Effect of Field Peas, Chickpeas and Lentils on Rumen Fermentation, Digestion and Microbial Protein Synthesis in Receiving Diets for Beef Cattle

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ABSTRACT

Pulse crop acres, particularly field peas and lentils, have been expanding in North Dakota. This study suggests pulse grains are a suitable substitute for corn and canola meal in receiving diets for beef cattle. Eight Holstein and eight Angus crossbred steers (1,122 ± 302 lbs. initial body weight) fitted with ruminal and duodenal cannulae were utilized in a completely randomized design to assess the effects of pulse grain inclusion in growing diets on intake, ruminal fermentation and site of digestion. Pulse grains (field peas, lentils or chickpeas) replaced corn and canola meal (CON) as the grain component in diets offered in unlimited amounts (ad libitum) as a total mixed ration (TMR). Treatments did not differ for dry-matter intake (DMI) (25.6 lbs., 2.32% of body weight; $P = 0.63$) or organic matter (OM) intake ($P = 0.63$). No treatment effects were observed when pulse grains replaced corn and canola meal for apparent ruminal ($P = 0.10$) and total tract OM digestion ($P = 0.40$). Treatment also did not influence crude protein (CP) intake ($P = 0.78$), microbial CP flow ($P = 0.46$), total tract CP flow ($P = 0.45$) and microbial efficiency ($P = 0.18$). Total tract acid detergent fiber (ADF) ($P = 0.004$) and neutral detergent fiber (NDF) ($P = 0.04$) digestion were greater with field peas vs. CON. Ruminal pH and ammonia (NH_3) were not different ($P > 0.15$) among treatments. Due to the moderately high levels of protein and energy that pulse grains contain, they are viable alternative for replacement of protein supplements in receiving diets for beef cattle.

Introduction

Pulse crop acres, particularly field peas and lentils, have been expanding in the northern Plains states and Canadian provinces. In 2004, North Dakota accounted for 31% and 61% of all lentil and field pea production, respectively, in the United States (NDASS, 2005). Field peas (*Pisum sativum*), lentils (*Lens esculenta*) and chickpeas (*Cicer arietinum L*.) are cool-season legumes well adapted to the soil and climate of the northern Plains (Miller, et al., 2002) and are nutrient-dense feed grains (Reed, et al., 2004) containing moderate levels of CP (22% to 29%, dry-matter basis) and energy (87% total digestible nutrients for field peas; NRC, 1988).

Peas have been incorporated into diets for sheep, dairy and beef with positive results (Corbett, et al., 1995; Loe, et al., 2000; Reed, et al., 2004). Data from previous beef research trials indicate peas are very palatable (Corbett, 1997) and improve the gain-to-feed ratio (G:F) in growing (Okine, 2001) and finishing diets (Birkelo, et al., 2000; Flatt and Stanton, 2000).

Procedures

Sixteen ruminally and duodenally cannulated steers (1,122 ± 302 lbs. initial body weight) were used in a completely randomized design to evaluate effects of replacing a portion of corn and canola meal in growing diets with pulse grains (field peas, chickpeas and lentils).

Steers were housed in an enclosed barn in individual stanchions (4-ft. by 7-ft.) on rubber mats that allowed for separation of urine and feces. Steers were fed diets in the form of a TMR at 7 a.m. and 7 p.m. daily and were allowed free access to water. Diets (Table 1) were offered to ensure ad libitum intakes and 10% feed refusal daily.

Steers with fistulae at ANPC.

Table 1. Formulation of dietary treatments in pulse grain receiving diets (%, DM basis).

	Treatments[a]			
Ingredient	Canola meal	Chickpeas	Field peas	Lentils
Grass hay	50	50	50	50
Dry-rolled corn	32.0	17.5	20.5	24.75
Canola meal	9.0	-	-	-
Chickpeas	-	23.5	-	-
Field peas	-	-	20.5	-
Lentils	-	-	-	16.25
De-sugared beet molasses	5.04	5.04	5.04	5.04
Soybean meal	0.40	0.40	0.40	0.40
Limestone	1.72	1.72	1.72	1.72
Di-calcium phosphate	1.07	1.07	1.07	1.07
Salt	0.48	0.48	0.48	0.48
Cr_2O_3	0.25	0.25	0.25	0.25
Trace mineral premix	0.03	0.03	0.03	0.03
Vitamin premix, (10:1)	0.01	0.01	0.01	0.01

[a]Legume grain replaced canola meal and part of corn.

