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Feeding Field Peas to Livestock

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Introduction to Field Pea

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Field pea (Pisum sativum L.) *is an annual cool-season legume crop that is grown around the world on over 25 million acres. Although many countries produce field pea, only a limited few such as Canada, Australia and the United States produce surplus amounts to be net exporters. A significant amount of field pea is produced annually in the upper Great Plains of the United States and the Prairie Provinces of Canada.*

In 2001, field pea was produced on 3,600,000 acres in Canada with an estimated yield of 3,150,400 tons. Total US production was 227,000 tons with North Dakota accounting for 86,000 tons (38%) from approximately 100,000 acres. Field pea production in the United States had been primarily in the Palouse region of Washington and Idaho. However, acreage shifts and expansions have occurred where now North Dakota and surrounding states have become the primary source of feed peas in the United States.

Projections are for continued expansion of field pea acres in North Dakota and surrounding states. This expansion comes as growers across the region begin to recognize that field pea is well adapted to most regions of the Great Plains and the crop contributes many positive benefits to their overall crop rotation. In addition, the marketplace has developed so growers can more readily market their crop both locally and regionally. Field pea yields compare favorably with spring wheat, and the general trend would be a higher expected yield for field pea versus spring wheat, within a specific region. Yield data from North Dakota State University research centers shows that field pea performs well across the state (Table 1).

Currently, about 30% of the domestic dry pea production is consumed in the food and feed markets within the United States. Efforts are being made to continually expand the feed market in the United States. As feed companies are finding the nutritional value of dry peas encouraging, they are drawn to experiment with field pea in their products. The ideal growing conditions within the upper Great Plains states and the expected acreage expansion will position the United States to successfully satisfy any expanding domestic feed markets

Field pea or “dry pea” differs from fresh peas in that field pea is marketed as a dry, shelled product for either human or livestock food, whereas fresh peas are marketed as a fresh or canned vegetable. Field peas are desirable for both human and livestock nutrition due to their contributions of protein, carbohydrates, and amino acids. Research has shown that field peas possess many positive attributes for animal nutrition and hence are an excellent supplement to beef, dairy, swine and poultry rations. The seed of field pea produces a dense product (test weight = 60 pounds per bushel) that stores well and is easily handled and processed.

Producers have the option of selecting field pea varieties with many contrasting characteristics. Seed color and seed size are two traits that vary and impact acceptance in the human edible market. However, all field pea varieties may be considered feed grade peas. Varieties intended for specialty markets, such as maple peas, often have brown colored seeds. These varieties have higher levels of tannin that may reduce palatability in livestock rations. The crude protein content of field pea may vary due to the influence of variety and the environment in which the crop was grown. Because of this variance the seed should be tested for protein levels to allow the most efficient utilization in rations.

Field pea may also be grown as a forage crop. When grown as a forage, field pea is typically planted as a mixture with cereal grains to enhance the protein concentration of the forage.

Field pea storage is handled like most other commodities that are raised in the upper Great Plains. This is especially the case for field peas intended for the feed markets where issues of maintaining human grade standards is not a concern. Storage on-farm or at local grain elevators positions the crop to be readily moved to processors or livestock operations through traditional truck and rail connections. Specific elevators are prepared to make unit train shipments of field peas to major domestic livestock operations or to international feed markets.

Table 1. Statewide field pea variety trials, 2000 – seed yield.

Variety	Carrington	Dickinson	Erie	Hettinger	Langdon	Minot	Williston	Average
	bushels/acre							
Yellow								
Carneval	50.7	40.9	45.6	30.2	68.5	61.5	48.4	49.4
Grande	35.8	46.0	39.1	27.1	59.5	47.4	50.7	43.7
Highlight	46.8	46.5	53.3	37.3	78.3	63.9	55.9	54.6
Profi	46.5	39.8	53.0	33.6	68.8	55.6	53.7	50.1
Trapper	23.0	44.0	16.6	12.0	28.6	32.2	46.3	29.0
Green								
Atomic	55.5	37.0	45.7	47.0	63.8	52.7	46.1	49.7
Majoret	48.8	43.9	48.7	35.1	66.1	63.7	47.5	50.5
Mean	50.4	43.2	46.0	35.3	67.5	56.6	50.9	—
LSD 5%	7.1	8.6	5.4	11.4	8.3	10.9	0.2	—

