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The Effect of Mulberry Leaf Meal Supplementation on Feed Intake and Body Weight Change of Indigenous Ethiopian Highland Sheep

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ABSTRACT

An experiment was conducted with the objective of evaluating the effect of dried mulberry leaf supplementation on feed intake and body weight gain of Wollo sheep. Twenty four sheep with average initial body weight of 19.1± 0.9 kg were used for the experiment. Sheep were blocked into six blocks and randomly assigned to the four treatments. Treatments were grass hay only (M0), grass hay *ad labitum* and dried mulberry leaf at 0.5 % body weight (M0.5), grass hay *ad libitum* and dried mulberry leaf at 1.5 % body weight (M1.5) and grass hay *ad libitum* and dried mulberry leaf at 2.5 % body weight (M2.5. The initial and final body weights were not significantly different ($p > 0.05$) among treatment means. The total body weight change and average daily weight gain were significantly different ($p < 0.05$) among treatment and was in the order of M1.5 = M2.5>M0.5>M0. Animals fed dried mulberry leaf at 1.5 and 2.5 % body weight had significantly higher ($p<0.05$) total body weight change and average daily weight gain. Feed conversion efficiency (FCE) among dietary treatments was significant ($p < 0.05$) and in the order of M1.5>M0.5 > M2.5 >M0.5. In conclusion, the highest increase in final body weight, average daily weight gain and feed conversion efficiency was found at a supplementation rate of 1.5 % body weight. Therefore, dried mulberry leaves can be used as a protein supplement to poor quality roughage feeds under smallholder farmers' conditions.

Keywords: Crude protein, Dry matter, Feed conversion efficiency.

INTRODUCTION

Sheep rearing has long tradition as well being an important economic and ecological niche in the agricultural systems of Ethiopia. The main producers are rural, resource poor farmers. Sheep are considered as living banks for their owners and serve as a means of ready cash income to meet immediate needs such as acquiring agricultural inputs, paying school fees or tuition, taxes, medical bills and purchasing large animals and a reserve against economic and agricultural production hardship or monetary saving and investment in addition to many of other socio-economic and cultural functions (Markos, 2006).

Farmers in the rural area do not have the opportunity to purchase balanced feed concentrates or the ingredients used in such feeds. Thus, they have to rely on crop residues, collected from their own farms, or foliage of multipurpose trees, shrubs and grasses, which they harvest from their farms or roadsides. In the tropics, a large part of animal feed is based on forages characterized by low productivity and low quality, with substantial seasonal fluctuations (Michael et al., 2012). The low nutritive value of tropical grasses and roughages commonly available for use in sheep production systems highlights the need for low cost supplementation to improve their productivity.

Mulberry leaves have a high potential as a protein rich forage supplement for animal production (Benavides et al., 2002) and can be used as the main feed for sheep (Prasad & Reddy, 1991; Liu et al., 2001). The need for a high quality feed for ruminants in the tropics, in particular for small ruminants, and the excellent characteristics of mulberry, are the justifications for the great enthusiasm over its use as a feed supplement.

The usefulness and potential of mulberry in animal production systems have been demonstrated in many countries around the world and reported to have excellent nutritional value as forage (Kamruzzaman et al., 2012). Mulberry foliage can

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be used as a supplement to poor quality forage based diets or as the main component of a ration in livestock production systems (Sanchez, 2001a). Benavides et al. (2002) reported live weight gains of 60, 75, 85 and 101grams/animal/day when mulberry was fed to Black belly sheep at 0, 0.5, 1 and 1.5 % of body weight on dry matter basis with king grass as a basal ration.

The available evidence in Ethiopia revealed that there is limited research information on the utilization and benefits of mulberry leaves as small ruminants feed and its adoption in the sheep feeding systems. Therefore, this study was carried out to evaluate the effect of dried mulberry leaf meal supplementation on feed intake and live weight gain of growing male Ethiopian highland sheep fed on a basal diet of native grass hay.

