Substituting Mulberry Leaves (*Morus indica* L.) for Concentrate Mix in the Diet of Lactating Holstein Friesian Cows

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The study was conducted to investigate the effect of replacing concentrate mix with mulberry leaves on intake, digestibility, milk yield and composition of Holstein Friesian dairy cows fed Rhodes grass hay as a basal diet. Four multi-parous lactating pure Holstein Friesian dairy cows in their mid-lactation stage were randomly allocated in a 4 x 4 Latin square switch-over design, with four treatments (Concentrate: Mulberry ratio, on DM basis) and four periods. Each period lasted 21 days. The treatments were: 100:0 (T₁), 75:25 (T₂), 50:50 (T₃), and 25:75 (T₄). The concentrate mix and mulberry leaves were offered daily at the rate of 0.5 kg l⁻¹ of milk. The dry matter intake, digestibility coefficients of nutrients tended to decrease with increasing replacement of mulberry leaves from 50% to 75% in the diet without significant effect on milk yield and its composition. Higher net income was observed in all mulberry leaves supplemented based diets than the control diet. It can be concluded that substitution of mulberry leaves for concentrate mix can be extended up to 50% in the diet of lactating cows for better milk production, feed utilization and profitability without affecting the milk composition.

**Keywords**: Dry matter intake, digestibility, milk yield, mulberry

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INTRODUCTION

Feed scarcity is often cited as the primary constraint to the development of dairy in crop-livestock mixed farming systems (Legesse et al., 2008). The range of technologies developed to address the issue of fodder shortages include improved forage species, various forage conservation techniques, and enhancement of nutritive value of straw and other residues through physical and chemical treatment (Lukuyu et al., 2010).

The ever increasing demand of cereal grains for human consumption coupled with reduction in land for fodder cultivation is decreasing the nutrient supply to ruminants. Thus, there is great need to explore alternative supplements which do not compete with humans. One way for increasing the quality and availability of feeds for dairy cows in the dry season may be through the use of fodder trees and shrubs such as mulberry (Morus indica L.). Mulberry foliage, characterized by its high digestibility and good protein content, has great possibilities for use in lactating dairy cows (Sanchez, 2000). The objectives of this study were to examine the effect of substituting mulberry leaves for concentrate mix on dry matter intake, milk yield, milk composition and nutrient digestibility in lactating Holstein Friesian dairy cows.

MATERIALS AND METHODS

Description of the study area

The study was conducted at the dairy farm of Alage Agricultural Technical and Vocational Education and Training College (longitude 38°28′E and latitude 07°42′N), which is located 217 km South of Addis Ababa. It lies in the dry plateau of the southwestern part of the Ethiopian mid rift valley system. The area has an altitude ranging from 1580 to 1600 masl with three distinct seasons namely; main rainy (June to September), short rainy (March to May) and dry (October to February) season. The mean annual average rainfall of the area is 800 mm and daily minimum and maximum temperature are 11°C and 29°C, respectively.

Experimental cows and their management

Four multi-parous pure Holstein Friesian cows aged 6 years and at their mid-lactation stage were used. The initial average milk yield was 13 kg d⁻¹ and body weight ranged from 402 to 438 kg. All cows were weighed and drenched with broad-spectrum anti-helminthetics prior to the start of the experiment. The cows were individually stall-fed in a ventilated barn with concrete floor and appropriate drainage slope and gutters. The cows were milked by hand in the barn twice daily at 4:00 am and 16:00 pm . The cows were let out for exercise for 30 minutes every day.

Experimental feeds and management

The feeds used in the experiment were native Rhodes grass hay, mulberry leaves and concentrates mixture. The grass hay was offered ad libitum each day at 8:00 am after clearing the refusal.

A concentrate mixture of 540 g kg⁻¹ wheat bran, 100 g kg⁻¹ wheat middling, 280 g kg⁻¹ noug seed cake, 50 g kg⁻¹ cotton seed cake, 20 g kg⁻¹ limestone and 10 g kg⁻¹ salt. The concentrate mix had 20% crude protein and 12 MJ kg⁻¹ DM. This was done according to the requirement for lactating dairy cows with a milk yield of 12-14 l d⁻¹ and a butter fat content of 4.5% as described in ARC (1990) when fed at the rate of 0.5 kg l⁻¹ of milk.

Mulberry leaves (Morus indica L.) were obtained from 4-year old mulberry tree plantation. Adequate quantities of fresh mulberry leaves were periodically harvested each morning at 8:00 am and afternoon at 16:00 pm. The leaves collected in the morning were kept for the afternoon meal while the leaves harvested during the late evenings were kept for the morning meal. In both cases, the leaves were mixed thoroughly and covered by plastic sheets till feeding time. The basal feed offered was adjusted daily by allowing 20% of refusal from previous day’s intake. The concentrate mix and mulberry leaves were offered with equal portions at 03:00 am and 15:00 pm during the morning and evening milking. Drinking water and salt were available freely at all times.

