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Field pea (*Pisum sativum*) inclusion in corn-based lamb finishing diets

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Abstract

Two hundred crossbred lambs were used to determine energy value and optimum inclusion level of field pea (*Pisum sativum*) in corn-based diets. In experiment one (Exp. 1), 100 crossbred lambs (33.9 ± 1.3 kg initial BW) were blocked by weight and sex (two blocks of ewe lambs per treatment; three blocks of ram lambs per treatment) and fed for 89 days. In experiment two (Exp. 2), 100 crossbred ram lambs (39.1 ± 0.2 kg initial BW) were blocked by weight (five pens per treatment) and fed for 63 days. Treatments for each experiment were similar; field pea replaced corn at 0, 150, 300, or 450 g/kg of the diet (DM basis). Diets contained 750 g/kg corn and/or field pea, 100 g/kg alfalfa hay, 50 g/kg concentrated separator byproduct (CSB), 60 g/kg soybean meal (SBM), and 40 g/kg supplement. In Exp. 2, a fifth treatment was added to evaluate if field pea can replace corn and SBM in high-grain diets (450 − SBM); this diet consisted of 450 g/kg field pea, 350 g/kg corn, 100 g/kg alfalfa, 50 g/kg CSB, and 50 g/kg supplement. Diets contained 28 mg/kg lasalocid and a minimum 149.6 g/kg CP, 7.6 g/kg Ca, 4.4 g/kg P, and 12.2 g/kg K. Only carcass data from ram lambs were recorded. Data for each experiment were analyzed separately with GLM procedure of SAS and linear, quadratic, and cubic effects of field pea were determined. In Exp. 1, a cubic ($P = 0.02$) response for DMI occurred, greater intake of 150 g/kg than 300 g/kg diet. No other performance measurements were affected by treatment. In Exp. 2, lambs fed 450 − SBM tended to be more efficient ($P = 0.10$) than lambs fed 450 + SBM. Carcass characteristics were not affected by treatment ($P > 0.10$). Based on lamb performance (Exp. 1) there was a tendency for a linear ($P = 0.10$) increase in dietary net energy. In Exp. 2, no difference in dietary net energy occurred with increasing level of field pea. Dietary net energy was greater for 450 − SBM compared with 450 + SBM. Average calculated NE_m and NE_g for field pea were 2.75 and 2.02 Mcal/kg, which was 14% greater than corn. Field pea is a suitable replacement for corn in lamb finishing diets and is at least equal in energy density to corn.

Keywords: Field pea; Lamb; Finishing; Energy; Protein

1. Introduction

Field pea (*Pisum sativum*) availability as a feedstuff for livestock has increased as the area planted to field pea in the northern Great Plains of North America has increased. Field pea is grown primarily for human consumption; however, surplus grain or grain that does not meet human food grade specifications is available for use as a livestock feed. Field pea is a legume grain high in crude protein (CP; 217.3 g/kg; Table 1), which is highly rumen degradable (RDP; 780 g/kg of CP; NRC, 1989). The starch content is 540 g/kg (McLean et al., 1974) and reported net energy for gain (NE_g) is 1.48 Mcal/kg (NRC, 1989).

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Table 1
Analyzed nutrient composition of field pea (*Pisum sativum*) in Exps. 1 and 2

Component	Field pea (g/kg DM basis)	
	Exp. 1	Exp. 2
Crude protein	227.6	206.9
Starch	412.9	470.7
NDF	160.3	157.3
ADF	84.9	57.5
Ca	1.3	1.2
P	6.3	6.0

Table 2
Ration composition (g/kg ration) and nutrient concentration of lamb finishing diets in Exp. 1 (DM basis)

