Peas Can Replace Soybean Meal and Corn Grain in Dairy Cow Diets

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ABSTRACT

The objective of this experiment was to investigate the effect of a partial substitution of soybean meal and corn grain with field peas in dairy cow diets on intake, milk yield and composition, nutrient digestibility, and urinary and fecal N losses. Twenty-four lactating Holstein cows were blocked into 2 groups based on parity, days in milk, and milk yield at the end of a 2-wk covariate period. Cows within group were randomly assigned to 1 of 2 treatments: control and pea diets. Approximately 45% of the corn grain and 78% of the soybean meal in the control diet were replaced with 15% (dry matter basis) field peas in the experimental diet. The peas used in the trial contained 25% crude protein and an estimated 1.98 Mcal of net energy for lactation/kg. The experiment continued for 70 d. Dry matter intake (25.9 and 26.3 kg/d; control and pea diets, respectively), milk yield (35.4 and 35.6 kg/d), 4% fat-corrected milk yield (33.0 and 34.6 kg/d), milk fat (3.54 and 3.76%) and protein (3.00 and 2.99%) content and yields, and milk N efficiency (26 and 24%) were not affected by diet. Concentration of milk urea nitrogen was also not affected by treatment (14.3 and 15.0 mg/dL, respectively). Intake of organic matter and N were not affected by diet, but intake of neutral detergent fiber was lower and that of starch greater with the control diet. Total tract apparent digestibility of starch was lower (92.1 vs. 88.3%, respectively) and that of dry matter and organic matter tended to be lower with the pea compared with the control diet. Urinary and fecal N losses were not different between the 2 diets. Panel evaluation of milk from the 2 diets indicated no differences in the organoleptic characteristics of milk. This experiment demonstrated that field peas could be safely fed to high-producing dairy cows at a 15% inclusion rate, replacing soybean meal and corn grain. At this inclusion rate, no effects on milk yield or milk composition were observed.

Key words: field pea, dairy cow, milk production

INTRODUCTION

The growing dairy industry in the Pacific Northwest, and particularly Idaho, offers an opportunity for expanding the markets for nontraditional, locally grown feedstuffs such as field peas. Field peas (or dry peas, split peas; *Pisum sativum*) have relatively high CP content and contain a significant amount of energy in the form of starch (NRC, 1998; Beyer et al., 2003), which makes them a unique feed that can be substituted for higher-priced protein and energy commodities like soybean meal (SBM), corn, and barley in dairy cow diets. In addition, leguminous seeds are rich in phenolic compounds (Duenãs et al., 2004), which have strong antioxidant activities and may contribute to milk flavor and enhance the healthful characteristics of milk (Besle et al., 2005; Moon et al., 2006). As are all legumes, peas are an excellent rotational crop in cereal production systems. Relevant research, cost, and availability are the key factors that will determine the feasibility of feeding this nontraditional feed to dairy cows. However, studies on feeding peas to dairy cows are very limited, particularly in North America. Contradictory results were reported from Australia (Valentine and Bartsch, 1990) and Canada (Corbett et al., 1995). Milk yield was increased with the inclusion of ground peas replacing barley grain in the former study, whereas partial substitution of barley grain, SBM, and canola meal with peas resulted in decreased milk yield of midlactation cows in the latter study. Another Canadian study (Petit et al., 1997) reported no effect of inclusion of 20% peas in the diet (replacing corn grain and SBM) on DMI and milk yield and composition. Other reports (Khorasani et al., 2001; Vanhatalo et al., 2004; Masoero et al., 2006) also found no effect of feeding peas on milk production or composition, or the results were influenced by differences in DM and CP intake (Froidmont and Bartiaux-Thill, 2004). The effect of feeding peas on milk organoleptic characteristics has not been studied in dairy cows. Thus, there is a need for more research, particularly in the United States, on the effects of inclusion of field peas in the diets of lactating dairy cows on milk yield and composition, digestibility of dietary nutrients, N losses, and organoleptic characteristics of milk.

The hypothesis tested in this experiment was that partial substitution of SBM and corn grain with peas

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in the diet of lactating dairy cows will not affect milk yield and composition. Our specific objectives were to investigate the effect of isonitrogenous and isoenergetic substitution of 15% of dietary DM (as solvent-extracted SBM and steam-rolled corn grain) with field peas in the diet of high-producing Holstein dairy cows on milk yield, composition, and organoleptic characteristics of milk, total tract digestibility, and urinary N losses.