Experimental design and treatments

The experimental design was a 4x4 Latin-Square Switch Over (4 cows, 4 periods, and 4 treatments). Each period consisted of 14 days of adaptation and 7 days of data collection. The experimental cows were randomly allotted to one of the following four dietary treatments:

\[ T_1 = \text{Formulated concentrate mix + ad lib grass hay (control)}, \]
\[ T_2 = 75\% \text{ concentrate mix + 25\% mulberry leaves + ad lib grass hay}, \]
\[ T_3 = 50\% \text{ concentrate mix + 50\% mulberry leaves + ad lib grass hay, and} \]
\[ T_4 = 25\% \text{ concentrate mix + 75\% mulberry leaves + ad lib grass hay} \]

Quantities of each feed component in the mixed diet were calculated based on the specified ratio of each treatment on DM basis.

Measurements

Feed offered and refused were measured and recorded for each cow to determine daily feed and nutrient intake. The quantity of concentrate mix offered daily was set at a rate of 0.5 kg l⁻¹ of milk.
The daily milk yield of individual cows was recorded using a Salter balance (Breckenell Special model) and about 100 ml thoroughly mixed composite (morning and afternoon) milk samples were taken using a glass measuring cylinder for each cow twice every week upon completion of the adaptation period. The milk samples were used to determine percentage of fat, protein and solids-not-fat.

i. Apparent dry matter digestibility

The apparent digestibility of the diet was determined using total collection methods for a period of 7 consecutive days every month from day 15 to 21 of each period. To minimize error in faeces collection, farm personnel were assigned around the clock only to scoop faeces into plastic buckets as soon as the animals defecated. Urinal contamination was minimized by frequent washing of the concrete floor with high pressure running water using a plastic water hose. The faeces of all cows were weighed every morning before feeding, and about 1% stored in a deep freezer (–4°C). At the end of the collection period, the 6 days pooled samples were subsequently thawed and mixed thoroughly and two sub-samples taken. For determining DM, the sample was oven dried at 105°C for 24 h, while the other sample was oven dried at 65°C for 72 h and ground using Cyclo-Tec sample mills to pass a 1mm sieve and stored in sample bottles at room temperature.

ii. Chemical composition

The chemical compositions of feed and faeces were analyzed for dry matter (DM), organic matter (OM), and kjeldahl-N according to AOAC (1990) procedures. Neutral detergent fibre (NDF), acid detergent fiber (ADF) and permanganate lignin were determined by the methods of Van Soest and Robertson (1985).

iii. Milk composition analysis

Milk fat, protein and solid-not-fat (SNF) were analyzed using Ekomilk Ultrasonic Milk Analyzers (Model, Verea Plast AD, Stara Zagora, Bulgaria).

Statistical analysis

Data from milk yield and compositions, voluntary DM and nutrient intakes and digestibility were subjected to analysis of variance (ANOVA) procedure for simple Latin Square Design using Statistical Analysis System (SAS Institute 1999). Treatment means were separated using Tukey HSD at P<0.05. The model used for the analysis of data was:

\[ Y_{ijk} = \mu + \alpha_i + \beta_j + T_k + e_{ijk} \]

Where,

- \( Y_{ijk} \) is the dependent variable (intake, digestibility, milk yield& composition, etc)
- \( \mu \) = overall mean,
- \( \alpha_i \) = effect of period (i=1-4)
- \( \beta_j \) = cow effect (j=1-4)
- \( T_k \) = effect of treatment (diet) (k=1-4)
- \( e_{ijk} \) = Randomly and independently distributed error term.

Partial budget analysis

A simple partial budget analysis was conducted based on calculation of the total cost of supplement feeds (concentrate and mulberry leaves) and basal diet (Rhodes grass hay), and considering milk sales price and labor cost incurred during the entire experimentation process. The milk price and the prices of concentrates were obtained from the market price prevalent in Zeway during the experimental period.

RESULTS AND DISCUSSION

Chemical composition

The crude protein (CP) content of the supplements (concentrate mix and mulberry leaves) was more than twice that of grass hay while the NDF value was higher in the grass hay (Table 1). The lignin concentration observed for mulberry leaves (4.6%) and grass hay (5.3%) was higher than that observed for the concentrate mix (3.8%). The hemicelluloses value of grass hay and concentrate mix was higher than that of mulberry leaves. The presence of higher fiber fractions limits voluntary feed intake and digestibility is limited (Casler and Jung, 2006).

