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Original Article

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

Amir Balakhial[1], Abasali Naserian[1,*], Alireza Heravi moussavi[2], and Reza Valizadeh[1]

[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

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ABSTRACT

Introduction: Providing good quality forage in dairy cattle diet is vital for the dairy farm industry. Canola forage was newly added to dairy cows' diet in Iran. The present study aimed to determine the effects of replacing corn silage with canola silage on feed intake, apparent digestibility, milk yield, milk composition, and thyroid hormone levels of dairy cattle in Mashhad, Iran.
Materials and methods: Nine Holstein cows were used in this study and were allocated in a 3×3 change over Latin square design study. The trial consisted of 3 periods, each lasting for 20 days. The first 15 days were considered an adaptation period. Experimental diets were formulated to provide 33% of the total dry matter (DM) as forage. Canola silage was substituted with corn silage at levels of 0, 50, and 100% of DM.
Results: Dietary concentrations of neutral detergent fiber (NDF) and acid detergent fiber increased when corn silage was replaced by canola silage. Replacing corn silage with canola silage caused a significant decrease in DMI. The apparent digestibility of DM and crude protein were not affected by dietary replacement of corn silage with canola silage; however, organic matter and digestibility of NDF decreased significantly. When corn silage was replaced by canola silage, there were no significant changes in milk yield, fat corrected milk, and milk composition in the investigated cattle, but milk protein changed significantly. The results indicated that 50% substitution of canola silage caused higher milk protein. Rumen fluid pH and its ammonia nitrogen concentration increased significantly in experimental animals. The concentrations of T_3 and T_4 decreased, whereas blood urea nitrogen concentration increased by dietary replacement of corn silage with canola silage.
Conclusion: Canola silage can be substituted with corn silage, and feeding canola silage can be beneficial in some aspects.

1. Introduction

Providing good quality forage in dairy cattle diet is vital for the dairy farm industry[1]. Low rain in the last decade has led to a decline in forage production in some semitropical countries, such as Iran[2]. On the other hand, Iran's government planned to increase vegetable oil production, which has increased canola cultivation over the past decade[2,3]. Canola is one of the oilseed plants that belong to the *Brassica* species[4]. A decreased environmental temperature or acute damage by pests makes canola cultivation difficult[5]. 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[6-8]. Moreover, a study on the effects of adding different levels of rapeseed (canola seed) silage on the diet of beef cattle indicated that tract

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digestibility and NDF were greater in high glucosinolate rapeseed varieties[9]. Given those mentioned above, 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 by 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 3×3 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 five 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; 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 ration (TMR) at 1000 and 1500 hours. Forage was 33% DM of the diet (Table 1). The experimental diet was substituted for 0, 50, and 100% with corn silage DM in the present study. Diet samples (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[10].

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[11], ADF, and NDF[12]. Cows were milked twice daily, and milk samples (10 ml) were collected four times (twice in the morning and twice in the evening) in the final two days of each period in the milking pallor 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 by zist shimi analyzing kits, Iran. Thyroid hormone was measured by radioimmunoassay procedure. Fecal samples were collected directly from the rectum in the last five days of each experimental period. Fecal samples of DM, ash, CP, ADF, NDF, and acid-insoluble ash (AIA) were collected and analyzed. Acid-insoluble ash was used as an indicator to determine the apparent digestibility of nutrients[12]. Ruminal fluid samples were taken 3 hours after feeding 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 chloric acid to 10 ml of ruminal fluid and stored at -20°C for further analysis.

Table 1. Ingredient and chemical composition of dairy cows' diets

Composition	Diet Canola silage replaced corn silage (TMR DM%) 0%	5% (% of DM)	10%
Corn silage	10	5	0
Canola silage	0	5	10
Alfalfa hay	23	23	23
Corn	20	20	20
Barley	10	10	10
Beat pulp	2	2	2
Soybean meal	6	6	6
Canola meal	8.5	8.5	8.5
Cotton seed meal	8	8	8
Wheat bran	3	3	3
Cotton seed	7	7	7
Fat powder	1.5	1.5	1.5
Mineral and Vitamin supplement	0.3	0.3	0.3
Calcium carbonate	0.5	0.5	0.5
Salt	0.2	0.2	0.2
Chemical			
DM (%)	74.63	69.44	64.93
NEL (Mcal/K)	1.6	1.6	1.61
CP (%) of DM	18	18.3	18.6
RUP (%) of DM	6	6.5	7
RDP (%) of DM	12	11.8	11.6
NFC (%) of DM	41.3	40.6	39.8
NDF (%) of DM	33.2	33.6	33.9
ADF (%) of DM	21	21.6	22.1
EE (%)	5.3	5.4	5.5
Ca (%)	0.9	0.9	0.9
P (%)	0.5	0.5	0.5

Samples of strained ruminal fluid were thawed and centrifuged at 30,000 g for 20 minutes at 4°C and supernatants were analyzed for NH_3 using the Kjeldahl method [12].

