Effect of Replacing Corn Silage with Canola Silage on Feed Intake, Nutrient Digestibility, Milk Yield, and Thyroid Hormones of Lactating Dairy Cows

Amir Balakhial, Abasali Naserian, Alireza Heravi moussavi, and Reza Valizadeh

1 Department of Animal Science, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran
2 Excellence Center for Animal Science, Ferdowsi University, Mashhad, Khorasan Razavi, Iran

* Corresponding author: Abasali Naserian, Department of Animal Science, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran.
Email: abasalin@gmail.com

1. Introduction

Providing good quality forage in dairy cattle diet is vital for the dairy farm industry. In some semitropical countries, such as Iran, low rain in the last decade has led to a decline in forage production. On the other hand, Iran’s government planned to increase vegetable oil production, which has increased canola cultivation over the past decade. Canola is one of the oilseed plants that belong to the Brassica species. Decrease in environment temperature or acute damage by pests makes canola cultivation difficult. In this situation, most farmers eliminate damaged canola forage by burning or burying it in the ground. In this condition, there is a question about the possibility of utilizing canola forage in ruminant nutrition. Some studies indicated the nutrient composition of canola silage and its positive effects on dairy cattle performance. Moreover, a study on the effects of adding different levels of rapeseed (canola seed) silage on the diet of beef cattle indicated that tract digestibility and NDF were greater in high glucosinolate rapeseed varieties. Given the above-mentioned, the...
The current study aimed to determine the effects of substituting corn silage with canola silage on feed intake and apparent digestibility of nutrients, milk yield, and milk composition.

2. Materials and Methods

2.1. Ethical approval

All animals were treated in accordance with the regulations on the guidelines of the Iranian Council of Animal Care (1995), and the experiment was approved by the Iranian Ministry of Agriculture (experimental permission no. 1828).

2.2. Experimental design

In the current study, 9 Holstein dairy cows with a mean parity of 2.5 (mean ± SD), mean body weight of 556 kg (mean ± SD), days in milk (DIM) of 89.3 ± 21.19 (mean ± SD), and milk yield of 41.7 ± 4.0 kg/ d (mean ± SD) were allocated in a 3x3 change over Latin square design study. This study contained three periods, each lasting 20 days. The first 15 days of each period were the adaptation period. Every 5 days, a composite diet sample was collected (4 times during each period). Both corn (Agratech 787, Agra Tech Seeds, Inc., Ashburn GA) and Canola (Hyola-308) were plated in the sandy soil on April 6, 2019, and irrigation was provided to supplement natural rainfall. Corn was chopped and stored in a concrete silo on August 11, 2019, and canola was mown on August 4, 2019, and allowed to wilt to approximately 20% DM before being chopped and stored in a concrete stave silo. Diet was offered twice daily as a total mixed rations (TMR) at 1000 hours and 1500 hours. Forage was 33% DM of the diet (Table 1). In the present study, the experimental diet was substituted for 0, 50, and 100% with corn silage DM. Samples of diet (0.5 kg) were collected during the experiment and stored at -20°C until analysis. The DM content of the experimental diet was determined by drying in the oven at 55°C for 48 hours.

After drying, ingredients and TMR were ground to pass through a 1-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA). Samples were analyzed for DM, CP, ash, ADF, and NDF. Cows were milked twice daily, and milk samples (10 ml) were collected 4 times (twice in the morning and twice in the evening) in the final two days of each period in the milking pail before milking from all quarters. Milk samples were transferred to the Dairy Laboratory of Mashhad Agricultural Organization, Mashhad, Iran, for nutrient composition analysis using a spectrum analyzer (FT400; Foss North America Inc., Eden Prairie, MN). Blood samples (5 ml) were collected from the jugular vein at the end of the experiment. Tubes were allowed to clot, and serum was centrifuged at 30000 rpm at 4°C for 45 minutes. Blood concentrations of urea nitrogen and glucose were measured using an enzymatic and colorimetric method, respectively, by zist shimi analyzing kits, Iran. Thyroid hormone was measured by radioimmunoassay procedure. Fecal samples were collected directly from the rectum in the last 5 days of each experimental period. Fecal samples were collected and analyzed in terms of DM, ash, CP, ADF, NDF, and acid insoluble ash (AIA). Acid insoluble ash was used as an indicator to determine the apparent digestibility of nutrients. Ruminal fluid samples were taken 3 hours after feeding time on the last day of each experimental period from the ventral sac of the rumen, and pH was determined. Ruminal fluid samples were preserved by adding 10 ml of ruminal fluid and stored at -20°C for further analysis.