Field Pea in Beef Cattle Diets

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Field peas have been successfully used in several beef cattle diets with equal or better performance compared to control rations. Peas are highly digestible in the rumen but the fermentation rate is slower than several other feeds for both starch and protein. Peas are palatable, with increased intake observed in some of the diets that included field peas. Processing peas does not appear to be critical based on available data. This nutrient-dense grain legume contains modest fiber levels, high energy levels, and is a good source of crude protein. Peas may be best utilized as a modest proportion of the concentrate in beef cattle rations. Creep feeds should contain 25% to 35% field peas but no more than ~67% peas for optimum return. Growing and finishing steers can utilize peas as a protein and energy source. Feeder cattle can utilize high levels of peas in the diet, but economics suggest usage in accordance with nutrient requirements. As a protein supplement, peas should be limited to 20% to 30% of the ration . Field peas are very palatable for beef cow supplementation and can be used in formulating range cake or supplements at any level that is economically competitive.

Introduction

Field peas are an energy- and protein-dense feedstuff that can compete with many other feeds for selected nutrients (Table 1). Energy content is comparative with barley and corn, and as a protein source peas are comparable to wheat midds, canola meal, and sunflower meal. Peas have not been widely used in beef diets in the U.S. because of availability and, to some extent, competitive prices. Beef cattle in the U.S. will be a salvage market for field peas, which are well accepted for ruminants in Europe, especially as a protein source in silage-based diets (Table 2).

Palatability, animal performance, and net return are the ultimate tests of the worth of a feed. Field peas may best be utilized in scenarios where nutrient density is important. Examples include diets where voluntary intake is limited, such as creep feed, receiving rations, or supplementing grazing livestock.

There is substantial positive anecdotal experience in feeding field peas to beef cattle. Research trials quantify comparative animal performance and specify optimum economic levels of use in specific diets. This paper summarizes research and recommendations for feeding field peas to beef cattle.

Palatability

Field peas have been observed to be highly palatable in some feeding trials. Feed intake has generally increased for diets with peas compared to diets without peas in several North Dakota State University trials and studies in Europe.

In a feedlot finishing experiment (Anderson, 1999b), peas were fed at 76% of the diet dry matter (76%) to determine if there were any palatability or anti-nutritional concerns. Intake was numerically greater for the pea treatment, suggesting no inhibitory factors were present. In a series of silage-based feeding studies in Europe (Weiss and Raymond, 1989), diets with peas were consumed at 102% of diets with soybean meal.

However, in a Colorado State University study (Flatt and Stanton, 2000) where stepped levels of peas (0, 5, 10, and 20% of ration dry matter) were included in finishing diets, a linear decrease in intake was observed, but gains were similar and feed efficiency improved with increasing proportion of peas. Reed et al. (2002a) also observed a decrease in intake when field peas were substituted for corn in a diet that was 50% grain. Digestibility of dry matter, organic matter, and neutral detergent fiber improved ($P < .08$) with increasing field pea levels in the ruminally canulated steers used in this 4 x 4 Latin Square design.

Table 1. Comparison of nutrients in field peas with other feedstuffs.

Item	Field Peas*	Corn**	Barley**	Wheat Midds**	Sunflower Meal**	Canola Meal**
Dry matter, %	89	89	89	89	92	82
	Dry matter basis					
TDN, %	87	90	88	80	65	69
NEg, Mcal/lb	.67	.70	.63	.58	.40	.45
Crude Protein, %	25.3	9.8	13.2	18.7	26.0	40.9
Calcium, %	.15	.03	.05	.17	.45	.70
Phosphorous, %	.44	.32	.35	1.01	1.02	1.20
Potassium, %	1.13	.44	.57	1.81	1.27	1.37

* - NRC, 1984; ** - NRC, 1996

Table 2. Performance of beef cattle fed field peas or soybean meal as protein supplements in corn silage based diets.