MATERIALS AND METHODS

Animals and Feeding

All procedures involving animals were approved by the University of Idaho Animal Care and Use Committee (Protocol 2005-59). Seventeen multiparous (average parity 3.1, SD = 1.09) and 7 primiparous Holstein cows were blocked based on parity, DIM, and milk yield during a 2-wk covariate period. Average DIM, BW, and milk yield of the cows before initiation of the experiment were (mean $\pm$ SD): 104 $\pm$ 39.3 d, 665 $\pm$ 69.2 kg, and 39 $\pm$ 5.9 kg/d, respectively. Cows were fed the control diet (Table 1) during the covariate period and randomly assigned (within block) to the control or pea diets for the remaining of the trial. The 2 diets were fed for 10 wk; the first 2 wk were allowed for adaptation and measurements were taken during the following 8 wk. Cows did not receive recombinant bST during the trial.

The diets were formulated (NRC, 2001) to provide similar amounts of NE_L, CP, RDP, and RUP and meet or exceed the nutrient requirements (at 25 kg/d DMI) of a Holstein cow yielding 35 kg of milk/d with 3.7% milk fat and 3.0% true protein. Approximately 45% of the corn grain and 78% of the SBM in the control diet were replaced with 15% (DM basis) field peas in the experimental diet. The peas used in the trial (Colombia Grain, Colfax, WA) were graded US No. 1 feed peas according to the US Standards for Feed Peas and contained 25% CP and estimated 1.98 Mcal of NE_L/kg (Table 1). The proportions of the other feed ingredients were similar between the 2 diets. Peas were coarsely ground through a hammer mill (New Holland, model 200, New Holland, PA) before feeding. The geometrical mean diameter of the ground peas was 1.44 mm (sieve shaker AS200, Retsch GmbH, Haan, Germany). Diets were fed as TMR at 0700 and 1700 h. Diets were mixed once daily, before the 0700 h feeding and were fed ad libitum to about 5 to 10% orts. Cows had free access to fresh water and salt blocks throughout the duration of the trial.

Sampling and Analyses

Individual forages, TMR, and orts were sampled daily, and concentrate feeds were sampled weekly.

Table 1. Ingredient and chemical composition of the diets fed in the trial

Ingredient	Diet (% DM basis)	
	Control	Pea
Alfalfa hay ¹	28.0	28.0
Corn silage ²	17.7	17.7
Cottonseed, whole with lint	7.0	7.0
Corn grain, steam-rolled	19.8	10.8
Soybean meal, solvent, 48% CP	7.4	1.6
Peas ³	—	15.0
Dry distiller grain with solubles	6.0	6.0
Barley grain, steam-rolled	12.0	11.8
Mineral/vitamin mix ⁴	2.1	2.1
Composition ⁵		
CP	15.7	15.5
RDP, % of CP	67.1	67.7
RUP, % of CP	32.9	32.3
NE _L , Mcal/kg DM	1.56	1.55
NDF	35.0	38.2
Starch	18.8	15.8
NFC	42.7	43.5

¹Alfalfa hay was 84% DM and (DM basis): 18.5% CP, and 43.4% NDF.

²Corn silage was 30% DM and (DM basis): 6.0% CP, and 48.2% NDF.

³Peas were US No. 1 Feed peas (Federal Grain Inspection Service, Moscow, ID) and contained 11% moisture and (DM basis): CP, 25.3% (83% soluble); starch, 48.0%; NDF, 9.2%; ADF, 5.1%; lignin, 0.3%; fat, 1.0%; ash, 2.1%; Ca, 0.08%; P, 0.41%; Mg, 0.12%; K, 0.92%; Na, 0.002%; S, 0.18%; Fe, 63 mg/kg; Zn, 43 mg/kg; Cu, 9 mg/kg; Mn, 11 mg/kg and estimated NE_L, 1.98 Mcal /kg; TDN 86%; and NFC, 67% (DairyOne, Ithaca, NY). Lysine and methionine concentrations were 6.48 and 0.88% of CP, respectively (Michigan State University, East Lansing).