Samples of strained ruminal fluid were thawed and centrifuged at 30,000 g for 20 minutes at 4°C and supernatants were analyzed for NH₃ using the Kjeldahl method.

2.3. Statistical analysis

The resulting data were statistically analyzed using the linear model in the statistical package for the social sciences (SPSS 16, Chicago, USA). Tukey test was chosen to determine the mean significant differences between treatments. The p < 0.05 was considered a significant difference between the experimental treatments.
3. Results and Discussion

The nutrient content of corn silage and canola silage is presented in Table 2. The DM content of corn silage was higher than canola silage (p < 0.05). Concentrations of CP in corn silage were lower than in canola silage, but NDF and ADF contents of canola silage were higher (p < 0.05).

Table 1 demonstrates the composition of the experimental diets. The results showed a decrease in the DM content of the diet by replacing corn silage with canola silage. Moreover, there was an increase in the CP, NDF, and ADF of experimental diets, which might be due to the higher fiber content of canola silage, compared to corn silage. The DM yield values between experimental treatments were significantly different (Table 3). The DMI decreased by increasing the substitution level of corn silage with canola silage (p < 0.05). 

<table>
<thead>
<tr>
<th>Item</th>
<th>Diet</th>
<th>DM (%)</th>
<th>OM (%)</th>
<th>CP (%)</th>
<th>NDF (%)</th>
<th>ADF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage replaced with canola silage (TMR) DM percent</td>
<td>0%</td>
<td>5%</td>
<td>10%</td>
<td>SE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>74.73 ± 0.28</td>
<td>73.38 ± 0.28</td>
<td>73.05 ± 0.28</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM</td>
<td>72.71 ± 0.28</td>
<td>71.37 ± 0.28</td>
<td>68.12 ± 0.28</td>
<td>1.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>67.42 ± 0.28</td>
<td>64.80 ± 0.28</td>
<td>63.92 ± 0.28</td>
<td>1.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDF</td>
<td>59.46 ± 0.28</td>
<td>58.53 ± 0.28</td>
<td>54.32 ± 0.28</td>
<td>1.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rumen fluid pH</td>
<td>6.43 ± 0.28</td>
<td>6.55 ± 0.28</td>
<td>6.56 ± 0.28</td>
<td>0.076</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The substitution of corn silage with canola silage (p < 0.05). Concentrations of CP, OM, and NDF of canola silage were higher (p < 0.05). The DM content of corn silage was lower than in canola silage, but NDF and ADF contents of canola silage were higher (p < 0.05).

Table 2. Chemical composition of corn silage and canola silage

<table>
<thead>
<tr>
<th>Composition</th>
<th>Silage</th>
<th>Corn</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM (%)</td>
<td>30.00 ± 1.70</td>
<td>19.50 ± 1.17</td>
<td></td>
</tr>
<tr>
<td>OM, (%) of DM</td>
<td>94.20 ± 1.20</td>
<td>90.00 ± 1.69</td>
<td></td>
</tr>
<tr>
<td>CP, (%) of DM</td>
<td>7.17 ± 0.52</td>
<td>16.57 ± 0.67</td>
<td></td>
</tr>
<tr>
<td>EE (%)</td>
<td>3.00 ± 0.28</td>
<td>4.80 ± 0.57</td>
<td></td>
</tr>
<tr>
<td>NDF, (%) of DM</td>
<td>43.60 ± 1.07</td>
<td>50.30 ± 2.29</td>
<td></td>
</tr>
<tr>
<td>ADF, (%) of DM</td>
<td>29.00 ± 1.40</td>
<td>38.00 ± 1.20</td>
<td></td>
</tr>
</tbody>
</table>
| DM: Dry matter; OM: Organic matter; CP: Crude protein; EE: Ether extract, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, a Superscript letters in rows show significant differences in the groups (p < 0.05)

It is suggested that an increase in diet NDF content by replacing canola silage with corn silage is associated with an increase in ruminal pH value. The substitution of corn silage with canola silage enhanced the CP content of diets, increasing ruminal NH3-N concentration.

