ABSTRACT

Four cubed rations of similar chemical composition were fed ad libitum to 16 lactating yearling Alpine goats. The rations contained 0, 15, 25, and 35% almond hulls; 0, .5, 1, and 1% urea; and 58.4, 42.5, 32.0, and 22.0% alfalfa hay (DM basis). Chromic oxide was added as a digestibility marker. Average nutrient composition of diets was 91% DM, 20% CP, 32% NDF, 9% ash, and 4.39 Mcal gross energy/kg. Goats were randomly assigned to one of four diet orders in four replications of a 4 × 4 Latin square, blocked by goat and period. Data were collected in the 3rd wk of each period.

Diets containing 25 and 35% almond hulls increased DM intake and reduced milk protein percent and digestibilities of DM, organic matter, ash, and NDF. Dry matter intake and weight gain were highest for the diet containing 35% almond hulls and 1% urea. Results indicate that almond hulls and urea can be fed to lactating goats up to these amounts without adversely affecting lactation.

INTRODUCTION

Feed costs can represent more than 50% of all dairy goat production costs (19); therefore, utilization of low cost by-products of known nutritive value is important if dairy goat producers are to succeed economically. Unfortunately, only limited performance data are available on by-product feeds for lactating goats in the United States.

Goats are able to use a wide variety of agricultural by-products for maintenance and growth (5, 10, 16, 17); however, less is known about how feeding by-products can affect lactation. Work in France (8), Pakistan (11), and Mexico (1) has shown feeding by-products can affect body weight, feed intake, digestibility, and yield and composition of milk.

Almond hulls (the dried fleshy pericarp of the almond fruit) were chosen for study because no work has been done on their feed value for lactating goats; almond hulls met criteria for acceptability set forth in a survey of dairy goat producers (Reed, unpublished data), and almond hulls are in abundant supply in California (3). Unlike many other horticultural by-products (pulps, pomaces), almond hulls are dried in the harvesting process. Low moisture content makes almond hulls attractive for livestock feed by reducing transportation costs and allowing for long-term storage.

The objective of this study was to evaluate the nutritive value of almond hulls as a feed for lactating dairy goats.

MATERIALS AND METHODS

Animals

Sixteen healthy yearling Alpine goats in early lactation (averaging 3 wk postpartum at start of experiment) were randomly assigned to four replications of a 4 × 4 Latin square design. Animals used in this trial were part of the caprine arthritis and encephalitis-free herd of the University of California-Davis Dairy Goat Facility and had freshened within a 3-wk period.

Diets

The ingredients of the four complete cubed rations are in Table 1. Chromic oxide was in-
TABLE 1. Diets for lactating goat digestion and performance study.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Control</th>
<th>15% AH$^1$</th>
<th>25% AH</th>
<th>35% AH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>58.4</td>
<td>42.5</td>
<td>32.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Barley</td>
<td>32.3</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
</tr>
<tr>
<td>CSM$^2$</td>
<td>6.1</td>
<td>6.0</td>
<td>6.1</td>
<td>6.0</td>
</tr>
<tr>
<td>Molasses</td>
<td>3.2</td>
<td>3.5</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Almond hulls</td>
<td>. . .</td>
<td>15.0</td>
<td>25.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Urea</td>
<td>. . .</td>
<td>.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Limestone</td>
<td>. . .</td>
<td>.5</td>
<td>.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1 AH = Almond hulls (predominately Ne Plus variety).

2 CSM = Cottonseed meal.

Inclusion in each diet at .2% of the ration on a DM basis. The actual chromium concentrations were determined in all diets after mixing. These latter figures were used to calculate digestion coefficients. Nutrient composition of the diets is in Table 2. Although the protein in the 35% almond hull (AH) diet was lower than the other diets, it was still more than adequate to meet nutritional requirements of a lactating goat (6, 12). The nutrient composition of the almond hulls used in this trial was 6.79% ash, 4.87% CP, 1.69% ether extract, 29.90% ADF, 38.49% NDF, 16.56% cellulose, and 13.34% crude lignin.

