Carcass and non-carcass characteristics of Tigray highland lambs fed mulberry (*Morus alba*) leaf meal at different supplementation levels

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**Abstract**

The study was carried out to evaluate the effect of mulberry (*Morus alba*) leaf meal levels on growth performance and carcass characteristics of Tigray highland lambs. The experiment consisted of five treatments; and conducted in a randomized complete block design using thirty intact yearlings Tigray highland male lambs. The experimental diets were 300g concentrate mix alone, 225g concentrate mix + 86.55g mulberry leaf, 150g concentrate mix + 173.1g mulberry leaf, 75g concentrate mix + 259.7g mulberry leaf and 346.2g mulberry leaf alone with barley straw ad libitum to all treatments. The mix was prepared from Noug seed cake and wheat bran at ratio of 1:2, respectively. Higher weights of total edible offal component, empty body weight, rib eye muscle area and slaughter weight were observed as a result of high level of mulberry leaf meal supplementation than the sole concentrate mix treatment. On the other hand, the dressing percentage on slaughter weight base as well as empty body weight base and hot carcass weight showed less difference (*p* > 0.05) between sole mulberry leaf meal and sole concentrate mix treatments. The result of the present study indicated that substitution of mulberry leaf meal for concentrate mix can be used effectively without affecting the results of growth parameters as well as edible or non edible offal components that can be achieved by sole concentrate supplementation. Hence, the finding revealed that feeding mulberry leaf meal alone to Tigray highland lambs could substitute the costly and even less accessible commercial concentrate mix to resource poor farmers and could result in reasonably better performance of lambs.

**Keywords:** Carcass, Edible offal, Mulberry, Non edible offal.

**INTRODUCTION**

In areas where livestock are closely integrated with crop production, crop residues are considered as valuable sources of ruminant feeds. The tendency of increased acreage of cropping land is always at the expenses of decreased available grazing lands, thus boost the importance of crop residues as animal feed resources. However, crop residues are of generally low in nutritive value and are fibrous having low digestible organic matter (OM) per kg dry matter (DM) and low crude protein (CP) content [8, 33, 31, 22, 23]. The increasing pressure on land and the growing demand for livestock products makes it crucial to ensure the effective use of feed resources, including crop residues and other agro-industrial by-products. With the increasing need of human population for animal products, there is a need of matching feed resources with animal nutrient requirements. Thus, supplementation of crop residues with agro-industrial by-products and/or plant protein sources will alleviate CP deficiency in fibrous feeds [36].

The commercial protein supplements are however, inaccessible and if any too expensive for the small scale farmers. Different studies indicated that mulberry is well comparable with leguminous multipurpose trees and concentrates as a feed for ruminants [8, 33, 31, 22, 23]. Habib et al. [18] evaluated the chemical composition of dried mulberry leaves and reported that it has comparable nutrient composition with that of commercial concentrates diets. However, the information on the feeding value of mulberry foliage and its concomitant effect on feed intake and carcass characteristics of lambs in Ethiopia are scanty and need further documentation. To this end FAO [13] suggested that the urgent need of the farmers for high quality feed for ruminants in developing countries can be achievable through intensive utilization of multipurpose trees and shrubs as they have better nutritional quality nearly equivalent to grain based concentrates.
According to Shayo [35], leaves of multipurpose trees like mulberry are highly digestible; contain high concentration of CP and minerals, and low cell wall contents. This important characteristic of the mulberry is a key attribute that makes it worthy of investigation as feed alternative for ruminants. Therefore, this study was carried out with the objective of investigating the effect of partial or full substitution of mulberry leaf meal for concentrate mix on performance and carcass characteristics of yearling Tigray highland lambs fed barley straw basal diet.

MATERIALS AND METHODS

Experimental animals, experimental design and treatments

Thirty intact yearlings Tigray highland male lambs with initial body weights of 17.8±0.95 kg (mean ± SD) having relatively similar body condition were used for the study. The lambs were quarantined, drenched against internal parasites, sprayed for ecto-parasites and vaccinated for anthrax as well as ovine pastealosis. The supplements were offered in two equal portions at 08:00 and 16:00 hours daily while the water and mineral salt licks were accessed freely to all lambs.