Item	Field pea in diet (g/kg)			
	0	150	300	450
Dry-rolled corn	750	600	450	300
Dry-rolled field pea	–	150	300	450
Alfalfa hay	100	100	100	100
CSB[a]	50	50	50	50
Soybean meal	60	60	60	60
Feather meal	8.0	8.0	8.0	8.0
Blood meal	2.0	2.0	2.0	2.0
Fine-ground corn	4.1	4.5	4.8	5.2
Limestone	12.0	11.6	11.3	10.9
Ammonium chloride	5.0	5.0	5.0	5.0
Urea	1.9	1.9	1.9	1.9
Salt	1.8	1.8	1.8	1.8
Mineral/vitamin premix[b]	5.0	5.0	5.0	5.0
Lasalocid premix[c]	0.2	0.2	0.2	0.2
Protein				
Crude[d]	158.9	187.1	197.2	216.4
Rumen degradable[e]	96.8	116.8	136.7	156.7
Rumen undegradable[e]	62.1	61.3	60.5	59.7
Metabolizable[f]	79.5	80.9	82.3	83.7
Ca[d]	11.5	10.7	10.0	9.2
P[d]	4.4	4.8	5.2	5.6

[a] Concentrated separator byproduct; desugared molasses.
[b] Contained 140 g/kg salt, 120 g/kg Ca, 100 g/kg P, 1.5 g/kg Mg, 0.5 g/kg K, 2750 mg/kg Fe, 2700 mg/kg Zn, 2450 mg/kg Mn, 100 mg/kg I, 50 mg/kg Se, 22 mg/kg Co, 660,000 IU/kg Vitamin A, 66,000 IU/kg Vitamin D, and 1320 IU/kg Vitamin E.
[c] Contained 149.9 g lasalocid/kg premix.
[d] Analyzed values.
[e] Calculated using tabular values.
[f] Calculated using methods of Burroughs et al. (1974).

Previous research has focused on using field pea as a protein source in diets for non-ruminants (Gatel, 1994) and dairy cattle (Corbett et al., 1995). Field pea has been shown to be an effective replacement for soybean meal (SBM; Corbett et al., 1995; Khorasani et al., 1992) and SBM and canola meal combinations (Petit et al., 1997) in diets fed to lactating dairy cows. Optimum inclusion level of field pea in non-ruminant diets have been suggested to be 250–333 g/kg (Castanon and Perez-Lanzac, 1990; Perez-Maldonado et al., 1999; Farrell et al., 1999).

Energy values for field pea fed in a growing ration to beef cattle suggest that field pea has a NE_g of 1.57 Mcal/kg (calculated from Bock et al., 2000). The energy value of field pea in high-grain diets has not been examined. Thus, our objective was to evaluate the apparent energy content relative to corn and optimum inclusion level of field pea in corn-based diets fed to finishing lambs.

2. Materials and methods

2.1. Experiment one (Exp. 1)

One hundred Columbia–Hampshire crossbred lambs (33.9 ± 1.3 kg initial body weight (BW)) were fed for 89 days to evaluate the energy value and optimum inclusion level of field peas in diets fed to lambs in a randomized complete block experiment. Lambs were blocked by weight and sex, and allotted randomly to dietary treatment (five lambs per pen). There were five blocks per treatment; two blocks of ewe lambs and three blocks of ram lambs. Lambs had free choice access to a corn–SBM-based creep and alfalfa hay prior to the start of the experiment.

Four dietary treatments were fed where dry-rolled field pea (cv. Profi; Table 1) replaced dry-rolled corn (DRC) at 0, 150, 300, or 450 g/kg of the diet on a dry matter (DM) basis. Diets contained 750 g/kg DRC or field pea, 100 g/kg alfalfa hay, 50 g/kg concentrated separator byproduct (CSB), and 100 g/kg supplement (Table 2). Field pea was processed through a roller mill so that most of the peas were cracked in half. Diets were formulated to contain a minimum 150 g/kg CP, 7.0 g/kg Ca, 3.6 g/kg P, 12.2 g/kg K, 1.74 Ca:P, and 28 mg/kg lasalocid. Lambs were fed a 15% (DM basis) roughage diet for the first 7 days of the experiment and a 10% (DM basis) roughage diet for the remainder of the experiment. All pens had a source of fresh water, an outdoor concrete run, sunflower hull bedding, and were cleaned weekly.