⁴Mineral-vitamin premix (Land O'Lakes, Saint Paul, MN) composition (as-is basis): Ca, 15.8%; P, 4.7%; Mg, 5.2%; Cl, 2.8%; K, 0.3%; Na, 6.5%; S, 0.3%; Co, 4.36 mg/kg; Cu, 928 mg/kg; I, 42 mg/kg; Fe, 189 mg/kg; Mn, 4.7 mg/kg; Se, 15.7 mg/kg; Zn, 4,649 mg/kg; vitamin A, 258,000 IU/kg; vitamin D, 45,900 IU/kg; and vitamin E, 1,839 IU/kg.

⁵RDP, RUP, NE_L, and NFC were estimated by NRC (2001); CP, starch, and forage composition were analyzed by Cumberland Valley Analytical Services Inc. (Maugansville, MD).

Samples were composited and analyzed for DM (65°C in a forced-air oven, dried to a constant weight) and ash/OM, N, NDF, and starch by Cumberland Valley Analytical Services, Inc. (Maugansville, MD). Composite TMR samples were analyzed for acid-insoluble ash (AIA; Van Keulen and Young, 1977).

Fecal grab samples (approximately 400 g/sample) were collected from each cow from the ground when fresh or from the rectum 3 times at 12-h intervals over the course of 2 d at the end of the covariate period and experimental wk 3, 6, and 9. Fecal samples were dried at 65°C in a forced-air oven to constant weight, ground through a 1-mm sieve, and composited per animal and period on a DM basis. Composite samples were analyzed for ash/OM, N, NDF, and starch as indicated earlier, and AIA. Apparent total tract digestibility was

estimated using AIA as an intrinsic digestibility marker (Foley et al., 2006).

Spot urine samples (approximately 300 mL/sample) were collected by massaging the vulva at the same times as the fecal samples were collected. Urine samples were acidified to a pH <3.0 by addition of 2 M H₂SO₄ and aliquots were diluted with distilled water. Diluted samples were then frozen at -20°C and later analyzed (1:20 dilution) for creatinine and urea (Broderick et al., 2007), allantoin (Foley et al., 2006), and uric acid (commercial kit; Teco Diagnostics, Anaheim, CA) and N (1:10 dilution; Foley et al., 2006).

Daily milk yields were recorded during the entire experiment. Milk samples were collected from the milking parlor twice daily on the last day of the covariate period and during wk 2, 4, 6, 8, and 10 of the experimental period. Milk samples were analyzed for fat, true protein, lactose, SNF, and MUN (Rocky Mountain DHIA, Logan, Utah).

In wk 6 of the experimental period, a composite milk sample (36 kg) from each treatment was collected into stainless steel milk cans, pasteurized, and assessed for organoleptic characteristics by a trained consumer panel at Washington State University (Pullman, WA). Raw milk was pasteurized at 72°C for 30 s using a continuous plate heat exchanger (Processing Machinery & Supply Co., Philadelphia, PA). Forty untrained panelists evaluated 4 milk samples per treatment in private booths using Compusense Five software (release 4.6, Guelph, Canada). A balanced reference duotrio test was used to determine the consumers' ability to distinguish differences between control samples. Panelists were then served 2 sets of samples in which the reference was either milk from the control diet or pea diet cows. In every set, one sample was identical to the reference and one was different. After being presented with a sample set, panelists were asked to identify the sample that tasted the same as the reference. Control and treatment serving was randomized, and samples were blind-coded using random 3-digit code numbers.

Statistical Analysis

Nutrient intake (except DMI), digestibility, and urine data were analyzed using analysis of covariance and the MIXED procedure of SAS (2003; SAS Inst., Inc., Cary, NC). The model used was

$$Y_{ijk} = \mu + \beta_i + \tau_j + \beta\tau_{ij} + c_K + e_{ijk} \quad [1]$$

where μ is the overall mean, β_i is the block effect, τ_j is the treatment effect, $\beta\tau_{ij}$ is the block $\times$ treatment interaction, c_K is the covariate, with the error term e_{ijk}

assumed to be normally distributed with mean = 0 and constant variance. Blocks and block $\times$ treatment interaction were random effects, whereas all others were fixed.