A complete randomized blocked design with five treatments of six animals each was employed and lambs were blocked on the basis of their initial body weight (overnight fasting) and the five treatments were randomly assigned to animals in the block. Lambs were housed in concrete floor that penned individually. The lambs were allocated to the diet groups where concentrate mix was progressively replaced by mulberry leaf meal from 0% to 100% at iso-nitrogenous level.

Table 1: Chemical composition of feeds used for the experiment

<table>
<thead>
<tr>
<th>Experimental feeds</th>
<th>DM (%)</th>
<th>OM</th>
<th>Ash</th>
<th>CP</th>
<th>NDF</th>
<th>ADF</th>
<th>ADL</th>
<th>EE</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley straw</td>
<td>96.0</td>
<td>92.5</td>
<td>7.5</td>
<td>4.0</td>
<td>78.6</td>
<td>49.6</td>
<td>8.6</td>
<td>1.3</td>
<td>57.6</td>
</tr>
<tr>
<td>Concentrate mix</td>
<td>90.2</td>
<td>92.3</td>
<td>7.66</td>
<td>22.0</td>
<td>35.2</td>
<td>20.2</td>
<td>3.39</td>
<td>7.16</td>
<td>13.3</td>
</tr>
<tr>
<td>Mulberry leaf meal</td>
<td>91.8</td>
<td>84.3</td>
<td>15.7</td>
<td>18.5</td>
<td>38.0</td>
<td>22.3</td>
<td>4.19</td>
<td>4.15</td>
<td>14.2</td>
</tr>
</tbody>
</table>

DM: Dry matter; OM: Organic matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin; EE: Ether Extract; CF: Crude fiber

The treatments were 300g concentrate mix alone, 225g concentrate mix + 86.55g mulberry leaf, 150g concentrate mix + 173.1g mulberry leaf, 75g concentrate mix + 259.7g mulberry leaf and 346.2g mulberry leaf alone with barley straw ad libitum to all treatments. The concentrate mix contained noug seed cake (NSC) and wheat bran (WB) at ratio of 1:2. Feeds offered to experimental lambs and corresponding refusals were weighed and recorded daily throughout the experimental period to determine daily feed intake of experimental lambs.

Chemical analysis of feed offer and refusals

Chemical compositions of the feed and refusal samples were determined at Holeta Agricultural Research Center, animal nutrition laboratory, Ethiopia. Samples of dried feeds and refusals were dried overnight at 105 °C in a forced draft oven for determination of total dry matter content. Ash content was determined by combusting samples at 550 °C overnight and organic matter (OM) content was calculated by difference (OM=100-ash content). Nitrogen (N) content was determined using the Kjeldahl method (AOAC, 1990)\[34\] and crude protein (CP) was calculated as N×6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed using the procedures of Van Soest and Robertson \[37\].

Carcass evaluation

At the end of feeding trial, all experimental lambs were slaughtered after overnight fasting for evaluation of carcass parameters. Empty body weight was calculated as slaughter weight less gut content. Hot carcass weight was estimated after removing weight of the head, skin, thoracic, abdominal and pelvic cavity contents, and the limbs. Dressing percentage was calculated as a ratio of hot carcass weight and slaughter weight or empty body weight basis. The rib eye muscle area is determined by measuring area of the Longissimus dorsi muscle exposed by cutting the carcass between the 12th and 13th ribs \[29\].

Statistical analysis

Data from the experiment were subjected to the analysis of variance (ANOVA) in a randomized complete block design using the general linear model procedure of SAS \[34\]. Individual differences between means were tested using Tukey HSD test. In all the comparisons, the level of significance was set at α = 0.05.