Dry matter and nutrient intake

The highest total dry matter intake was measured in cows placed on T2 and T3 (Table 2). This dry matter intake decreased as the level of mulberry substitution increased to 75%. Nearly 50% of the total intake was contributed from the supplements, of which one-third of it was from mulberry leaves. The relatively higher dry matter intake observed when mulberry included at 50% might be associated with improved rumen fermentation and rate of digestion without affecting cellolytic micro-organisms. Mulberry inclusion improved dry matter intake in T2 and T3 as compared with T1 (concentrates only) suggesting the potential of the leaves in improving intake. The inclusion of 75% mulberry markedly reduced the crude protein intake, owing to the presence of higher lignin concentration. Intake is more closely related to the rate of digestion of the diet than to digestibility per se, the faster the rate of digestion, the more rapidly is the digestion tract emptied and the more space is made available for the next meal (McDonald et al., 2002).

Apparent dry matter digestibility

The coefficients of digestibility for DM, OM, CP, NDF and ADF for lactating dairy cows fed grass hay supplemented with different proportions of mulberry leaves and concentrate diet are presented in Table 3.
The value of dry matter digestibility was reduced when mulberry leaves were included at 75%. The inclusion of mulberry up to 50% produced comparable digestibility value as that of the concentrate mix. Kandylis et al. (2009) reported no significant difference in nutrient digestibility when mulberry leaves partially replaced lucerne hay and concentrates in the diet of sheep.

Both dry matter and NDF digestibility significantly (P<0.05) declined with the highest mulberry substitution in the diet (T4). Digestibility appears to be affected by the inclusion of higher proportion of the mulberry leaves. The depression in DM as well as NDF digestibility in T4 might be due to relatively higher concentration lignin in the leaves compared with concentrate mix. It is known that high lignin concentration suppresses the functioning of rumen microorganisms (Casler and Jung, 2006).

**Milk yield and composition**

Although no statistical differences in milk yield and composition were detected among treatments, T3 produced more yield (49, 35 and 42 ml) than T1, T2 and T4, respectively (Table 4). There was no significant difference in milk composition (milk fat, protein and solid not fat) among treatments, suggesting the potential of mulberry leaves in producing comparable product as concentrate mix. Benavides et al. (2000) 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 (Pham et al., 2007).

**Economic analysis**

Economic feasibility of substituting concentrates with mulberry leaves for lactating Holstein cows fed ad libitum grass hay is presented in Table 5. The result of partial budget analysis revealed that mulberry inclusion resulted in higher profit than the control diet (T1). Both T3 and T4 gave the highest net benefit (P<0.05) as compared with T1 and T2. The increased net benefit obtained for cows on T3 and T4 was generally due to the low cost of mulberry production which substituted more expensive concentrate mix. The total cost of establishing 1 ha of mulberry in the present trial was about Birr 1.32 kg⁻¹ forage DM harvested while the cost of concentrate was over Birr 2.022 kg⁻¹ DM.

Despite variation in the degree of profit or reduction in feeding cost, including mulberry supplementation in dairy cattle increases the net benefit. The variation in the degree of profitability of mulberry inclusion might be due to differences in the cost and production of basal diet as well as supplements (concentrates and mulberry) used among different localities and possible variation in the price of output products. More importantly, a rational dairy farmer has to make a compromised decision for a more sustainable biological output and reasonable profit in drawing any definitive conclusion on the supplements proportion. Therefore, it can be concluded that application of such forage tree technology on the farm is profitable and contributes more in improving family economy.

**CONCLUSION**

Mulberry leaves by virtue of its high crude protein and low fiber content, appears to be an excellent supplement comparable to a commercial concentrate mix. The dry matter intake, digestibility coefficients of nutrients tended to decrease with increasing replacement of mulberry leaves from 50% to 75% in the diet without significant effect on milk yield and its composition. Higher net income was observed in all mulberry leaves supplemented based diets than the control diet. Based on the present findings, it can be concluded that up to 50% substitution of mulberry leaves for concentrate mix in the diet of lactating cows results in better milk production, feed utilization and profitability without affecting the milk composition of cow.

**REFERENCES**


Casler MD and Jung HJ. 2006. Relationships of fibre, lignin, and phenolics to in vitro fibre digestibility in three perennial grasses. Animal Feed Science and Technology 125, 151-161.