Dry matter intake and milk production and composition data were analyzed as repeated measures. The model used was

$$Y_{ijkl} = \mu + \beta_i + \tau_j + \beta\tau_{ij} + c_K + D_l + \tau D_{jl} + e_{ijkl}, \quad [2]$$

where μ is the overall mean, β_i is the block effect, τ_j is the treatment effect, $\beta\tau_{ij}$ is the block $\times$ treatment interaction, c_K is the covariate, D_l is the time effect, τD_{jl} is the treatment $\times$ time interaction, with the error term e_{ijkl} assumed to be normally distributed with mean = 0 and constant variance. Blocks and block $\times$ treatment interaction were random effects, whereas all others were fixed.

Statistical difference was declared at $P \leq 0.05$. Milk organoleptic characteristics data were analyzed using ANOVA.

RESULTS AND DISCUSSION

The 2 diets had similar concentrations of CP, RDP, RUP, NE_L, and NFC, but the pea diet had slightly greater NDF and lower starch content (Table 1), which reflects the difference in starch content between corn grain and peas. The diets were originally formulated to contain 18% CP, but the source of the alfalfa hay changed immediately before the initiation of the trial and the diets fed during the trial had significantly lower CP content than initially targeted. The peas used in this trial contained 25.3% CP and 48.0% starch. Pea cultivars may vary significantly in their composition, particularly protein and starch (Reichert and MacKenzie, 1982; Wang and Daun, 2004; Tzitzikas et al., 2006). Peas contain high proportions of lysine (7.4%) and arginine in their protein and have relatively low proportions of methionine, cystine, and tryptophan (Lalles, 1993). On a CP basis, the lysine and methionine content of the peas used in the current trial was 6.48 and 0.88%, respectively (see Table 1 footnote). Thus, the pea diet provided slightly more lysine (6.43 vs. 6.27%) and less methionine (1.78 vs. 1.89%), as a proportion of MP, compared the control diet (NRC, 2001). Apparently, both diets in this trial supplied less lysine and methionine than recommended by NRC (2001). If peas are replacing feeds with higher methionine contents (such as corn grain and SBM) in the diets of high-producing dairy cows, provision of additional methionine may be necessary.

Dry matter intake and milk yield were not different ($P = 0.67$ and 0.79 , respectively) between the 2 diets

Table 2. Effect of inclusion of field peas in the diet on DMI, milk yield and composition, and BW change in lactating dairy cows (least squares means; $n = 1,608$, DMI and milk yield; $n = 120$, milk composition)

Item	Diet		SE	$P =^1$
	Control	Pea		
DMI, kg/d	25.9	26.3	0.67	0.67
Milk yield, kg/d	35.4	35.6	0.85	0.79
4% FCM, kg/d	33.0	34.6	1.38	0.41
Milk yield/DMI	1.47	1.38	0.044	0.18
Milk fat, %	3.54	3.76	0.124	0.15
Milk fat, kg/d	1.25	1.27	0.058	0.81
Milk true protein, %	3.00	2.99	0.046	0.85
Milk true protein, kg/d	1.05	1.02	0.039	0.53
Milk lactose, %	4.84	4.86	0.026	0.43
Milk lactose, kg/d	1.67	1.72	0.064	0.56
Milk SNF, %	8.76	8.79	0.050	0.63
Milk SNF, kg/d	4.01	3.96	0.044	0.37
MUN, mg/dL	14.3	15.0	0.35	0.24
BW gain, kg/d	0.47	0.40	0.103	0.58

¹Main effect of diet.

(Table 2). Fat-corrected milk yield and concentration and yield of milk components were also not affected ($P = 0.15$ to 0.85 , respectively) by inclusion of 15% peas in the diet. Milk fat percentage was numerically greater (by 6%; $P = 0.15$) with the pea diet compared with the control diet. Milk urea N levels were also not different ($P = 0.24$) between the diets. Cows on both diets gained similar BW ($P = 0.58$) during the trial.

Data on the effect of field peas on productivity of dairy cows are scarce. An Australian study with relatively low-producing dairy cows (milk yield of 18 to 20 kg/d) reported a 0.9 kg/d increase in milk yield with the inclusion of 3.5 kg/d of ground peas replacing barley grain (Valentine and Bartsch, 1990). Milk fat content was not affected by the treatments, but milk protein concentration and yield were increased by the pea compared with the control, barley diet. The basal diet in the Australian study had rather low CP content (8 to 9%) and the response to inclusion of peas (as well as other leguminous seeds) was apparently due to an increase in dietary protein supply. A Canadian study with dairy cows producing around 30 kg of milk/d, reported that isonitrogenous and isoenergetic substitution of barley grain, SBM, and canola meal with field peas (in a pelleted supplement) resulted in decreased milk yield (by 10%) of midlactation cows (Corbett et al., 1995). Milk production of the same cows in early and late lactation was not affected by the substitution. The authors reported increased milk fat percentage with the pea diet in early lactation cows; thus, FCM was not different between the 2 diets. Similar to the present experiment, Petit et al. (1997) replaced 20% of dietary DM (as corn grain and SBM) with ground or extruded peas and reported no effect of diet on DMI and milk