RESULTS

Live weight change and feed conversion efficiency

Average daily gain (ADG) was significantly (p < 0.05) higher at 150CM: 173MLM than the other treatments (Table 2). Lambs fed from 150CM: 173MLM to 346MLM (treatments with higher proportion of mulberry leaf meal) gained 1.3 – 1.5 kg extra body weight compared to those fed 300CM (sole concentrate mix) by growing at an average of 9.2 to 13.9 g greater rate per day. However, difference in feed conversion efficiency among treatments except 150CM: 173MLM, which showed significantly (p < 0.05) higher feed conversion efficiency than the 300CM and 225CM: 87MLM, was not significant (p > 0.05) though 75 CM: 260MLM and 346MLM supplemented lambs relatively tended to have better feed conversion efficiency than lambs supplemented with 300CM and 225CM: 87MLM. In general, all the experimental sheep showed good growth performances throughout the experimental period.
Table 2: Growth performance parameters of Tigray highland lambs supplemented with different levels of dried mulberry leaf meal and concentrate mix

<table>
<thead>
<tr>
<th>Treatments</th>
<th>300 CM</th>
<th>225CM: 87MLM</th>
<th>150 CM: 173 MLM</th>
<th>75 CM: 260 MLM</th>
<th>346MLM</th>
<th>SEM</th>
<th>SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial body weight (kg)</td>
<td>17.5</td>
<td>17.8</td>
<td>17.8</td>
<td>17.8</td>
<td>18</td>
<td>0.59</td>
<td>0.94</td>
</tr>
<tr>
<td>Final body weight (kg)</td>
<td>23.2a</td>
<td>23.6a</td>
<td>24.7a</td>
<td>24.6a</td>
<td>24.5a</td>
<td>0.42</td>
<td>0.005</td>
</tr>
<tr>
<td>Slaughter weight (kg)</td>
<td>23.0b</td>
<td>23.5b</td>
<td>24.5b</td>
<td>24.4b</td>
<td>24.3b</td>
<td>0.39</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Average daily gain (g/day)</td>
<td>63.0b</td>
<td>64.8b</td>
<td>76.9b</td>
<td>75.0ab</td>
<td>72.2ab</td>
<td>4.28</td>
<td>0.012</td>
</tr>
<tr>
<td>Feed conversion efficiency (g gain/g fed)</td>
<td>0.075b</td>
<td>0.075b</td>
<td>0.089b</td>
<td>0.085ab</td>
<td>0.079ab</td>
<td>0.005</td>
<td>0.042</td>
</tr>
</tbody>
</table>

*Means with different superscript letters in a row differ significantly.
CM: concentrate mix; MLM: mulberry leaf meal; 300CM: ad libitum barley straw + 300g concentrate mix;
225CM:87 MLM: ad libitum barley straw + 225g concentrate mix + 86.55g mulberry leaf meal;
150 CM:173MLM: ad libitum barley straw + 150g concentrate mix + 173.1g mulberry leaf meal;
75 CM:260MLM: ad libitum barley straw + 75g concentrate mix + 259.7g mulberry leaf meal;
346MLM: ad libitum barley straw +346.2g mulberry leaf meal; SEM: standard error of the mean;
SL: significant level.

Effect on main carcass traits

The slaughters weight, empty body weight and rib eye muscle area indicated higher (p<0.05) in the sole mulberry leaf meal supplemented groups than those supplemented with concentrate mix alone. Moreover, hot carcass weight indicated significantly (p<0.05) higher in 150CM: 173MLM than 300CM and 225CM: 87MLM. Nevertheless there was less difference among 150CM: 173MLM, 75 CM: 260MLM and 346MLM for hot carcass weight and rib eye muscle area.

Table 3: Carcass characteristics of Tigray highland lambs supplemented with different levels of dried mulberry leaf meal and concentrate mix