Trial	Cattle Type	Percent Peas	Gain Ratio	Intake Ratio	Feed Efficiency Ratio
1	Normandy	29	103	99	95
2	Normandy	26	101	103	104
3	Holstein cross	25	103	104	103
4	Charolais	23	100	102	100
5	Charolais	23	103	101	96
Mean			102	102	100

Adapted from Weiss and Raymond, 1989

Rumen Degradability

Peas are known to contain highly degradable protein estimated at 78% to 94% digested in the rumen (NRC, 1989; Aufrere et al., 1994) leaving modest amounts as by-pass or escape protein. However, the disappearance rate (1.6% per hour) is slower during the first six hours (Lindberg, 1981) for peas than soybean meal (4.5% per hour) but increases in rate thereafter. The more slowly degraded or sustained release nitrogen fraction found in peas should be beneficial for growth of rumen microbes and be a positive influence on rumen ph and feed efficiency.

Processing Field Peas

A trial with field peas in growing cattle diets was conducted using individually fed steers in a Calan headgate facility at NDSU (Bock, 2000). Seven steers were assigned to each of three treatments. Treatments were whole peas, rolled peas, or ground peas fed as 40% of the totally mixed diet. No differences (P>.10) in intake, gain, or feed efficiency were observed.

A South Dakota State University finishing trial (Birkelo et al., 2000) included a whole pea and rolled pea treatment, with peas included at 10% of the dry matter intake. No statistical differences (P>.10) were detected due to processing method.

Considering these trials, it appears that processing field peas is not necessary for feeding. However, whole peas do not mix as well in totally mixed diets. Further processing research is warranted.

Effect of Variety

Variation in protein content exists among varieties. A trial comparing Profi vs. Integra (24% vs. 17% crude protein) (Bock and Anderson, 2001) suggests that there are animal performance differences due to varieties related to protein level even though the control diet contained protein levels, recommended by NRC (1996).

Creep Feed Research

In a two-year study (Anderson, 1999a) with 128 cow/calf pairs, wheat midds and field peas were offered in four reciprocal combinations as creep feeds to determine optimum level of peas (Table 3). Treatments were reciprocal amounts of dry rolled peas and pelleted wheat midds at 0-100%, 33-67%, 67-33%, and 100-0%, respectively. Peas were coarsely rolled and wheat midds were fed as ¼ inch diameter pellets. Nutrients in peas and wheat midds (Table 1) were not identical, but the protein content of each exceeded recommended levels for creep feed (14-16%).

Feed intake increased (P<.05) with increasing level of field peas in the diet (Table 3). Calves offered 100% midds consumed 5.89 lbs of creep feed per day compared to 8.72 for calves offered 100% field peas during the 56-day study period.

Calf gains increased from 2.82 pounds per day at 100% midds to 3.17 lb at 67% and 100% peas. Gains from 33% peas averaged 3.11 pounds per day. Feed efficiency decreased, however, with increasing pea levels.

Feed cost per pound of gain was similar ($.065 per pound) at 0 and 33% field peas using $60/ton for midds and $2.20 for peas, but decreased efficiency caused an increase to over $.10 per pound for the 100% pea treatment. The added value from additional weight gain exceeded added feed cost at higher pea levels; however, the optimum level in this study was 67% peas. When weaned calves sell for $90/cwt, peas substituted for wheat midds in creep rations at 33, 67, and 100%, respectively, will result in a return of $5.20, $8.06, and $3.38 /60 lb bushel. This study indicates peas are a very palatable and economical for creep fed calves at 67% of the diet or less.