Table 3. Effect of inclusion of field peas in the diet on intake and apparent total tract digestibility of nutrients in lactating dairy cows (least squares means; $n = 24$)

Item	Diet		SE	$P =^1$
	Control	Pea		
Intake, kg/d				
OM	23.5	24.3	0.65	0.43
N	0.642	0.656	0.0179	0.58
NDF	9.0	10.1	0.26	0.01
Starch	4.8	4.2	0.13	0.004
Apparent digestibility, %				
DM	74.5	72.5	0.97	0.07
OM	76.0	74.0	1.00	0.07
N	73.6	72.7	0.87	0.48
NDF	61.4	61.1	1.46	0.88
Starch	92.1	88.3	0.82	0.004

¹Main effect of diet.

yield and composition. Milk urea N concentration appeared to be increased by the pea diets, as was BUN. In another Canadian study, an increased proportion of peas in the diet (from 10 to 30%, replacing SBM and barley grain) did not affect milk yield and composition, except that there was a quadratic increase in milk protein concentration compared with the control diet (Khorasani et al., 2001). Compared with SBM, inclusion of 14% peas (DM basis) in the diet decreased milk yield and concentration of MUN in Holstein dairy cows producing 36 kg of milk/d, but these results were apparently influenced by reduced DM and CP intake with the pea diet (Froidmont and Bartiaux-Thill, 2004). Masoero et al. (2006) substituted unprocessed or extruded peas for SBM at 12% of dietary DM and found no differences in DMI and milk yield and composition among diets. Replacing a portion of a barley-based concentrate with dry or ensiled peas in the diet of Finnish Ayrshire cows produced no effect in milk yield and composition (Vanhatalo et al., 2004). Overall, published reports and data from this experiment suggest that inclusion of 15 to 20% peas in dairy cow diets does not have a significant impact on milk yield and composition.

Intake of OM and N was not different ($P = 0.43$ and 0.58 , respectively) between the 2 diets (Table 3). Intake of NDF was lower ($P = 0.01$) and that of starch was greater ($P = 0.004$) for the control compared with the pea diet. Total tract apparent digestibility of N and NDF were not affected ($P = 0.48$ and 0.88 , respectively) by diet, but digestibility of starch was lower ($P = 0.004$) with the pea diet compared with the control. Digestibility of DM and OM also tended to be lower ($P = 0.07$) with the pea diet. Because digestibility of NDF and N were similar between the diets, it was the lower digestibility of dietary starch that caused the numerical decrease in DM digestibility of the pea diet. The greater

Table 4. Effect of inclusion of field peas in the diet on N utilization in lactating dairy cows (least squares means; n = 24)

Item	Diet		SE	<i>P</i> = ¹
	Control	Pea		
N intake, g/d	642	656	17.9	0.58
Milk protein N, ² g/d	166	160	5.6	0.40
Milk protein N/N intake	0.26	0.24	0.009	0.23
Fecal N, g/d	172	180	6.7	0.33
Fecal N/N intake	0.26	0.27	0.009	0.48
Urinary N, g/d	238	256	10.9	0.19
Urinary N/N intake	0.37	0.39	0.017	0.39
Urea N, g/d	151	151	5.26	0.92
Proportion of total N	0.64	0.60	0.020	0.22
Proportion of N intake	0.24	0.23	0.008	0.76
Allantoin, mmol/d	443	468	26.3	0.41
Uric acid, mmol/d	63	66	5.9	0.69
Allantoin and uric acid, mmol/d	508	533	29.6	0.45

¹Main effect of diet.²Milk protein N yield = milk true protein yield ÷ 6.38.

starch intake with the control diet did not have an effect on fiber digestibility.