<table>
<thead>
<tr>
<th>Carcass weight</th>
<th>Treatments</th>
<th>300 CM</th>
<th>225CM: 87MLM</th>
<th>150 CM: 173 MLM</th>
<th>75 CM: 260 MLM</th>
<th>346MLM</th>
<th>SEM</th>
<th>SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBW (kg)</td>
<td></td>
<td>19.3</td>
<td>19.8</td>
<td>20.7</td>
<td>20.5</td>
<td>20.5</td>
<td>0.36</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>HCW (kg)</td>
<td></td>
<td>10.6</td>
<td>10.9</td>
<td>11.8</td>
<td>11.5</td>
<td>11.5</td>
<td>0.32</td>
<td>0.0003</td>
</tr>
<tr>
<td>DP (EBW basis)</td>
<td></td>
<td>54.8</td>
<td>55.1</td>
<td>56.8</td>
<td>56.1</td>
<td>56.4</td>
<td>0.65</td>
<td>0.0047</td>
</tr>
<tr>
<td>DP (SBW basis)</td>
<td></td>
<td>46.1</td>
<td>46.4</td>
<td>48.0</td>
<td>47.1</td>
<td>47.4</td>
<td>0.65</td>
<td>0.0087</td>
</tr>
<tr>
<td>Rib eye muscle area cm²</td>
<td></td>
<td>9.0</td>
<td>9.3</td>
<td>9.9</td>
<td>9.8</td>
<td>9.6</td>
<td>0.18</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

*Means with different superscript letters in a row differ significantly.
CM: concentrate mix; MLM: mulberry leaf meal; 300CM: ad libitum barley straw + 300g concentrate mix;
225CM:87 MLM: ad libitum barley straw + 225g concentrate mix + 86.55g mulberry leaf meal;
150 CM:173MLM: ad libitum barley straw + 150g concentrate mix + 173.1g mulberry leaf meal;
75 CM:260MLM: ad libitum barley straw + 75g concentrate mix + 259.7g mulberry leaf meal;
346MLM: ad libitum barley straw +346.2g mulberry leaf meal; SEM: standard error of the mean;
SL: significant level; SBW: slaughter body weight; EBW: empty body weight; HCW: hot carcass weight; DP: dressing percentage

Effect on Edible offal components

According to table 4, 150CM: 173MLM, 75 CM: 260MLM and 346MLM indicated higher (p<0.05) empty gut, heart, tail, total visceral fat and TEOW than 300CM and 225CM: 87MLM. However, the above parameters showed less difference between 300CM and 225CM: 87MLM. Similarly, less difference was observed among 150CM: 173MLM, 75 CM: 260MLM and 346MLM for the mentioned parameters.

Table 4: Response to supplementation with partial or full substituted concentrate mix with mulberry leaves on edible offal of Tigray highland lambs

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments</th>
<th>300CM</th>
<th>225CM: 87MLM</th>
<th>150 CM: 173 MLM</th>
<th>75 CM: 260 MLM</th>
<th>346MLM</th>
<th>SEM</th>
<th>SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty gut</td>
<td></td>
<td>1.57†</td>
<td>1.58†</td>
<td>1.66†</td>
<td>1.68†</td>
<td>1.67†</td>
<td>0.029</td>
<td>0.0009</td>
</tr>
<tr>
<td>Head with tongue</td>
<td></td>
<td>2.06†</td>
<td>1.952</td>
<td>2.003</td>
<td>2.005</td>
<td>1.984</td>
<td>0.031</td>
<td>0.4307</td>
</tr>
<tr>
<td>Kidney</td>
<td></td>
<td>0.070a</td>
<td>0.069b</td>
<td>0.076*</td>
<td>0.074a</td>
<td>0.074a</td>
<td>0.002</td>
<td>0.0219</td>
</tr>
<tr>
<td>Liver with bile</td>
<td></td>
<td>0.340†</td>
<td>0.338†</td>
<td>0.348*</td>
<td>0.353*</td>
<td>0.359*</td>
<td>0.005</td>
<td>0.0013</td>
</tr>
<tr>
<td>Testis</td>
<td></td>
<td>0.256</td>
<td>0.254</td>
<td>0.248</td>
<td>0.258</td>
<td>0.262</td>
<td>0.008</td>
<td>0.5489</td>
</tr>
<tr>
<td>Heart</td>
<td></td>
<td>0.095a</td>
<td>0.095b</td>
<td>0.101†</td>
<td>0.102†</td>
<td>0.102†</td>
<td>0.002</td>
<td>0.0005</td>
</tr>
<tr>
<td>Tail</td>
<td></td>
<td>0.514†</td>
<td>0.511†</td>
<td>0.536*</td>
<td>0.545*</td>
<td>0.536*</td>
<td>0.010</td>
<td>0.0086</td>
</tr>
<tr>
<td>Total visceral fat*</td>
<td></td>
<td>0.308†</td>
<td>0.303†</td>
<td>0.331†</td>
<td>0.322*</td>
<td>0.321†</td>
<td>0.002</td>
<td>0.0007</td>
</tr>
<tr>
<td>TEOW</td>
<td></td>
<td>5.15†</td>
<td>5.10†</td>
<td>5.30†</td>
<td>5.31†</td>
<td>5.31†</td>
<td>0.041</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