Replacing corn silage with canola silage did not change milk yield, FCM (4%), and milk chemical composition (Table 4), but protein in the group where 50% of corn silage was replaced with canola silage was higher than in other treatments (p < 0.05).

Blood glucose and BUN concentration were influenced as canola silage was replaced with corn silage (Table 5). Replacement of corn silage with canola silage results in an increase in diets CP content so it can be effective in enhancing BUN concentration. Increased content, solubility, and degradability of dietary protein can lead to increased ammonia concentrations in the rumen, resulting in high blood BUN concentrations.

It is indicated that increasing rumen propionate concentration as a result of fermentation of tyfon (Brassica) forage carbohydrates enhances blood glucose concentration. Serum T3 and T4 concentrations were affected by increasing substitution levels of corn silage with canola silage (Table 5). Glucosinolate contains Brassica has a negative impact on thyroid gland function by interfering with iodine uptake.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Diet</th>
<th>Corn silage replaced with canola silage (TMR DM percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk, (kg/d)</td>
<td>36.48 ± 0.28</td>
<td>35.64 ± 0.28</td>
</tr>
<tr>
<td>4% FCM, (kg/d)</td>
<td>32.16 ± 0.28</td>
<td>31.59 ± 0.28</td>
</tr>
<tr>
<td>TS (%)</td>
<td>11.73 ± 0.28</td>
<td>11.77 ± 0.28</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>3.03 ± 0.04</td>
<td>2.87 ± 0.04</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>4.75 ± 0.04</td>
<td>4.77 ± 0.04</td>
</tr>
<tr>
<td>SNF (%)</td>
<td>8.52 ± 0.04</td>
<td>8.47 ± 0.04</td>
</tr>
</tbody>
</table>
| a Superscript letters in rows show significant differences in the groups (p < 0.05), FCM: Fat corrected milk, TS: Total solid, CP: Crude protein, SNF: Solids non-fat, SE: Standard error
Table 5. Blood glucose, BUN, and thyroid hormones concentration of dairy cows fed diets containing different proportions of canola silage and corn silage

<table>
<thead>
<tr>
<th>Item</th>
<th>Diet of Corn Silage replaced by Canola Silage (TMR DM percent)</th>
<th>% (of DM)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (mg/dl)</td>
<td></td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>BUN (mg/dl)</td>
<td></td>
<td>52.55±a</td>
<td>53.88±ab</td>
</tr>
<tr>
<td>T3 (mg/dl)</td>
<td></td>
<td>15.21±a</td>
<td>17.71±ab</td>
</tr>
<tr>
<td>T4 (μg/dl)</td>
<td></td>
<td>5.60±a</td>
<td>111.27±ab</td>
</tr>
<tr>
<td>T3 (μg/dl)</td>
<td></td>
<td>5.76±a</td>
<td>4.96±a</td>
</tr>
</tbody>
</table>

*a* Superscript letters in rows show significant differences in the groups (p < 0.05). BUN: Blood urea nitrogen; T3: Triiodothyronine, T4: Thyroid hormone.

A study reported a reduction in T₄ concentration and an enhancement in T₃ concentration in lambs due to diets containing rape27.

Seeds are the major source of glucosinolates in the canola plant2. Although in this study the concentrations of glucosinolates did not measure. It seems that the canola pods in canola forage can increase glucosinolates concentration in diets as canola silage was replaced with corn silage. It diminished the levels of T₄ and T₃ in cows treated with 100% canola silage.

4. Conclusion

The DM content of corn silage was higher than canola silage. Concentrations of CP in corn silage were lower than canola silage, but NDF and ADF content of canola silage was higher than corn silage. Canola silage can be replaced by corn silage, and feeding canola silage can be beneficial in some aspects. The high fiber content of canola silage can limit DMI since it is important to take more studies about the application level of canola silage in dairy cattle diets.

Declarations

**Competing interests**

There is no conflict of interest.

**Authors’ contribution**

The final manuscript draft was reviewed by all authors, who also gave their approval.

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**Ethical considerations**

Ethical issues (including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) have been checked by all the authors.

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References