**Digestion Trial**

Prior to the trial, the control diet was offered to all subjects for 1 wk to familiarize goats with a cubed diet and prime the digesta with chromic oxide. Goats were penned individually and had free access to water. They were fed ad libitum and milked twice daily. Mineralized salt blocks were offered while goats were on the milking stand. Each period consisted of 21 d: 14 d of adjustment to each diet followed by sample collection for the last 7 d. Goats were weighed before and after each period. Fecal grab samples taken prior to each milking were combined within period and goat for nutrient and chromium analysis. Chromic oxide is excreted quantitatively from the animal, and so its increased concentration in the fecal matter can be used to determine the digestibility of the feed (13). Feed was weighed out twice daily, and twice daily subsamples of each diet were pooled by period for analysis. Feed refusals were weighed and reserved for nutrient analysis weekly. Feed, fecal, and refusal samples were analyzed according to AOAC methods for DM, organic matter, ash, chromium (4), and USDA methods for NDF (9).

TABLE 2. Composition of diets for digestion and performance studies.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Crude protein (%) dry matter</th>
<th>Neutral detergent fiber (%) dry matter</th>
<th>Ash (%) dry matter</th>
<th>Gross energy (Mcal/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>20.56</td>
<td>31.63</td>
<td>9.72</td>
<td>4.40</td>
</tr>
<tr>
<td>15% AH$^1$</td>
<td>20.31</td>
<td>32.93</td>
<td>8.75</td>
<td>4.38</td>
</tr>
<tr>
<td>25% AH</td>
<td>19.94</td>
<td>32.20</td>
<td>8.58</td>
<td>4.39</td>
</tr>
<tr>
<td>35% AH</td>
<td>18.06</td>
<td>32.61</td>
<td>8.08</td>
<td>4.38</td>
</tr>
</tbody>
</table>

1 AH = Almond hulls (predominately Ne Plus variety).
TABLE 3. Apparent digestibility coefficients * for diets.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>15% AH 2</th>
<th>25% AH</th>
<th>35% AH</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>15.3</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td></td>
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<tr>
<td>DM</td>
<td>67.04a</td>
<td>67.51a</td>
<td>63.41b</td>
<td>64.17b</td>
<td>.67</td>
</tr>
<tr>
<td>Organic matter</td>
<td>67.98a</td>
<td>68.68a</td>
<td>64.73b</td>
<td>65.59b</td>
<td>.66</td>
</tr>
<tr>
<td>Ash</td>
<td>58.57a</td>
<td>54.99a</td>
<td>48.85b</td>
<td>47.45b</td>
<td>.57</td>
</tr>
<tr>
<td>NDF</td>
<td>36.08a</td>
<td>38.02a</td>
<td>28.91b</td>
<td>31.17b</td>
<td>1.30</td>
</tr>
</tbody>
</table>

* Means in same row with different superscripts differ (P<.05).

1 Digestion coefficients expressed as mean percentage with pooled standard error of the means (SE).

2 AH = Almond hulls (predominantly Ne Plus variety).

One refusal sample lost from control group.

RESULTS AND DISCUSSION

Results of the digestibility study are in Table 3. Feed intake and production responses are in Table 4. Although digestibilities of various nutrient components were lower in diets containing 25 and 35% AH (P<.05), DM intake was greater with 25 and 35% AH diets (P<.05) than controls, and weight gain was higher for 35% AH diet than for 15% AH (P<.05). Milk yield was essentially identical with production of about 3.6 kg milk per goat/d. Similar results have been observed with dairy cattle (2). Protein percentage of milk from goats fed 35% AH was lower than 25% AH. Milk protein yield and fat yield were not significantly affected by diet.

The other dietary treatments were slightly higher in protein than the 35% AH diet, and the 25% AH diet contained more added NPN than...
the 35% AH diet. Because all diets probably exceeded N requirements, the three that were the most excessive in N very likely resulted in higher blood and, therefore, milk urea (7, 18). This extra NPN in the milk would have been counted as protein by the Kjeldahl analysis employed in these experiments. The apparent reduced milk CP value observed with the 35% AH diet may have been due to reduced milk NPN relative to other dietary treatments.

CONCLUSIONS

Results indicate that the performance of animals fed almond hulls and urea as a replacement for alfalfa is predictable from chemical analysis of the feeds, but more detailed work is needed regarding specific mechanisms of how this is accomplished. When the price of alfalfa is higher than that of a 30:1, 25:1, or 35:1 mixture of almond hulls and urea, such mixtures can be substituted for the alfalfa (up to 15, 25, and 35% of the diet, respectively) and provide for lower feed costs without losses in milk production or significant changes in milk composition.

REFERENCES