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CM: concentrate mix; MLM: mulberry leaf meal; 300CM: ad libitum barley straw + 300g concentrate mix;
225CM:87 MLM: ad libitum barley straw + 225g concentrate mix + 86.55g mulberry leaf meal;
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75 CM:260MLM: ad libitum barley straw + 75g concentrate mix + 259.7g mulberry leaf meal;
346MLM: ad libitum barley straw +346.2g mulberry leaf meal; SEM: standard error of the mean;
SL: significant level; TEOW: Total edible offal weight
**Effect on non-edible offal components**

The values of gut contents, skin and legs, esophagus, urinary bladder and TNEOW indicated less (p>0.05) difference between sole mulberry leaf meal and sole concentrate mix. However, the values of spleen increased with increased proportion of mulberry leaf meal in the diet.

**Table 5: Response to supplementation with partial or full substituted concentrate mix with mulberry leaves on non edible offal components of Tigray highland lambs**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gut contents</td>
<td>3.652</td>
<td>3.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.805&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.900&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.843&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.084</td>
<td>0.0098</td>
</tr>
<tr>
<td>Skin and legs</td>
<td>2.492</td>
<td>2.483&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.520&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.555&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.507&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.031</td>
<td>0.0257</td>
</tr>
<tr>
<td>Blood</td>
<td>0.693</td>
<td>0.684</td>
<td>0.707</td>
<td>0.714</td>
<td>0.713</td>
<td>0.010</td>
<td>0.127</td>
</tr>
<tr>
<td>Penis</td>
<td>0.054</td>
<td>0.055</td>
<td>0.057</td>
<td>0.060</td>
<td>0.056</td>
<td>0.002</td>
<td>0.115</td>
</tr>
<tr>
<td>Esophagus</td>
<td>0.034&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.032&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.036&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.037&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.036&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.001</td>
<td>0.0039</td>
</tr>
<tr>
<td>Lung with trachea</td>
<td>0.261</td>
<td>0.245</td>
<td>0.270</td>
<td>0.269</td>
<td>0.255</td>
<td>0.021</td>
<td>0.231</td>
</tr>
<tr>
<td>Spleen</td>
<td>0.027&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.027&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.030&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.031&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.031&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>0.025&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.024&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.025&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.027&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.026&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.001</td>
<td>0.0346</td>
</tr>
<tr>
<td>TNEOW</td>
<td>7.24</td>
<td>7.36</td>
<td>7.45</td>
<td>7.59</td>
<td>7.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.093</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<sup>a</sup>Means in the same row with different superscript differ significantly.

CM: concentrate mix; MLM: mulberry leaf meal; 300CM: ad libitum barley straw + 300g concentrate mix; 225CM: ad libitum barley straw + 225g concentrate mix + 86.55g mulberry leaf meal; 150 CM: 173MLM: ad libitum barley straw + 150g concentrate mix + 173.1g mulberry leaf meal; 75 CM: 260 ML: ad libitum barley straw + 75g concentrate mix + 259.7g mulberry leaf meal; 346MLM: ad libitum barley straw +346.2g mulberry leaf meal; SEM: standard error of the mean; SL: significant level; TNEOW: Total non edible offal weight.