MATERIALS AND METHODS

Study site:

The study was conducted at Sirinka Agricultural Research Center (SARC), North Wollo Zone of Amhara region, located at 508 km away from Addis Ababa. Sirinka is situated at 11^{o}N - 12^{o} N latitude, 39^{0} $30^{'}$- 40^{0} E longitude and at an altitude of 1,850 meter above sea level (SARC, unpublished).

Experimental animals and their management:

Twenty four growing entire male Wollo sheep about one year old (age determined by dentition and information obtained from the owners) were purchased from the local market and ear tagged at the experiment site. Before the commencement of the experiment, sheep were treated against internal and external parasites. To fully acquaint sheep with their new surroundings and experimental diets, the actual study period of ninety days was preceded by a preliminary feeding period of three weeks. Then after, sheep were grouped into six blocks based on their initial body weight and treatments were allocated randomly.

Experimental sheep were kept in door in individual pens and offered their respective treatment for the whole trial period. Individual pens were equipped with feeding trough for hay, separate plastic buckets for dried mulberry leaf and watering. During the preliminary feeding period, sheep were offered dried mulberry leaf so as to adapt them to the treatment diets to which they were allocated prior to the beginning of the experiment.

Experimental diet:

Fresh mulberry leaves (S 30) were harvested manually and leaves were trimmed from its stalks/ twigs. The harvested fresh leaves have been dried uniformly. After complete drying, leaves were stored at room temperature for feeding. For ease of feeding local grass hay was chopped in to the size of 3 to 5 cm and used as a basal diet during the trial period. Chopped local grass hay and mulberry leave were offered separately

Dried mulberry leaf supplements were offered in two equal portions at 08:00 and 15:30 hours daily. Water and salt lick were accessed freely to all animals. Hay and dried mulberry leaves offers and corresponding refusals were weighed and recorded daily once in the morning before the next feeding throughout the experimental period.

Experimental design and treatments:

The design of the experiment was randomized complete block design (RCBD) with four treatments and each treatment comprised of six animals. Experimental sheep were blocked based on the basis of overnight fasting of their initial body weight in to six blocks. To full fill the energy requirement of the experimental animals, hundred fifty grams of crushed sorghum grain per head per day were offered throughout the experimental period. Experimental animal were randomly allotted to the four treatments. They are

Treatment 1 = Local grass hay only (Control)

Treatment 2 = Local grass hay *ad libitum* + Mulberry leaf at 0.5 % live weight on DM basis (air dried)

Treatment 3 = Local grass hay *ad libitum* +Mulberry leaf at 1.5 % live weight on DM basis (air dried)

Treatment 4= Local grass hay *ad libitum* + Mulberry leaf at 2.5 % live weight on DM basis (air dried)

Feed chemical composition:

Feed samples were analyzed for dry matter (DM), ash and nitrogen (N) following the procedure of AOAC (1990). Crude protein (CP) was determined by multiplying N by a value of 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedure of Van Soest et al. *(*1991).

Data collection and analysis:

Feed offered and refusal were collected and weighted daily throughout the experimental period. Body weight of animals was taken every seven days interval (before the morning feeding) with Salter balance (50 kg capacity of 200 gm precision). Data on feed intake and body weight change were analyzed using the general linear model (GLM) procedure of SAS, 2003 Version 9. Mean comparison was made using Tukey's adjustment.

The model used for analysis was:

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$$Yij = \mu + \alpha_i + \beta_j + e_{ij}$$

Where

Y_{ij} = Response variable
μ = overall mean
α_i= effect of treatment
β_j = effect of block
e_{ij} = random error

RESULTS

The chemical composition of hay and mulberry leaf meal is presented in Table 1. Besides, the crude protein content of feeds and their average daily intake of local sheep across the experimental period are presented in Table 2.