Diets consisted of 50% grass hay (8.9% CP, 74.4% NDF, 44.8% ADF, 9.3% ash) chopped in a tub grinder to pass through a 1.5-inch screen, and a 41% blend of dry-rolled corn, canola meal or pulse grain, with 5% sugar beet concentrated separator byproduct (CSB) and 4% supplement (DM basis; Table 1).

Treatments consisted of (DM basis): 1) control, based on corn and canola meal, 2) corn and chickpeas, 3) corn and field peas and, 4) corn and lentils, with pulse grain replacing corn and canola meal in the concentrate mixture. Pulse grains were processed (dry rolled) by roller mill. Diets were formulated to contain a minimum of 12% CP and calcium to phosphorus ratio of 2:1.

Experimental length was 21 days, allowing 14 days for adaptation to diet and seven days for sample collection. Feed refusal samples were measured to determine DMI. Total fecal output was measured to determine total tract digestion. Intestinal samples were taken during a four-day period to estimate nutrient flow. Ruminal fluid samples were collected and analyzed for NH_3, volatile fatty acid concentrations and pH. On day 21, ruminal evacuations were conducted to determine ruminal fill.

Results

Treatment did not affect dry-matter intake (*P* = 0.63; 25.6 ± 2.1 lbs./day). Similarly, no effects were observed for post-ruminal or total tract OM digestion (*P* = 0.15 and 0.40, respectively). True ruminal and post-ruminal CP digestion was lower (*P* = 0.04 and 0.07, respectively; Table 2) for field peas when compared with CON. Treatment did not affect total tract CP digestion (*P* = 0.45). By design, dietary nitrogen (N) was similar among treatments. Because CP intake and ruminally-degradable protein (RDP) was similar among treatments, no treatment differences were expected for CP digestibility. Microbial efficiency (g microbial N/kg truly OM fermented) was not different (*P* = 0.18; 17.0 ± 1.2) with treatment of pulse grains and was within expected ranges.

Table 2. Effect of pulse grain on OM and CP digestion in steers.

	Treatments					P-Value	Contrasts[a]		
Item	Canola Meal	Chickpeas	Field peas	Lentils	SEM[b]	Trt	Chickpeas	Field peas	Lentils
OM digestion, % of intake									
True ruminal	61.9	66.3	61.8	67.4	1.9	0.14	0.13	0.98	0.07
Intestinal	16.2	12.3	16.7	6.5	3.3	0.15	0.42	0.92	0.05
Total tract	64.7	65.6	65.1	61.9	1.6	0.40	0.70	0.86	0.24
CP digestion, % of intake									
True ruminal	44.6	49.3	35.7	50.2	2.7	0.01	0.25	0.01	0.18
Intestinal	57.9	54.8	73.6	47.9	5.5	0.04	0.70	0.07	0.22
Total tract	55.3	54.9	53.5	49.9	2.5	0.45	0.92	0.64	0.16
Microbial efficiency[c]	17.7	16.6	19.2	15.3	1.2	0.18	0.52	0.4	0.17

[a]Probabilities for contrasts, canola meal vs. grain legume (chickpeas, field peas and lentils).

[b]n = 4.

[c]Grams microbial N per kg OM truly fermented.

Total tract NDF digestion (66.7% vs. 61.8%; *P* = 0.02) and ADF digestion (65.1% vs. 58.9%; *P* = 0.01) were greater when comparing field pea with the CON treatment. Intake of NDF (*P* = 0.18) and ADF (*P* = 0.11) trended higher for pulse grains vs. CON. The combination of the greater NDF/ADF dietary content and intake levels observed on the field pea treatment resulted in increased total tract fiber digestion, compared with CON. The inclusion of chickpeas (*P* = 0.68 and 0.55) and lentils (*P* ≥ 0.83 and 0.98), respectively, did not affect total tract NDF/ADF digestion.

Ruminal pH (P = 0.18; 6.4 ± 0.08) was not different among treatments. The inclusion of pulse grain in receiving diets affected total volatile fatty acid (VFA) concentration, as field pea (58.11 ± 2.63mM; P = 0.009) and lentil (53.42 ± 2.63mM; P < 0.001) diets had lower total VFA concentration than CON. Ruminal acetate concentrations for chickpeas (P = 0.02; 58.83 vs. 63.61 mM), field peas (P = 0.03; 60.47 vs. 63.61 mM) and lentils (P = 0.01; 60.07 vs. 63.61 mM) were lower than the CON treatment. Ruminal ammonia concentration 6.63 ± 0.71mM were not different among treatments.

Implications

The data suggests pulse grains are a suitable substitute for corn and canola meal in receiving diets for beef cattle.

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