In another creep feeding study in North Dakota, field peas were included in limited intake creep feeds offered to calves grazing short grass prairie with their dams (Landblom et al., 2000). If creep feeds act as a supplement to intake of grazed forage, it may be more economical to limit feed. Eighty cow/calf pairs were used to compare four treatments including 1) no creep feed; 2) 33% peas; 3) 67% peas, and 4) 100% peas. Wheat midds were used in the diet in reciprocal amounts with peas. Salt was added to limit intake at a rate of 8% during the first 28 days and 16% during the last 49 days of the trial period. Intake was approximately 3 lbs per head daily for all creep rations (Table 4). Gains tended to be greater (P =.11) for all creep feed treatments vs. no creep feed. No differences (P>.10) were observed due to level of peas, but the 67% pea diet provided numerically superior gains and feed efficiency. Greatest economic return was observed in the 67% field pea diet with a net return of $1.00 for each dollar spent on creep feed, essentially a 100% return on investment.

Table 3. Creep feeds with increasing levels of field peas.

	Treatment				
Item	0% Peas	33% Peas	67% Peas	100% Peas	St Err.
No. pairs/replicates	31/4	32/4	32/4	33/4	—
Initial wt, lb	361	353	362	358	11.37
Final wt, lb	519	527	540	535	13.35
DM intake, lb	5.89 [a]	6.43 [a,b]	7.63 [b]	8.72 [c]	.43
Avg. daily gain, lb	2.82 [a]	3.11 [b]	3.17 [b]	3.17 [b]	.14
Gain/feed	.48 [a]	.49 [a]	.42 [a,b]	.38 [b]	.03
Value added above feed cost, $/hd	—	9.66	10.83	6.99	—

a,b,c - values with different superscripts are significantly different, (P<.05)

Anderson, 1999a

Table 4. Limiting intake of pea/wheat midds creep feed with salt.

	Treatment				
Item	No Creep	33% Peas	67% Peas	100% Peas	P - value
No. pairs/replicates	22/2	22/2	22/2	22/2	—
Initial wt, lb	413.5	427.3	427.3	409.6	—
Final wt, lb	597.7	660.2	688.0	63.06	.11
DM intake, lb	0	2.93	3.19	3.03	—
Avg. daily gain, lb	1.65	2.08	2.33	1.97	.11
Gain/feed	—	.147	.210	.080	.48
Value added above feed cost, $/hd	—	13.33	24.91	–4.65	—

Landblom et al., 2001

Field Peas in Feedlot Diets

The greatest potential volume for use of field peas in the Northern Plains states and Prairie Provinces is in feeder calf diets. However, field peas will have to compete economically with other feeds such as barley and wheat midds based on nutrient costs. Peas should be used in balanced diets based on nutrient requirements (NRC, 1996) and performance goals. The relatively high protein content of peas and available energy make this feedstuff most useful at low to modest levels. This section reports research using field peas in diets for wintering and growing steers and heifers and for finishing steers.

Growing Experiments

Field peas are widely used by cattlemen as a protein supplement for wintering calves. The optimum level of peas in a forage-based diet was investigated by Reed et al. (2002b).

Field peas were offered at 0, 2, 4, and 6 pounds in a 4 x 4 Latin Square trial to steers consuming medium quality grass hay. Total dry matter and organic matter intake increased (P<.05) with increasing field pea supplement level but forage dry matter and organic matter decreased (P<.05) as expected.

Rumen volatile fatty acids, total tract crude protein digestibility, and apparent ruminal dry matter digestibility tended to increase linearly (P=.09) with increasing field pea level. Peas had no effect (P>.11) on total tract dry matter or organic matter digestibility. Field peas acted like other cereal grains in supplementing forage diets.

Weaned crossbred steer calves were fed three 60% concentrate diet treatments of 1) barley with canola meal at crude protein levels recommended by NRC (1996); 2) barley with canola meal added to equalize the crude protein level of the field pea diet; and 3) field peas as the concentrate source (Table 5). The protein level in the field pea diet exceeded NRC (1996) recommended nutrient requirements. Dry matter intake of the growing diet with field peas was numerically greater than the control (12.3%) and barley plus canola meal (9.3%). Similarly, gains were numerically greater from the pea diet over the barley treatment (16.8%) and barley plus canola meal (7%). Feed efficiency improved numerically with peas in the diet over the barley (5.8%) and barley-canola (3.4%) treatments. In this trial, the breakeven price for a bushel of peas is approximately 170% of the price of a bushel of barley for growing calf diets (Anderson, 1999b).