Table 1. Chemical composition of hay and mulberry leaves on DM basis

Feeds	DM (%)	Ash (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)
H	88	12.2	6.36	74.4	64.4	35.5
M	90	19.7	15.3	36.7	28.9	11.1

H – Hay; M – Mulberry; DM: Dry Matter, CP: Crude Protein, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, ADL: Acid Detergent Lignin

In the current study, the average daily intakes of hay among treatments were 511, 448, 426 and 432 grams/ day on DM basis, respectively. Likewise, the daily dried mulberry leaf intake of animals assigned to treatment two, treatment three and treatment four were 80, 258 and 411 grams per day

Table 2. Average daily intake of hay and dried mulberry leaf meal; and crude protein content

Treatments	Daily intake (g/day of DM)			Crude Protein (% in DM)		
	H	M	T	H	M	T
M0	511	0	511	32.5	0	32.5
M0.5	448	80	528	28.5	12.2	40.7
M1.5	426	258	684	27.1	39.4	66.5
M2.5	432	411	843	27.5	62.7	90.2

H – Hay; M – Mulberry; T – Total; DM: Dry Matter

Table 3. The nitrogen detergent fiber (NDF) content of respective treatment feeds

Treatments	NDF (%)
M0	74.4 %
M0.5	68.7 %
M1.5	60.2 %
M2.5	56.0 %

Since the animals were blocked based on their initial body weight before assigning to treatments, initial body weight was similar among treatments as expected. Body weight change, average daily weight gain and feed conversion efficiency of the sheep consumed experimental feed is presented in Table 4.

The overall mean initial body weight, final body weight, body weight change, average daily weight gain, and feed conversion efficiency were 19.1 kg, 23.1 kg, 4.74 kg, 0.053 kg and 0.06, respectively. The initial as well as the final body weight were not significantly different (p>0.05) among treatment means. Nevertheless, M1.5 (Local grass hay *ad libitum* + Mulberry leaf at 1.5 % live weight on) have the highest final body weight value.

The total body weight change and average daily weight gain were significantly different (p< 0.05) among treatments and was in the order of M1.5 = M2.5 > M0.5 > M0. Animals fed dried mulberry leaf at 1.5 and 2.5 % body weight had significantly higher (p<0.05) total body weight change and average daily weight gain in comparison to animals fed dried mulberry leaf at 0.5% of their initial body weight.

The average body weight change of growing lambs fed hay and dried mulberry leaf across the feeding period is presented in Figure 1. As a general fact, protein is required both as a source of nitrogen for the ruminal bacteria and to supply amino acids for protein synthesis in the animal's body. When the level of protein is low in the diet, digestion of carbohydrates in the rumen will slow and intake of feed will decrease. On the other hand, inadequate levels of protein in the diet can negatively affect growth rate because insufficient amino acids are

Table 4: Body weight change, average daily weight gain and feed conversion efficiency of indigenous Ethiopian highland sheep consumed hay and dried mulberry leaf

Parameters	M0	M0.5	M1.5	M2.5	*P* value
Initial BW (kg)	19.0	18.6	19.6	19.1	0.8874
Final BW (kg)	21.4	23.2	25.6	25.0	0.0994
Total BW change (kg)	2.40^{b}	4.66^{ab}	6.00^{a}	5.90^{a}	0.0010
ADWG (kg/d/head0029	0.027^{b}	0.052^{ab}	0.067^{a}	0.066^{a}	0.0010
FCE (ADWG/daily TDMI)	0.035^{b}	0.068^{a}	0.071^{a}	0.057^{ab}	0.0039

^{ab}Means within rows with different superscripts differ significantly (P< 0.05); BW = Body weight; ADWG = average daily weight gain; FCE = feed conversion efficiency; TDMI = total dry matter intake; M0 = Hay *ad libitum*; M0.5 = hay *ad libitum* + 0.5% BW dried mulberry leaf; Treatment 3= hay *ad libitum* + 1.5 % BW dried mulberry leaf; Treatment 4= hay *ad libitum* + 2.5 % BW dried mulberry leaf;