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[7-13]. The DMI values between experimental treatments were significantly different (Table 3). The DMI decreased by increasing the substitution level of corn silage with canola silage ($p < 0.05$). *Brassica* forage contains 80-95% water, limiting DMI from the gut fill effect[14-16]. The NDF content in the ruminants' diet is an important chemical predictor of DMI[17]. The DMI has a positive correlation with NDF concentration and limits food intake[10,18]. Therefore, an increase in the NDF content of diets caused by substituting corn silage with canola silage can effectively limit DMI[9,19]. Nutrient apparent digestibility of diets is presented in Table 3. The dietry replacement of corn silage with canola silage did not affect the digestibility of DM and CP. However, the apparent digestibility of NDF ($p < 0.05$) and OM ($p < 0.05$) decreased as a result of canola silage replacement. The findings of a study on feed intake and apparent digestibility of diet supplemented with *Brassica* hay in Lambs showed that hay plus tyfon (*Brassica*) diets exhibited negative associations in apparent digestibility of NDF, and ADF[9]. Likewise, the results of the current study indicated that canola, similar to tyfon decreased the apparent digestibility of NDF.

The current study showed an increase in rumen pH and NH_3-N concentration in the dietry replacement of corn silage with canola silage ($p < 0.05$, Table 3). Chewing activity increases by intake of forage due to its fibers[3]. Chewing time increase with an increase in the proportion of NDF in the diet that stimulates saliva secretion[20]. Saliva contains half the bicarbonate entering the rumen that helps to buffer the acids produced during fermentation[18,19,21].

It is suggested that an increase in diet NDF content by replacing canola silage with corn silage is associated with increased ruminal pH value. The substitution of corn silage with canola silage enhanced the CP content of diets, increasing ruminal NH_3-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 replaced 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[22]. 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[23].

Serum T_3 and T_4 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[24-26].

Table 2. Chemical composition of corn silage and canola silage

Composition	Silage: Corn	Silage: Canola
DM (%)	30.00 ± 1.70[a]	19.50 ± 1.17[b]
OM (%) of DM	94.20 ± 1.20	90.00 ± 1.69
CP (%) of DM	7.17 ± 0.528[a]	16.57 ± 0.67[b]
EE (%)	3.00 ± 0.28	4.80 ± 0.37
NDF (%) of DM	43.60 ± 1.07[a]	50.30 ± 2.29[b]
ADF (%) of DM	29.00 ± 1.40[a]	38.00 ± 1.20[b]

DM: Dry matter; OM: Organic matter, CP: Crude protein, EE: Ether extract, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, [ab] Superscript letters in rows show significant differences in the groups ($p < 0.05$)

Table 3. Feed intake, nutrient digestibility and rumen fermentative parameters of primiparous cows fed diets containing different proportions of canola silage and corn silage

Item	Diet: Corn silage replaced with canola silage (TMR DM percent) 0% (% of DM)	5%	10%	SE
DMI (kg/d)	21.60[a]	20.90[ab]	20.38[b]	
Apparent digestibility (%)				
DM	74.73	73.38	73.05	0.76
OM	72.71[a]	71.37[a]	68.12[b]	1.04
CP	67.42	64.80	63.92	1.26
NDF	59.46[a]	58.53[a]	54.32[b]	1.37
Rumen fluid pH	6.43	6.55	6.56	0.076
Rumen NH_3-N (mg/dl)	20.97	20.99	22.27	2.22

[ab] Superscript letters in rows show significant differences in the groups ($p < 0.05$), DM: Dry matter; OM: Organic matter, CP: Crude protein; NDF: Neutral detergent fiber, SE: Standard error

Table 4. Lactation performance of primiparous cows fed diets containing different proportions of canola silage and corn silage

Composition	Diet: Corn silage replaced by canola silage (TMR DM percent) 0% (% of DM)	5%	10%	SE
Milk, (kg/d)	36.48	35.64	36.04	0.425
4% FCM, (kg/d)	32.16	31.59	32.25	0.593
TS (%)	11.73	11.77	11.81	0.091
CP (%)	3.03[a]	2.87[b]	3.00[a]	0.044
Fat (%)	3.21	3.24	3.29	0.083
Lactose (%)	4.75	4.77	4.77	0.053
SNF (%)	8.52	8.47	8.51	0.08

[ab] 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

Item	Diet			SE
	Corn silage replaced by canola silage (TMR DM percent)			
	0%	50%	100%	
		(% of DM)		
Glucose (mg/dl)	52.55[b]	53.88[ab]	56.77[a]	2.19
BUN (mg/dl)	15.21[b]	17.71[ab]	19.79[a]	1.41
T3 (ng/dl)	124.55[a]	111.27[ab]	99.44[b]	9.4
T4 (µg/dl)	5.76[a]	5.60[a]	4.96[b]	0.23

[ab] Superscript letters in rows show significant differences in the groups ($p < 0.05$), BUN: Blood urea nitrogen, T3: Triiodothyronine, T4: Tetraiodothyronine, SE: Standard error

A study reported a reduction in T_4 concentration and an enhancement in T_3 concentration in lambs due to diets containing rape[27].

Seeds are the major source of glucosinolates in the canola plant[7]. 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 T_4 and T_3 in cows treated with 100% canola silage.

4. Conclusion

The moisture content of corn silage exceeded that of canola silage. The corn silage's CP (crude protein) was lower than canola silage. In contrast, the NDF (neutral detergent fiber) and ADF (acid detergent fiber) content in canola silage surpassed that of corn silage. Corn silage can be used as a substitute for canola silage, and incorporating canola silage into feed can be advantageous in certain aspects. However, the high fiber content in canola silage may limit dry matter intake (DMI). Therefore, further research is needed to determine the appropriate application 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 approved it.

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Ethical considerations

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

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