**DISCUSSIONS**

**Body weight gain**

The final weight and average daily gain were significantly (p<0.05) improved when concentrate was partially or fully substituted by mulberry leaf meal in the current study. Rubanza et al. [32] also indicated a better growth performance when meals of forage trees like A. nilotica, A. polyacantha and L. leucocephala were supplemented in combination with other concentrate diets for goats that is in support of the current finding. However, contrary to the present study, insignificant results for final body weight, average daily gain and feed conversion efficiency were reported in all treatments by Dereje [10] for Arsi-bale goats when supplemented with inclusion of different levels of dried mulberry leaf in concentrate mix consisted of wheat bran and noug seed cake. The 150CM: 173MLM composition showed slightly higher value for all body weight measurement parameters. This might be resulted due to the additive effect of mulberry and might be depicted better when 150CM: 173MLM composition of concentrate with mulberry leaf meal is supplemented. In agreement with the present result, Benavides [31] in the study of mulberry as sheep feed noted the presence of an additive effect of mulberry rather than a substitution effect. Likewise, Miller et al. [26] suggested supplementation of growing goats with a high energy ration in combination with mulberry during the finishing period to induce better performance than the sole concentrate supplement.

The average daily weight gain obtained in the present study was in the range of 38.0-101 g/day reported by González and Milera [16] and Benavides [17] in weaned goats supplemented with various levels (0, 0.5, 1.5 and 2.5% BW) of mulberry forage to ad libitum consumption of Guinea grass (Panicum maximum) and for Black belly sheep that consumed King Grass and supplemented with concentrate containing 0, 0.5, 1 and 1.5% of BW of mulberry leaf, respectively. Moreover, the average daily weight gain of lambs in the present experiment was higher than average daily gain of 55 g reported by Liu et al. [21] for growing sheep of the Huzhou breed supplemented with 240 gair dried mulberry leaves. Desta et al. [11] also noted similar figures (60.93 -70.74g) of average daily gain for Abergelle rams supplemented with mulberry leaves. Nevertheless, higher average daily gain of 121-125 g/day by Miller et al. [26] and 80 g and 90 g by Martin et al. [24] were reported for weaned goats consumed Pangola grass hay ad libitum and supplemented with three levels (0, 50 and 100%) of dried mulberry leaves in combination with a commercial goat ration, respectively. Cuong et al. [9] also noted that the potential of fresh mulberry leaves replaced cottonseed meal in the diets of growing cattle with no reduction in live weight gain and feed conversion rate.

In line with the present finding, diets supplemented with mulberry leaves have been reported to lead in increased body weight gains in growing lambs [8] and growing goats [10]. Moreover, Ba et al. [6] also noted that milk production increased with the increased levels of mulberry offered to goats. Similarly, Ba et al. [6] also noted that mulberry foliage silage could be safely used as the sole feed for growing goats. Benavides [8] also observed no difference in milk yield among groups of grazing dairy cattle supplemented with either concentrate or mulberry leaves. Replacing the mulberry for soybean meal in diets for dairy cows did not affect milk yield or quality [31]. All these authors emphasized the potential of mulberry to replace the costly concentrate diets to resource poor farmers.

**Carcass characteristics**

The significantly higher carcass traits in 150CM: 173MLM compared with 300CM (sole concentrate mix) obtained in the current finding might be due to higher feed conversion efficiency and average body weight gain. Carcass weight, dressing percentage and rib eye muscle area were greater for animals supplemented with 150CM: 173MLM than those supplemented with higher proportion of concentrate mix groups. This is in line with the average body weight gain and feed conversion efficiency obtained in the current study. The slaughter weight and empty body weight resulted higher (p<0.05) in sole mulberry leaf meal as compared to the whole concentrate mix. This
justifies the potential of mulberry leaf meal to replace partially or fully to the commercial concentrate mixture.

The higher values of dressing percentage based on empty body weight than dressing percentage based on slaughter weight base might be due to the influence of digesta on dressing percentage. Dressing percentage based on empty body weight (54.4-56.8 %) obtained in this study was comparable to 53-56.3% [11], 53-57% [12] and 55.7-56.4% [19]. However, Neamn [28] and Zemichael [30] reported lower results of dressing percentage based on empty body weight 48.6-50% and 47-53%, respectively than the current study.