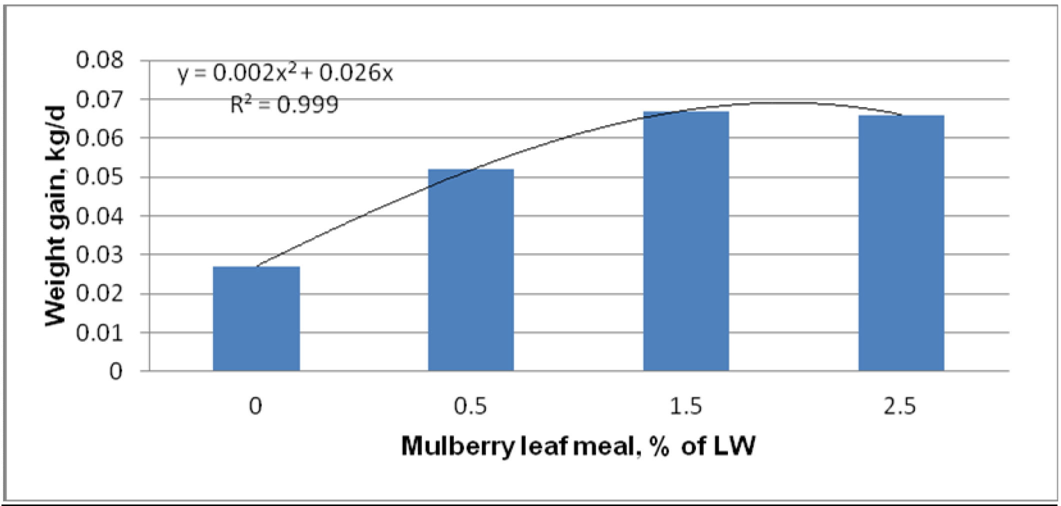

Figure1: Trends in body weight change of growing Wollo sheep supplemented with dried mulberry leaf

getting to the intestines to be absorbed by the body.

The trend of weight changes across the experimental period revealed that the prominent weight increase was in animals supplemented with dried mulberry leaf at a rate of 1.5 % live weight. Whereas, there was a decline in weight gain of animals supplemented with dried mulberry leaf beyond 1.5% live weight. The reason is that unlike energy, excess of protein is not stored in the body of the sheep; it is excreted in the urine as urea and further increment of body weight is not possible.

In this study feed conversion efficiency (FCE) difference among the dietary treatments was observed and supplemented animals had statistically higher feed conversion efficiency ($p< 0.05$) than the un-supplemented animals. Feed conversion efficiency was significantly difference ($p<0.05$) in the order of M1.5, M0.5 > M2.5 > M0. However, there was no significant difference $p>0.05$) among M0.5 and M1.5.

The correlation coefficient (r) between hay and mulberry intake; and body weight gain was 0.601 and 0.685. Indeed, results of this experiment reveled the existence of positive and statistically significant correlation between body weight gain and hay intake ($p<0.0019$) and mulberry intake ($p<0.0002$) of experimental animals. Generally, correlation coefficients have to be seen carefully. If the values are converted in to coefficient of determination, they can explain only 36% of the variance in weight gain and about 65% of the variance component is due to other factors.

DISCUSSION

The Ash value of hay used in this experiment is higher than the reports of Hagos et al. (2015), and Gebeyew et al. (2015), but in agreement with Huneganaw (2015). The NDF value of hay is also higher than Huneganaw (2015) and Gebeyew et al. (2015), but nearly similar with Aschalew & Getachew (2013). Besides, the ADF and ADL values are higher than Huneganaw (2015), Aschalew & Getachew (2013), and Gebeyew et al. (2015).

The CP content of hay (6.36%) was lower than the reports of Huneganaw (2015) (7.78%), Hagos et al. (2015) (9.85%), Birhanu et al. (2013) (6.23%), and Gebeyew et al. (2015) (9.10%). It was established that crude protein (CP) content of 7 % and below hamper rumen microbial activity and inhibits fiber digestion leading to depression of forage intake, but values above the critical value can satisfy the minimum level of CP required for microbial function (Van Soset, 1994). Thus, the hay used in the current experiment can be classified as low quality and may not satisfy maintenance requirement of animals.