Diets were fed in bunk feeders and feed offered was adjusted daily. Feedstuff samples were taken weekly and analyzed for CP, Ca, P (AOAC, 1997), NDF, ADF (Goering and Van Soest, 1970) and starch (Herrera-Saldana and Huber, 1989). Refused feed was measured weekly, sub-sampled, and dried at 55 °C for 48 h. Initial and final weights were an average of two consecutive day weights; interim weights were single day weights taken every 21 days. On weighing days, lambs were weighed in the morning prior to feeding. Data from all lambs were used in performance evaluation; however, only carcass data from ram lambs were collected and evaluated.

2.2. Experiment two (Exp. 2)

One hundred Columbia–Hampshire cross ram lambs (39.1 ± 0.2 kg initial BW) were used in a randomized complete block design experiment. They were blocked by weight and allotted randomly to dietary treatment (five pens per treatment and four lambs per pen). Lambs were fed for 63 days to evaluate the energy value and optimal inclusion level of field pea in lamb finishing diets.

Dietary ingredients and nutrient composition (Table 3) were similar to Exp. 1. An additional dietary treatment was added to evaluate a more practical diet where protein was not overfed. This diet contained 450 g/kg dry-rolled field pea, replacing DRC and all the SBM (450 − SBM). The nutrient content of field pea used in Exp. 2 is located in Table 1. Housing, diet

Table 3
Ration composition (g/kg of ration) and nutrient concentration of lamb finishing diets in Exp. 2 (DM basis)

Item	Field pea in diet (g/kg)				
	0	150	300	450 + SBM	450 − SBM
Dry-rolled corn	750	600	450	300	350
Dry-rolled field pea	–	150	300	450	450
Alfalfa hay	100	100	100	100	100
CSB[a]	50	50	50	50	50
Soybean meal	60	60	60	60	–
Feather meal	8.0	8.0	8.0	8.0	8.0
Blood meal	2.0	2.0	2.0	2.0	2.0
Fine-ground corn	–	0.4	0.7	1.1	8.6
Limestone	11.6	11.2	10.9	10.5	13.0
Ammonium chloride	5.0	5.0	5.0	5.0	5.0
Urea	1.9	1.9	1.9	1.9	1.9
Salt	2.8	2.8	2.8	2.8	2.8
Mineral/vitamin premix[b]	8.5	8.5	8.5	8.5	8.5
Lasalocid premix[c]	0.2	0.2	0.2	0.2	0.2
Protein					
Crude[d]	149.6	166.4	182.9	199.5	177.2
Rumen degradable[e]	92.7	110.5	128.1	145.8	129.5
Rumen undegradable[e]	56.9	55.9	54.8	53.7	47.7
Metabolizable[f]	74.5	75.8	77.1	78.4	72.5
Ca[d]	7.6	7.6	7.6	7.6	7.5
P[d]	5.6	5.7	5.8	5.9	5.6

[a] Concentrated separator byproduct; desugared molasses.
[b] Contained 130 g/kg salt, 100 g/kg Ca, 100 g/kg P, 2 g/kg K, 1.5 g/kg Mg, 2750 mg/kg Fe, 2690 mg/kg Zn, 1200 mg/kg Mn, 100 mg/kg I, 35 mg/kg Se, 20 mg/kg Co, 110,000 IU/kg Vitamin A, 27,500 IU/kg Vitamin D, and 660 IU/kg Vitamin E.
[c] Contained 149.9 g lasalocid/kg premix.
[d] Analyzed values.
[e] Calculated using tabular values.
[f] Calculated using methods of Burroughs et al. (1974).

preparation, diet delivery, and lamb weighing were similar to Exp. 1. Hot carcass weight and marbling were not recorded due to an oversight at the slaughter facility.