Growing heifer calves were fed field peas as an isonitrogenous replacement for barley and soybean meal with no effect (P>.10) on intake, gain, or feed efficiency (Poland and Landblom, 1998).
In another study, performance was similar but intake decreased (P<.10) in the pea diet, tending to improve feed efficiency. Peas were used as a protein source compared to soybean meal in silage-based diets with several European trials reported by Wiess and Raymond (1989). In five trials, intake of pea supplemented diets averaged 102% of control, gain averaged 102% of controls, and feed conversion was equal (Table 2).

In a demonstration trial, wintering replacement heifer calves were fed 5 pounds of either field peas or wheat midds in a limit fed, forage-based diet. Similar gains and feed efficiency were observed (Anderson, 1998).

Finishing Experiments

Steer calves were fed totally mixed finishing diets with dry rolled barley and canola meal or field peas as the grain source. TMR diets were fed to appetite once daily in fenceline bunks. Feed intake tended to be greater for peas (4.7%) than barley in the finishing diets. Daily gain increased 5.5% (.20 lb / hd / d) for peas over barley. Feed efficiency was equal (Table 6). Carcass traits were similar with the exception of marbling scores and the percent choice carcasses, which were greater (P<.05) for steers fed field peas. Feed cost per pound of gain would be equal with peas at $2.03 per 60 lb bushel compared to barley at $1.50. The reader could interpret that peas are worth 135% the price of a bushel of barley when used as the primary concentrate in finishing diets (Anderson, 1999b).

Field peas were used as a protein supplement at 10% of the finishing diet dry matter in comparison with soybean meal in a South Dakota State University study (Birkelo et al., 2000). No differences were observed (P<.05) in any of the feedlot performance or carcass traits measured (Table 7); however, the first 56-day period produced improved gains and feed conversion for the field pea diets.

Flatt and Stanton, (2000) fed peas at 0, 5, 10 and 20% of finishing diets to steers and heifers substituting field pea protein for soybean meal.

Table 5. Field peas in diets for growing steer calves.

	Treatment			
Item	Control-Barley	Barley/Canola Meal	Field Peas	Std Err
No head / reps	27 / 4	27 / 4	26 / 4	—
Initial wt, lb	579	581	578	20.7
Final wt, lb	707	717	727	21.8
DM intake, lb	15.32	16.01	17.21	.56
DM intake, % BW	2.39 [a]	2.47 [a,b]	2.65 [b]	.09
Avg. daily gain, lb	2.61	2.78	3.05	.22
Gain / feed	.170	.174	.180	.016
Fecal nitrogen, %	12.38 [a]	15.12 [b]	18.89 [c]	1.76
Feed cost / lb gain, $	.223	.231	.210	—

a,b,c - values with different superscripts are significantly different, (P<.05)
Anderson, 1999b

Table 6. Field peas in diets for finishing steers.

	Treatment		
Item	Barley/Canola Meal	Field Peas	Std Err
No. steers / reps	41 / 4	42 / 4	—
Initial wt, lb	711	716	14.5
Final wt, lb	1158	1177	21.2
DM intake, lb	21.54	22.59	.45
Avg. daily gain, lb	3.63	3.83	.13
Gain / feed	.170	.171	.01
Feed cost / lb gain, $	.230	.245	—
Dressing percent	62.1	62.3	.01
Yield grade	2.14	2.35	.13
Marbling score	369 [a]	395 [b]	7.12
Percent Choice / Prime	24.8	43.9	—

a,b - values with different superscripts are significantly different, (P<.05)
Anderson, 1999b

The Profi peas in their trial were 20% protein. Increasing levels of peas decreased intake (P<.05) but did not affect gain, thereby improving feed efficiency linearly with increasing field pea level (P<.05). Carcass traits were not affected (Table 8). Mortality was lower for the calves fed any amount of field peas over control (P<.05).