The crude protein (CP) value for dried mulberry leaf (15.3%) was lower than the reports of Yao et al. (2000) (20.1%) and Massimo et al. (2005) (21.05 %); but higher than David et al. (2005) (13.76 %); in agreement with Dereje (2015) (15.2%); and within the range reported by Sanchez (2001a) (15-28 %).

The Ash content of dried mulberry leaf (19.7 %) was higher than the value reported by David et al. (2005) (13.07), Massimo et al. (2005) (13.31) and Dereje (2015) (14.9%); but similar to the report of Shayo (1997) and Sanchez (2001b). The acid detergent lignin (ADL) content of dried mulberry leaf of this study (11.1) was nearly similar with the values reported by Dereje (2015) (11.8%); but higher than the value of Shayo (1997) (8.1%), Yoa et al. (2000) (4.1%) and Mitiku (2011) (4.6%). The acid detergent fiber (ADF) content (28.9 %) is also higher than the reports of Yao et al. (2000) (14.8%), Massimo et al. (2005) (19.72) and Schemidek et al. (2000) (17.22%). The neutral detergent fiber (NDF) content (36.7%) is higher than the values reported by David (2005) (24%), Massimo et al. (2005) (22.88), Yao et al. (2000) (26.8), Mitiku (2011) (34.3%); but lower than Dereje (2015) (39.5%). Feeds with NDF below 45% are grouped as high quality feeds (Manuel, 2000**)** and mulberry can be a member of such group of feed.

Dietary protein supplementation is known to improve intake by increasing nitrogen supply to the rumen microbes (Van Soest, 1994) and this was attributed to the positive effects of increasing microbial population and efficiency thus enabling them to increase the rate of breakdown of the digesta, consequently increase the nutrient intake and body weight. National Research Council (1985) recommended a diet containing 14.5% CP for maximum growth of early weaned lambs. The optimum dietary level of proteinaecous supplementary forages was reported to be 30 to 50 % or 0.9 to 1.5 % of live weight (Devendra, 1988). Kay & Dearmid (1973) indicated that a dietary CP content of 11% was ideal for normal weight gain by sheep and goats. Getahun (2015) has concluded that the optimum dietary CP for improved performance and feed utilization of yearling Arsi-Bale lambs, growing from 17 to 25 kg, is about 12%.

The average daily weight gain of Wollo sheep of the current study (52-67 g/day) were higher than the values noted by Hagos (2014) for local sheep (42 g) supplemented with 280 g/day dried Sesbania seseban leaf; lower than Tibebu et al. (2009) for sheep fed diet containing 300 g/kg Sesbania foliage(103g); nearly comparable with Desta et al. (2016) for Abergelle rams (75.71g) supplemented with 300 g dried Sesbania seseban leaf and Feleke et al. (2011) for Adilo sheep (79 g) supplemented with 300 g dried Moringa leaf. Therefore, the dietary CP content of mulberry (15.3% CP) in this study can improve feed utilization and performance of tropical sheep.

CONCLUSION

The experiment was conducted to evaluate the effect of dried mulberry leaves (*Morus spp.*), supplementation on feed intake and body weight change of indigenous Ethiopian highland sheep. In this experiment, final body weight, average daily weight gain and feed conversion efficiency were significantly affected by the supplementation of dried mulberry leaf. The highest increase in final body weight, average daily weight gain and feed conversion efficiency was found at a supplementation rate of 1.5 % initial body weights. The improved feed conversion efficiency seemed to be related to higher nutrient concentration of mulberry and the consequent increase in body weight gain. The reduction in the feed conversion efficiency of control lambs could be associated with low CP and high fibre content of the grass hay.

The dietary CP content of mulberry in this study satisfies the CP requirement of tropical sheep. Therefore, dried mulberry leaves can be used as a protein supplement to poor quality roughage feeds under smallholder farmers' condition, where accesses to conventional protein sources are limited, if not impossible, and expensive. Besides, further research is needed on the optimum substitution rate of dried mulberry leaf to concentrate mix under small holder feeding systems of sheep husbandry.

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