2.3. Calculations, measurements, and statistics

Dry matter intake was calculated by subtracting refused feed from feed offered (DM basis). Calculation of DMI relative to BW was calculated by dividing the overall mean DMI by the mean of initial and final BW. Average daily gain was calculated by subtracting initial weight from final weight and dividing by days on feed. Dietary metabolizable protein was calculated using the methods of Burroughs et al. (1974) with the assumptions that 8.5% of total digestible nutrients (TDN) was converted to bacterial crude protein, 80% of the protein bypassing the rumen (rumen undegradable protein) was digestible, 80% of microbial protein was true protein, and 80% of true microbial protein was digested in the small intestine. Rumen degradable protein, expressed relative to crude protein, were based on tabular values; in Exp. 1 were 447 g/kg for com, 840 g/kg for alfalfa hay, 650 g/kg for SBM, 300 g/kg for feather meal, 250 g/kg for blood meal (NRC, 1996), 780 g/kg for field pea (NRC, 1989), and 1000 g/kg for CSB. In Exp. 2, alfalfa rumen degradable protein was changed to 820 g/kg of CP because of lower quality alfalfa hay used in Exp. 2 compared with Exp. 1 (210.4 g/kg versus 170.1 g/kg CP, and 506.1 g/kg versus 614.7 g/kg neutral detergent fiber for Exp. 1 versus Exp. 2, respectively).

Dietary net energy was calculated using iterations based on tabular energy values and measured lamb performance (DMI and ADG) following the system described by Larson et al. (1993) with modifications made with respect to species (NRC, 1985). Lamb net energy requirements (Mcal per day) for maintenance (NE_mR) and gain (NE_gR) were calculated using equations: $NE_mR = 0.056 \times BW^{0.75}$ and $NE_gR = 0.276 \times BW^{0.75} \times ADG$ (NRC, 1985), where average BW (kg) and ADG (kg per day) during the experiment were used.

After carcasses had been chilled for 24 h, they were split between the 12th and 13th rib in order to measure ribeye area, fat thickness, bodywall thickness, and marbling. Ribeye area, fat thickness, and bodywall thickness were traced on 14 cm × 20 cm × 0.008 cm matte acetate paper at the slaughter facility for later analysis. Fat thickness over the 12th rib was measured at the center of the ribeye and bodywall thickness was measured 13 cm from the backbone. The same individual assessed marbling, flank streaking, and conformation score for Exps. 1 and 2. USDA quality grade was calculated as the average of flank streaking and conformation scores (Boggs and Merkel, 1993). USDA yield grade was calculated using the following equation: Yield grade $= 0.4 + 25.4 \times$ 12th rib fat thickness in cm (Boggs and Merkel, 1993).

Performance and carcass data were analyzed with GLM procedure of SAS (SAS 6.12; SAS Institute, Cary, NC) as a randomized complete block design; pen was used as experimental unit. Lambs were blocked by sex (Exp. 1) and weight (Exps. 1 and 2). The model included treatment and block. Means of treatments 0, 150, 300, and 450 g/kg field pea were analyzed with linear, quadratic, and cubic contrasts. In Exp. 2, a pre-planned contrast was used to compare the 450 + SBM with the 450 − SBM treatments.

3. Results

3.1. Experiment one

Treatment did not affect initial or final weight ($P > 0.13$; Table 4). There was a cubic response ($P = 0.02$) in DMI where DMI decreased from the 150 to the 300 g/kg field pea diet. However, when intake is expressed relative to mean BW, no differences were detected ($P > 0.14$). Gain and gain:feed were not affected by treatment ($P > 0.21$). No carcass characteristics were affected by treatment ($P > 0.18$).

Apparent dietary net energy (Table 4) for maintenance (NE_m) and gain (NE_g) were calculated from lamb performance. There was a tendency for a linear ($P = 0.10$) increase in apparent dietary NE_m and NE_g as level of field pea increased.