Table 1. Dry matter, organic matter, crude protein and fiber contents of concentrate mix, mulberry leaves and grass hay

<table>
<thead>
<tr>
<th>Chemical composition</th>
<th>Concentrate mix</th>
<th>Mulberry leaves</th>
<th>Grass hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (g kg(^{-1}))</td>
<td>883.5</td>
<td>295.8</td>
<td>898</td>
</tr>
<tr>
<td>Organic matter</td>
<td>931.5</td>
<td>789.9</td>
<td>847.9</td>
</tr>
<tr>
<td>Crude protein</td>
<td>198.6</td>
<td>161.2</td>
<td>86.3</td>
</tr>
<tr>
<td>Neutral Detergent Fiber</td>
<td>480.4</td>
<td>343.7</td>
<td>723.8</td>
</tr>
<tr>
<td>Acid Detergent Fiber</td>
<td>168.6</td>
<td>287.6</td>
<td>373.6</td>
</tr>
<tr>
<td>Acid Detergent Lignin</td>
<td>38.4</td>
<td>46.5</td>
<td>53.4</td>
</tr>
</tbody>
</table>

Table 2. Dry matter and Nutrient intake of lactating Holstein cows fed on different proportion of concentrate mix and mulberry leaves.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter intake (kg d(^{-1}))</td>
<td>(T_1)</td>
</tr>
<tr>
<td>Grass hay</td>
<td>7.57(^a)</td>
</tr>
<tr>
<td>Concentrates</td>
<td>4.96</td>
</tr>
<tr>
<td>Mulberry leaves</td>
<td>(-)</td>
</tr>
<tr>
<td>Total</td>
<td>12.54(^bc)</td>
</tr>
</tbody>
</table>

Table 3. Apparent DM and Nutrient digestibility of lactating Holstein cows fed on different proportion of concentrate mix and mulberry leaves

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMD</td>
<td>(T_1)</td>
</tr>
<tr>
<td>OMD</td>
<td>65.51(^a)</td>
</tr>
<tr>
<td>CPD</td>
<td>73.42(^a)</td>
</tr>
<tr>
<td>NDFD</td>
<td>54.43(^a)</td>
</tr>
</tbody>
</table>

Means within row with different superscript letter are statistically different (P<0.05). DMD = dry matter digestibility; OMD = organic matter digestibility; CPD = crude protein digestibility; NDFD = neutral detergent fiber digestibility.

Table 4. Milk yield and composition of cows fed diets containing different percentage of concentrates and mulberry leaves.

<table>
<thead>
<tr>
<th>Treatments</th>
<th></th>
<th></th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield (kg d(^{-1}))</td>
<td>(T_1)</td>
<td>(T_2)</td>
<td>(T_3)</td>
</tr>
<tr>
<td>Protein</td>
<td>3.57</td>
<td>3.51</td>
<td>3.57</td>
</tr>
<tr>
<td>Fat</td>
<td>3.96</td>
<td>3.72</td>
<td>4.02</td>
</tr>
<tr>
<td>SNF</td>
<td>8.25</td>
<td>8.69</td>
<td>8.42</td>
</tr>
</tbody>
</table>

Table 5. Partial budget analysis of lactating Holstein cows fed on different proportion of concentrate mix and mulberry leaves

<table>
<thead>
<tr>
<th>Variables</th>
<th>Treatment s</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit (ETB cow(^{-1}) d(^{-1}))</td>
<td>(T_1)</td>
<td>(T_2)</td>
</tr>
<tr>
<td>Milk yield (kg d(^{-1}))</td>
<td>10.73</td>
<td>10.87</td>
</tr>
<tr>
<td>Gross yield benefit (ETB)</td>
<td>53.66</td>
<td>54.37</td>
</tr>
<tr>
<td>Variable costs (ETB cow(^{-1}) d(^{-1}))</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Cost of grass hay</td>
<td>8.33</td>
<td>8.73</td>
</tr>
<tr>
<td>Cost of mulberry</td>
<td>0</td>
<td>1.92</td>
</tr>
<tr>
<td>Cost of concentrate</td>
<td>10.05</td>
<td>7.61</td>
</tr>
<tr>
<td>Cost of supplement</td>
<td>10.05</td>
<td>9.53</td>
</tr>
<tr>
<td>Total variable cost (ETB cow(^{-1}) d(^{-1}))</td>
<td>18.38</td>
<td>18.26</td>
</tr>
<tr>
<td>Net benefit (ETB cow(^{-1}) d(^{-1}))</td>
<td>35.28(^a)</td>
<td>36.11(^a)</td>
</tr>
<tr>
<td>Profitability (%)</td>
<td>65.74(^a)</td>
<td>66.41(^a)</td>
</tr>
</tbody>
</table>

\(^{a,b,c}\) means within row not bearing a similar superscript letter are statistically different (P<0.05).