Effects of incorporating cactus pear (*Opuntia ficus-indica*) and urea-treatment of straw on the performance of sheep.

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**Abstract**

Ethiopia's livestock, the largest in Africa, is contributing little in ensuring food-security, mainly attributed to poor feed quality and unavailability. Due to its adaptability, cactus pear established its own environmental niche on marginal lands in arid areas of Ethiopia and elsewhere. It is widely used as forage, especially during critical periods of feed shortage. Compositionally, cactus pear is rich (dry matter basis) in readily digestible carbohydrate. The other abundant feed resources are cereal residues, which are of low nutritive value. Urea-treatment has been proposed for enhancing their quality. Lack of readily digestible organic matter, which cactus pear has, limits the efficient utilisation of urea-treated straw. Thus, this study aimed at investigating the effects of cactus pear inclusion and urea-treatment of straw on the performance of sheep. A three-months experiment laid out in a randomised complete block design with eight sheep/treatment. Diets consisted of untreated wheat straw (S) [T1], S + cactus pear (C) [T2], S + C + wheat bran (WB) [T3], urea-treated straw (UTS) [T4], UTS + C [T5] and UTS + C + WB [T6]. The rate of supplements (C and/or WB) was 40%. Diets were offered in individual troughs twice daily, aiming at 20% refusals. At the end of the feeding trial, four sheep/group were transferred to metabolic crates for the digestibility trial (7 days). Data were subject to ANOVA using the SAS software JMP 5. Urea-treatment improved crude protein content of straw from 2.68 to 8.69% and apparent dry matter digestibility (DMD) from 55% (T1) to 65% (T4). Highly significant differences (p<0.001) were observed for total dry matter intake (DMI), DMD and live weight change. DMI was highest in T5 and T6 (90 and 84 g/kgW0.75, respectively) and lowest in T1 (55 g/kgW0.75). DMD was highest in T2 and T5 (65%) and lowest in T1 (55%). Sheep on T6 had the highest live weight gain (75.5 g/day) followed by sheep on T3 and T5 (41.5 and 38.0 g/day, respectively). In conclusion, cactus pear and urea-treatment significantly increased total feed intake. Under conditions of this experiment, cactus pear could substitute wheat bran, provided that straw is urea-treated. Diet six (T6) appears to be a promising package for dry season feeding systems that could enhance productivity of livestock and thereby improve the livelihood of farmers.

**Key words:** Feed intake, digestibility, sheep performance, cactus pear, wheat bran, urea-treatment

**Introduction**

Ethiopia's livestock, the largest in Africa, is contributing little in ensuring food-security, mainly attributed to poor feed quality and unavailability. Due to its adaptability, cactus pear established its own environmental niche on marginal lands in arid areas of Ethiopia and elsewhere. After its introduction to Ethiopia, in the mid 19th century, cactus pear's cladodes are widely used as forage...
for ruminants while its fruits have become popular for human consumption. Chemical composition studies indicated that cactus pear is rich (on dry matter basis) in readily digestible carbohydrate that it may serve as a good sources of fermentable ME. Although it has been used as an animal feed for a long period of time its nutritive value, especially for farm animals, has received little research attention.

Cereal residues are the other abundant feed resources in Ethiopia. According to Alemu et al. (1991), 63% of the cereal straws produced in the central highlands of Ethiopia were used for animal feed. Crop residues are, however, low in nutritive value. To make maximum use of crop residues, urea-treatment has been suggested to be the most favoured method for enhancing their quality in the tropics (Owen and Jayasuria, 1989). However, lack of readily digestible organic matter, which cactus pear has, limits the efficient utilisation of urea-treated straw. Thus, this study aimed at investigating the effects of cactus pear inclusion and urea-treatment of straw under tropical livestock production settings.

**Materials and methods**

A three-months experiment was conducted in Mekelle University, which is located at 13° 28’ N and 39° 29’ E, Tigray, northern Ethiopia. The soil on which the cactus pear was grown is of litosol type (Fassil Kebede, 1998, personal communication). The altitude is 2100 m a.s.l. and the rainfall pattern is erratic and irregular with an annual average of 600 mm.