3.2. Experiment two

Body weight, DM intake, gain, and feed efficiency were not affected by field pea ($P > 0.14$; Table 5). Soybean meal did not affect ($P > 0.14$) gain or feed intake in lambs fed 450 g/kg field peas. However, lambs fed 450 g/kg field pea without SBM

Table 4
Effect of treatment on lamb performance, carcass characteristics, and apparent dietary energy in Exp. 1

Item	Field pea in diet (g/kg DM basis)				S.E.M.[a]	Contrast		
	0	150	300	450		Linear	Quadratic	Cubic
Weight (kg)								
Initial	33.5	34.3	32.8	35.0	1.3	0.61[b]	0.56	0.33
Final	61.3	64.3	62.7	65.7	1.6	0.14	0.99	0.24
Dry matter intake								
kg per day	1.59	1.66	1.55	1.62	0.03	0.97	0.99	0.02
g/kg of BW	33.5	33.6	32.6	32.3	0.7	0.15	0.81	0.51
ADG (g)	311	337	335	343	18	0.25	0.63	0.65
Gain:feed (g/kg)	197	205	218	213	10	0.22	0.52	0.63
Carcass characteristics								
Hot carcass weight (kg)	32.2	32.9	31.4	34.3	1.4	0.47	0.44	0.32
Ribeye area (cm^2)	17.6	17.8	16.8	17.2	0.5	0.35	0.83	0.29
Fat thickness (cm)	0.56	0.46	0.52	0.49	0.08	0.66	0.62	0.51
Bodywall (cm)	2.22	2.13	1.98	2.06	0.23	0.56	0.74	0.78
USDA yield grade	2.62	2.21	2.46	2.33	0.32	0.68	0.68	0.50
Dress (%)	51.3	49.9	49.8	50.6	0.7	0.54	0.18	0.92
Marbling[c]	379	392	386	383	13	0.90	0.58	0.70
USDA quality grade[d]	11.70	11.18	11.20	11.57	0.27	0.76	0.88	0.27
Apparent dietary net energy (Mcal/kg)								
Maintenance	2.08	2.16	2.22	2.25	0.07	0.10	0.73	0.95
Gain	1.41	1.48	1.54	1.56	0.06	0.10	0.69	0.90

[a] $n = 5$ for all carcass characteristics, where $n = 3$
[b] Probability of greater F.
[c] Slight = 300, small = 400
[d] 10 = Low choice; 13 = low prime.

(450 − SBM) tended to be more efficient ($P = 0.10$) compared with lambs fed 450 g/kg field pea with SBM (450 + SBM).

Addition of field pea did not elicit any response ($P > 0.15$) with respect to carcass characteristics; moreover, there were no differences ($P > 0.52$) in carcass characteristics (Table 5) between the 450 g/kg field pea diets with or without SBM.

No differences in apparent dietary NE_m or NE_g occurred ($P > 0.23$) as level of field pea increased (Table 5). The 450 − SBM diet was more energy dense ($P = 0.05$) than the 450 + SBM diet.

4. Discussion

Incorporating field pea into diets fed to ruminants has primarily been done as a replacement of a protein source. Field pea has been shown to be an effective substitute for SBM in early lactation diets (Petit et al., 1997) and canola meal and SBM in high-producing dairy cow diets (Corbett et al., 1995). In a review of feeding field pea to cattle, Corbett (1994) concluded that field pea can be used as a major source of dietary protein. When incorporating field pea into diets fed to lambs, Purroy et al. (1992) reported an increase in DM digestibility and a decrease in N retention when field pea replaced 22.6 and 34.2% of the barley and 39.1 and 100% of the SBM in high-concentrate diets; furthermore, internal fat depots were increased, suggesting that field pea is higher in NE_g than SBM and barley.

We did not measure any effect of diet on fat thickness, bodywall thickness, or yield grade. These measurements would suggest carcass composition and body weight gain were similar between treatments.