Beef Cow Supplementation Research

There is very little research on feeding peas to beef cows; however, it is practiced widely where peas are grown. Schaefer et al (2000) substituted stepped levels of field peas for a barley-canola meal protein supplement in diets for gestating cows consuming grass hay. No differences (P>.10) were observed in cow gain, condition score, calving or other performance traits.

General Feeding Recommendations

The major factor in considering to use field peas in beef cattle diets is the cost of protein and / or energy from other feedstuffs available. Growing peas as a protein source may reduce off-farm expenses and provide nutrition for improved animal performance, leading to increased net returns for an integrated crop / livestock enterprise. All trials with beef cattle report equal or better performance compared to other experimental diets. The nutrient density of field peas is greater than most other feedstuffs, so including peas in limit fed applications may be the best use of this feed. This use includes creep feed, growing calves, and supplementing forage diets (i.e.range cake).

Processing peas does not appear to be essential for satisfactory performance but diets mix better when peas are coarsely rolled. Field peas and other feeds should not be fed at protein levels above NRC (1996) recommendations to prevent extra nitrogen from entering the atmosphere through volatilization or feed yard runoff with high nitrogen levels entering the water table.

Table 7. Field peas in finishing diets for heavy feeders.

	Treatment		
	Control	**Whole Peas**	**Rolled Peas**
Percent of peas, DM basis	0	10	10
No head / reps	52 / 6	52 / 6	52 / 6
Initial wt, lb	917	912	914
Final wt, lb	1333	1322	1332
DM intake, lb	24.27	23.75	23.89
Avg. daily gain, lb	3.94	3.90	3.98
Gain / feed	.162	.164	.166
Dressing percent	59.0	59.1	58.1
Yield grade	2.6	2.5	2.6
Percent Choice / Prime	76.5	82.4	84.3

Birkelo et al., 2000

Table 8. Increasing levels of field peas in diets for growing and finishing steers.

	Treatment				
	0% Peas	**5% Peas**	**10% Peas**	**20% Peas**	**Std Err**
No hd / reps	75 / 6	78 / 6	78 / 6	78 / 6	—
Initial wt, lb	608	601	597	602	31.65
Final wt, lb	1139	1130	1107	1120	38.05
DM intake, lb, [a,b]	20.65	19.42	18.87	18.48	.64
Avg daily gain, lb	3.17	3.14	3.06	3.12	.11
Gain / feed, [a,b]	.153	.161	.162	.168	.03
Dressing percent	63.71	63.72	63.01	63.50	.39
Yield grade	2.35	2.38	2.29	2.37	.10
Marbling score	2.28	2.12	2.40	2.42	.12
Percent Choice / Prime	85.33	85.90	75.95	75.00	4.48
Morbidity	13.5	14.4	15.7	11.8	6.71
Mortality, [a,b]	6.7	1.5	0	.8	1.38

a – linear effect of increasing peas in the diet (P<.05)
b – significant effect of peas (P<.05), 0% vs. 5, 10, and 20%
Flatt and Stanton, 2000

Implications

Peas have proven to be biologically and economically competitive as a protein and energy source for beef cattle. Peas can be included in creep feeds, growing and finishing diets, and for supplementing beef cows. The major determining factor in purchasing field peas for beef cattle is price comparison with other feedstuffs, based on respective nutrient content. Feeding home grown peas may reduce off-farm purchases for protein and enhance sustainability of cropping system(s).

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Field Peas in Dairy Cattle Diets

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Field peas can be regarded as an acceptable source of protein when properly balanced in the diet with bypass protein sources. Given our present knowledge of ruminant nutrition, peas can safely be fed with minor restrictions. Conservative recommendations generally suggest limiting peas to 15 to 20% of concentrate or 7 to 10% of total mixed ration (TMR) on a dry matter basis. In general, palatability and protein degradability will restrict use without loss of intake, making peas a reasonable substitute for soybean meal or canola meal as a protein source for dairy cows.