In the study by Petit et al. (1997), apparent total tract digestibility of DM and N was greater for the extruded peas and appeared to be increased for the ground pea diet compared with the control. Digestibility of dietary fiber was similar among the diets. Khorasani et al. (2001) reported a quadratic reduction in apparent total tract digestibility of fiber (NDF and ADF) with an increasing proportion of peas in the diet. Compared with SBM, inclusion of 14% peas (dietary DM basis) resulted in decreased N digestibility but increased crude fiber digestibility in the study of Froidmont and Bartiaux-Thill (2004). In contrast to results from the present experiment, Vanhatalo et al. (2004) reported increased ruminal and total tract apparent digestibility of OM when peas replaced a portion of a barley-based concentrate in the diet of Finnish Ayrshire cows. In beef cattle, increased supplementation of field peas to a grass hay diet linearly increased apparent total tract digestibility of dietary N, but had no effect on ruminal or total tract OM digestibility (Reed et al., 2004). In summary, the effect of peas on dietary nutrient digestibility is inconsistent. Composition of the basal diet, inclusion rate, level of intake and production, and pea cultivar (which is rarely reported) are most likely among the factors responsible for this variable effect.

The efficiency of utilization of dietary N for milk protein synthesis was similar (*P* = 0.23) between the 2 diets (Table 4). Excretion of N with feces and urine were also not different (*P* = 0.33 and 0.19, respectively) between the control and pea diets. Overall excretion of urinary urea and as a proportion of N intake were not affected (*P* = 0.92 and 0.76, respectively) by the inclusion of peas in the diet. In contrast to these results,

Petit et al. (1997) reported increased urinary N losses when peas (ground or extruded) replaced 20% of dietary DM. Excretion of allantoin and uric acid, as indicators of ruminal synthesis and postruminal absorption of microbial protein, was similar (*P* = 0.41 to 0.69) between the 2 diets, which suggests similar outflow of microbial protein from the rumen.

Panel evaluation of milk from the 2 diets indicated no differences in the organoleptic characteristics of milk (*P* = 0.71). Regardless of whether the experimental or the control sample was presented as the reference, panelists guessed right or wrong about 50% of the time; 19 correct answers and 21 wrong answers for both orders of presentation. Thus, the inclusion of peas in the diet did not appear to affect the organoleptic characteristics of milk. To our knowledge, this is the first report on the effect of peas on organoleptic characteristics of bovine milk. An extension publication from Tulare County, California, suggested that green peas cause little or no feed flavor in goat milk (TriCounty Goat Newsletter; University of California Cooperative Extension; available from <http://www.saanendoah.com/milkqf.html>). Legume seeds are rich in plant secondary metabolites (Troszynska et al., 1997; Shahidi et al., 2001; Duenãs et al., 2004), which are known to influence the taste and preservation of food and to improve human health (Poulet et al., 2002). The seed coat and the cotyledon of peas contain high concentrations of flavonoid (quercetin, luteolin, and apigenin) and nonflavonoid (hydroxybenzoic and hydroxycinnamic acids) phenolic compounds (Duenãs et al., 2004). These compounds have strong antioxidant activities, may contribute to milk flavor, and are characterized as health-promoting and cancer-preventive agents (Besle et al., 2005; Duenãs et al., 2006; Moon et al., 2006). The diet can have a powerful effect on milk composition. In the study by Besle et al. (2005), concentration of phenolic compounds in milk varied from 4.0 to 10.8 mg/L depending on the amount of concentrate and the type of forage in the diet of dairy cows. Phenolic compounds were not analyzed in milk samples from this experiment, but future investigation of the effect of peas and other leguminous seeds on milk phenolic, particularly flavonoid, concentration may be warranted.

CONCLUSIONS

This experiment demonstrated that ground field peas could be safely fed to high-producing dairy cows at a 15% inclusion rate, replacing SBM and corn grain. At this substitution rate, no effects on DMI, milk yield, or milk composition were observed. Concentration of methionine in pea protein is lower than in SBM and cereal grains and provision of supplemental methionine

may be necessary when peas are fed to high-producing dairy cows. Total tract apparent digestibility of starch was decreased with the pea diet, which resulted in a slight decrease in dietary DM and OM digestibility, compared with the control diet. Urinary and fecal N losses were not affected by diet. Panel evaluation of milk from the experimental cows indicated no differences in the organoleptic characteristics of milk between the 2 diets.

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