Field pea had apparent NE_g values 24% (1.83 Mcal/kg) and 3% (1.52 Mcal/kg) greater than DRC (1.48 Mcal/kg; NRC, 1985) in Exps. 1 and 2, respectively. The increase in apparent dietary NE_g that occurred when a portion of corn and all of the SBM

Table 5
Effect of treatment on lamb performance, carcass characteristics, and apparent dietary energy in Exp. 2

Item	Field peas (g/kg DM basis)					S.E.M.[a]	Contrast			
	0	150	300	450 + SBM	450 − SBM		Linear	Quadratic	Cubic	±SBM
Weight (kg)										
Initial	39.1	39.2	39.1	39.1	39.0	0.20	0.98[b]	0.73	0.66	0.81
Final	61.3	62.3	62.2	60.4	62.2	0.91	0.50	0.14	0.93	0.18
Dry matter intake										
kg per day	1.58	1.66	1.57	1.58	1.56	0.05	0.52	0.28	0.86	0.86
g/kg of BW	31.9	32.8	31.2	31.7	31.0	0.9	0.76	0.26	0.61	0.61
ADG (g)	353	367	366	338	368	14	0.49	0.15	0.85	0.15
Gain:feed (g/kg)	223	223	233	217	237	8	0.82	0.35	0.32	0.10
Carcass characteristics										
Rib-eye area (cm^2)	14.9	15.7	15.9	16.0	16.3	0.6	0.20	0.54	0.86	0.70
Fat thickness (cm)	0.40	0.38	0.40	0.33	0.37	0.04	0.35	0.62	0.54	0.55
Bodywall (cm)	2.16	1.95	1.95	2.08	2.18	0.11	0.63	0.16	0.89	0.53
USDA yield grade	1.97	1.88	1.96	1.70	1.85	0.17	0.35	0.62	0.54	0.55
USDA quality grade[c]	10.61	10.66	10.67	10.48	10.58	0.17	0.63	0.48	0.83	0.68
Apparent dietary net energy (Mcal/kg)										
Maintenance	2.31	2.30	2.40	2.23	2.43	0.07	0.63	0.25	0.24	0.05
Gain	1.62	1.61	1.69	1.54	1.72	0.06	0.62	0.24	0.24	0.05

[a] $n = 5$.
[b] Probability of greater F.
[c] 10 = Low choice; 13 = low prime.

were replaced with field pea in the 450 g/kg field pea diet without SBM agrees with the results of Purroy et al. (1992) when they replaced barley and SBM with field pea. The increase in apparent dietary NE_g that occurred when SBM was removed from the 450 g/kg field pea diet suggests that protein was overfed becoming an energetic burden and/or that DRC was higher in apparent NE_g than SBM. The NRC (1985) lists similar energy values with corn at 1.48 Mcal NE_g/kg and SBM at 1.50 Mcal NE_g/kg. Urea synthesis from ammonia derived from deaminated excess amino acids requires 3 mol ATP/mol urea (Murray et al., 1993). If urea synthesis was creating an energetic burden, and this difference was measured when SBM replaced corn, the energetic density of field pea in this experiment may be underestimated.

According to the NRC (1985) lambs weighing between 30 and 60 kg that have high growth potential have a dietary crude protein requirement of 150 g/kg. The positive response in feed intake observed in lambs consuming the 150 g/kg field pea diet in Exp. 1 may be explained by increased dietary crude protein due in part to field pea, compared with corn, being higher in CP (217.3 g/kg versus 98.8 g/kg DM, respectively) and RDP (780 g/kg versus 447 g/kg CP, respectively). Based on Burroughs et al. (1974) equations, RDP may have limited rumen microbial fermentation. Research with beef cattle indicates RDP limits gain and feed efficiency in corn-based finishing diets (Cooper et al., 2002; Milton et al., 1997).

However, without any increase in growth or feed efficiency occurring with increasing level of RDP in our experiments, we conclude that the RDP requirement was met with the 0 g/kg field pea diet. This is in agreement with Krehbiel and Ferrell (1999), who concluded that once RDP has been met, no further increase in performance would be expected by increasing levels of RDP.

5. Implications

Field pea can be substituted for corn and soybean meal in lamb finishing diets without adversely affecting performance at inclusion levels up to 450 g/kg of the diet dry matter; however, nitrogen may be overfed at the 450 g/kg level. Based on the performance of lambs in these experiments the apparent net energy for gain of field pea is at least equal to corn.

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