The dressing percentage based on slaughter weight base in the current study ranged between 46.1-48.0%, which seemed in agreement with the 47.3-48.6% for Tigray highland sheep [10]. Nevertheless, lower results on dressing percentages of 32-38%, 38-39.6%, 39.5-43.4% and 36-38.4% on slaughter weight basis than the current study were reported by Neamn [28] and Gebretinsae [14] for local sheep, Zemichael [30] for Arado sheep and Mulu [27] for Wogera sheep, respectively. Generally, the variations in carcass traits in this study and other results of previous studies might be due to variations in age and breed of sheep, and quantity and quality of basal and supplement feeds used during the experiment. In agreement with this, McDonald et al. [25] noted that, nutrition, age, sex, genetics, season and other related factors affect the growth and carcass traits of animals.

Rib eye muscle area is an indicator of muscling and amount of lean meat in the carcass. The rib eye muscle area in the current study was in the range of 9.0-9.9 cm² that is comparable with 8.6-9.5, 6.3-9.2 and 8.2-10.4 cm² reported by Abebe [1], Amare et al. [4] and Emebet [12] for supplemented groups of Black Head Ogaden sheep, Tigray Highland sheep and Arsi-Bale sheep, respectively. Lower values of rib eye muscle area than the present study were reported by Desta et al. [11] (8.43-8.98 cm²), Guesh [17] (6.7-7.3 cm²), Neamn [28] (4.5-6.5), Hagos [19] (5.7-6.4 cm²) and Hirut [20] (7-8.4 cm²) for yearling intact male Abergelle sheep, Black Head Ogaden sheep, local sheep, Tigray Highland sheep and Hararge Highland sheep, respectively. However, rib eye muscle area in the current study was lower than the values of 13-19.5 and 11.5-12.75cm² reported by Mulu [27] and Zemichael [30] for supplemented groups of Wogera sheep and Arado sheep, respectively. The differences in rib eye muscle area reported by various authors might be due to variations in the amount and quality of supplements and variations in sheep breeds used for the experiment. Rib eye muscle area is affected by the weight and musculature of the live animal [29] and it is increased with carcass weight [30] and this report conforms to the result of the current finding.

The total edible offal as well as the total visceral fat deposition indicated higher in the higher proportion of mulberry leaf supplemented lamb than the higher proportion of concentrate supplemented groups. This idea is confirmed by Araba et al. [2] who noted that fat deposition followed the trend of gain as faster gaining animals deposited more fat. Therefore, the result of the present study indicated that substitution of mulberry leaf meal for concentrate mix can be used effectively without affecting the result of growth performance, carcass parameters, edible or non edible offal components that can be achieved by sole concentrate supplementation.

CONCLUSION

Base on the above findings with 18.5% CP, the mulberry leaf meal can be considered as a medium protein feeds. As it is easily available in the locality of the farmers in the study area, the plant can substitute other commercial protein supplements which are too expensive and not affordable by low income farmers as well. The slaughter weight and empty weight resulted higher in sole mulberry leaf meal as compared to the whole concentrate mix. The result of the present study indicated that substitution of mulberry leaf meal for concentrate mix can be used effectively without affecting the result of edible or non edible offal components that can be achieved by sole concentrate supplementation.

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REFERENCES

14. Mezgebo G. Effects of Supplemented dried branches of Acacia senegal and cactus cladodes on feed intake, digestibility, body weight gain and carcass characteristics of local male sheep fed barley straw. Thesis
presented to the School of Graduate Studies of Haramaya University, Ethiopia. 2011; 73p.


19. Abreha H. Effects of supplementation with air dried leaves of African wild olive (Olea africana), red thorn (Acacia lubah) and their mixtures on performance of Tigray highland sheep fed grass hay. Thesis presented to the School of Graduate Studies of Haramaya University, Ethiopia, 2011; 104p.


27. Moges M. Effect of feeding different levels of breweries’ dried grain on live weight and carcass characteristics of Wogera sheep fed on hay basal diet. Thesis presented to school of graduate studies, Haramaya University, Ethiopia, 2005; 56p.

28. Gebresilassie N. Effect of supplementation with dried leaves of Acacia Albida, Acacia seyal and their mixture on feed intake, digestibility, live weight gain and carcass characteristics of local sheep fed barley straw as basal diet. Thesis presented to the School of Graduate Studies of Haramaya University, Ethiopia, 2011; 79p.