The experiment was laid out in a randomised complete block design with eight- (8) male growing sheep per treatment. Diets consisted of untreated straw (S) [T1], S+ cactus (C) [T2], S+C+ wheat bran (WB) [T3], urea-treated straw (UTS) [T4], UTS+C [T5] and UTS+C+WB [T6]. The rate of supplements (C and/or WB) was 40% of total diet. Cactus pear cladodes from plants naturally grown along the marginal lands in the premises of Mekelle University were daily collected, spines burned off and chopped. Wheat bran was bought from the nearby milling factory. Urea treatment of straw (5% urea) was done as outlined in Preston (1995). Treatment feeds were offered in individual troughs twice daily at 9:00 and 16:00 o’clock. Common salt licks were available *ad libitum* while water was provided twice per day. Feed consumption and refusals were recorded daily. Animals were weighed weekly on the same day before being fed and watered. At the end of the feeding trial, four- (4) sheep per treatment group were transferred to metabolic crates and adapted to metabolic crates and carrying faecal bags for three days. Faeces and urine collection was carried out for seven (7) days.

Dry matter DM), crude fibre (CF), crude protein (CP), ether extract (EE) and ash were determined according to proximate method while neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Goering and van Soest (1970). Data were subject to ANOVA using the SAS software JMP 5. Significant differences between treatment means were tested by Tukey's pairwise comparison.

**Results and discussion**

**Chemical composition of treatment feeds**

The chemical composition of treatment feeds is indicated on Table 1 below. The dry matter (DM) content of cactus pear (12.23%) was found to be within previously reported ranges (Gregory and Felker, 1992; Felker, 1995; Lopez et al., 2001). Comparable values of crude protein (CP) content have been reported for cactus pear grown on poor soils (De Kock, 1980; Flachowsky and Yami, 1985; Hanselka and Paschal, 1990). The crude ash content (19.89%) was similar to the level obtained by Flachowsky and Yami (1985) (20%) for Ethiopian cactus pear collected from the eastern part of the country.
Table 1: Chemical composition of treatment feeds used in the feeding and digestibility trials

<table>
<thead>
<tr>
<th></th>
<th>DM (%)</th>
<th>CP</th>
<th>EE</th>
<th>NDF</th>
<th>ADF</th>
<th>ADL</th>
<th>CF</th>
<th>ASH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cactus pear</td>
<td>12.23</td>
<td>5.06</td>
<td>1.19</td>
<td>23.88</td>
<td>16.24</td>
<td>3.06</td>
<td>10.92</td>
<td>19.89</td>
</tr>
<tr>
<td>Untreated wheat straw</td>
<td>92.80</td>
<td>2.68</td>
<td>0.48</td>
<td>75.87</td>
<td>46.96</td>
<td>6.57</td>
<td>41.22</td>
<td>10.98</td>
</tr>
<tr>
<td>Urea-treated wheat straw</td>
<td>60.59</td>
<td>8.69</td>
<td>0.47</td>
<td>75.64</td>
<td>49.10</td>
<td>6.51</td>
<td>42.50</td>
<td>10.03</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>89.45</td>
<td>14.57</td>
<td>5.04</td>
<td>40.12</td>
<td>10.91</td>
<td>1.96</td>
<td>8.99</td>
<td>4.43</td>
</tr>
</tbody>
</table>

The improvement of the CP content of wheat straw from 2.68% (untreated) to 8.69% (urea-treated) was very significant. This level of CP could be sufficient for maintenance of live weight and to maximise digestibility of DM and NDF of straw-based diets (Weidmeier, et al. 1983).

**Dry matter intake (DMI)**

Treatment effects on DMI are presented in Figure 1 below. There were highly significant differences among treatment means (p<0.001), except between T₅ and T₆. The highest DMI was recorded in the latter two treatments (T₅ and T₆). The DMI recorded on T₅ (90 g DM/kgW₀.⁷⁵) is higher than the value Mengistu (2001) reported for urea-treated wheat straw and cactus pear (72 g DM/kgW₀.⁷⁵), the latter fed ad libitum. Though wheat straw is reported to be inferior to other cereal residues in Ethiopia (Lulseged and Jemal, 1989), DMI of sheep in T₁ was noticeably high (2.5% of live weight), which is comparable to the level reported for superior residues like teff straw (1.81-2.92% of live weight in sheep) (Bonsi et al. 1995).

**Figure 1: Mean total dry matter intake of sheep during the feeding trail**

Cactus pear inclusion increased total DMI by 38.5% (T₁ Vs T₂), relatively lower than what Shoop et al. (1977) found in heifers (43%). Increase of intake of barley straw, due to cactus pear inclusion, has also been reported by Ben Salem et al. (1996). This may be attributed to the high soluble fraction in cactus pear (76%, on DM basis) (Table 1) as feeds rich in fermentable components could increase outflow rate (Orskov, 1991b) and thereby feed intake.

