheat bran and 516.3g/kg DM in T1 treatment diet while the lowest effective degradability of DM (246.7g/kg DM) in dietary ingredients was recorded in pasture hay and 487.4g/kg DM in T3 treatment diet.

Ingredients and treatment diets	Degradability parameters				
	a (g/kgDM)	b(g/kg DM)	c/hour	PD (g/kgDM)	ED (g/kg DM)
Ingredients					
Pasture hay	78	462	0.023	540	246.7
Lablab Purpureus	182	497	0.072	679	501.5
Noug seed cake	190	586	0.058	776	536.8
Wheat bran	345	521	0.049	866	631.8
Maize grain	276	568	0.043	844	570.3
Treatment diets					
T1	256	497	0.044	753	516.3
T2	211	509	0.056	720	507.9
T3	187	504	0.059	691	487.4
T4	176	523	0.067	699	503.5
T5	177	519	0.072	696	510.7

Table 4: In-sacco dry matter degradability parameters of dietary ingredients and treatment diets

DM = Dry matter; a= Rapidly soluble (degradable) fraction;b= Slowly degradable fraction; PD= Potential degradability; c= Degradation rate; ED= Effective degradability; T1=430g of grass hay+100%CM or 400g CM; T2=430g+75%CM+25%LP; T3=430g+50%CM+50%LP T4=430g+25%CM+75%LP; T5=430g+100%LP or 400g LP.

Conclusion

The result of present study revealed that sole Labab Purpureus (100% Lablab Purpureus) is a potential alternative supplementation with relatively high level of protein, nitrogen degradation and undegradable protein for sheep. The next recommended supplementation according to the study was 75% Lablab Purpureus and 25% concentrate mixture.

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