Urea-treatment of wheat straw resulted in a 50% increase in DMI (T₁ Vs T₄) (Figure 1), which is in agreement with reports by Orskov (1991a) and far greater than attainable improvements suggested by Ibrahim (1991) (10-35% increase).

Diets T₃ to T₆ provided CP above the maintenance requirement of the sheep. While CP intake in T₁ only reached 0.4 times maintenance, cactus pear inclusion (T₂) increased this value to 0.8 (Figure 2).
Dry matter digestibility (DMD)
Urea-treatment of wheat straw increased DMD by 5 percentage units (Figure 3), an increase of 9%, very close to the minimum expected improvement (10-15%) (Orskov, 1991a) but reasonable improvement compared to Ibrahim's (1991) suggestion (2-25%). The improvement of the DMD of UTS was more apparent when cactus pear was included (from 60% (T4) to 65% (T3)). This could indicate that the lower-than-average improvement in DMD by urea-treatment alone could be attributed to the lack of readily available organic matter.

Growth performance of sheep
Treatment effect on live weight change is indicated on Table 2. Generally, there were highly significant differences among treatment means (p<0.001) in terms of live weight change, except between T1 and T2, and T3 and T5. The latter indicates that given straw is urea-treated cactus pear could replace wheat bran. In this regard Ben Salem, et al. (2004) concluded that in the presence of N source (soybean) cactus pear may replace barley grains without any effect on growth rate of sheep. Though sheep in T5 and T6 consumed the same amount of DM (Figure 1), sheep in the former performed less (+38.00 g/day) that the latter (75.50 g/day). This might be attributed to wheat bran inclusion in T6, which is relatively high in protein and phosphorus (Preston, 1995), or the presence of oxalates in cactus pear (Ben Salem, et al., 2005, in press). Though sheep in T5 and T6 consumed the same amount of DM (Figure 1), sheep in the former performed less (+38.00 g/day), indicating that there still was an imbalance in terms of nutrients. Taking the representative growth rates of 12-months old Ethiopian highland sheep types under research station management conditions (33.5, 25.8 and 24.8 g/day, for Horro, Afar and Blackhead Ogaden types, respectively) (Wilson, 1991), however, the performance of the sheep in T3, T5 and T6 was commendable.
Table 2: Mean daily live weight change of sheep during the feeding trial

<table>
<thead>
<tr>
<th>Treatment groups*</th>
<th>Initial weight (kg)</th>
<th>Final weight (kg)</th>
<th>Live weight change (g/day)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated wheat straw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (0/0)</td>
<td>17.50</td>
<td>15.50</td>
<td>-22.00d</td>
</tr>
<tr>
<td>2(40/0)</td>
<td>18.00</td>
<td>15.50</td>
<td>-27.50d</td>
</tr>
<tr>
<td>3(20/20)</td>
<td>18.00</td>
<td>22.00</td>
<td>+41.50b</td>
</tr>
<tr>
<td>Urea-treated wheat straw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4(0/0)</td>
<td>18.25</td>
<td>19.00</td>
<td>+14.00c</td>
</tr>
<tr>
<td>5(40/0)</td>
<td>18.00</td>
<td>21.00</td>
<td>+38.00b</td>
</tr>
<tr>
<td>6(20/20)</td>
<td>18.75</td>
<td>25.50</td>
<td>+75.50a</td>
</tr>
</tbody>
</table>

*Rate of supplements, cactus:wheat bran proportion (%)

** Different superscripts show statistical differences (p<0.001).

The major reason for the loss in live weight observed on animals in T₁ and T₂, might not be attributed to low voluntary feed intake per se, because the sheep consumed 2.5% of their live weight (Figure 1), but probably to the low protein and mineral contents (especially phosphorus) in both wheat straw and cactus pear (Rematal et al. 1987; Gregory and Felker, 1992; Firew, 1995).

Conclusions
Cactus pear and urea-treatment significantly increased total feed intake. Provided that straw is urea-treated, cactus pear could substitute wheat bran, an important alternative for farmers who do not have access to wheat bran or cannot afford to buy. Diet six(T₆) appears to be a promising package for dry season feeding systems that could enhance productivity of livestock and thereby improve the livelihood of resource poor farmers under arid conditions.

References