The amount of peas used should be governed by the cost of competing protein sources and the cost of providing higher bypass protein supplements for highly productive animals. Minimal processing of field peas is required for animal feeding.

The relatively slow degradation rate of starch in peas may be beneficial in animals fed diets containing a high concentration of grain. No anti-nutritional components are apparent when feeding field peas.

Introduction

Nearly every crop grown for food will have grain deemed unacceptable for its intended use, primarily the result of weather loss, storage, or harvest damage. Livestock provide a source of utilization for salvage crops. In many cases, especially in times of low market prices, peas and many other grain crops have significant added value when included in animal diets.

Compared to soybean meal or canola meal, peas contain approximately half as much crude protein (25.6 vs. 46.3%) lower rumen undegradable protein content (20 vs. 34.6%), and more acid detergent fiber (20.5 vs. 10%) [National Research Council (NRC), 2001]. In addition, peas contain a high level of starch (54%; McLean et al., 1974). This makes peas a unique dual purpose feed, rich in both energy and protein (Table 1). Pea protein is rapidly degraded in the rumen, but the starch is slowly degraded. Therefore, the value of peas differs depending on diet formulation, age of the animal, and type of processing used (Marquardt and Bell, 1988).

Discussion

Composition relative to ruminants

Pea seeds consist of a high quality protein with an average crude protein content between 20 and 25% dry matter DM (Lalles, 1993). Reichert and MacKenzie (1982) reported a considerable range (14 to 28.5% DM cv. Trapper) in protein of feed peas and reported that starch accounted for most of the difference in protein content, while the remainder of variation was due to lipid, neutral detergent fiber (NDF), soluble sugars, and ash. Pea protein is highly soluble at over 70% of crude protein (CP) (National Research Council, 2001); Christensen et al., 2000; Mustafa et al., 1998; Walhain et al., 1992). Pea protein is characterized by a high rumen degradability and a low bypass protein value (20%) (NRC, 2001; Mustafa et al., 1998).

Weaned calves

Peas have been successfully fed to young calves in a University of Alberta study (de Boer et al., 1991; Table 2). The calves averaged 95 days of age and were one to four weeks post-weaning at the onset of the experiment. Average daily gain, dry matter intake of concentrate and hay, and feed conversion efficiency were not different for the control and pea-based concentrates. The results show that peas can be used as a replacement for other protein and barley sources in the

Table 1. Typical nutrient analysis of pea seed (Pisum spp.) for dairy cattle (NRC Dairy Nutrient Requirements, 1989 and 2001).

TDN, %	87.0	
Digestible Energy, Mcal / kg (Mcal / lb)	1.74	*(0.79)*
Metabolizable Energy, Mcal / kg (Mcal / lb)	1.55	*(0.70)*
Net Energy for Maintenance, Mcal / kg (Mcal / lb)	0.98	*(0.44)*
Net Energy for Growth, Mcal / kg (Mcal / lb)	0.67	*(0.30)*
Net Energy for Lactation, Mcal / kg (Mcal / lb)	0.91	*(0.41)*
Crude Protein, %	25.6	
Rumen Degraded Protein, % of CP	≅ 78.0	
Rumen Undegraded Protein, % of CP	≅ 22.0	
Ash, %	3.7	
Lipids, %	1.5	
Fiber, %	6.7	
Soluble Crude Fiber, % [a]	0.0	
Starch, %	≅ 54.0	
Sugar, %	6.5	
Cystine, % of CP	1.42	
Histidine, % of CP	2.59	
Isoleucine, % of CP	4.09	
Leucine, % of CP	7.24	
Lysine, % of CP	7.17	
Methionine, % of CP	1.00	
Phenylalainine, % of CP	3.83	
Tryptophan, % of CP	0.90	
Threonine, % of CP	3.75	
Valine, % of CP	4.67	

[a] The neutral detergent fiber content of peas, which approximates the sum of hemicellulose, cellulose, and lignin present in the cell wall, was negatively correlated with the content of pea protein (Reichert and MacKenzie, 1982). Because the majority of fiber exists in the form of hemicellulose and cellulose with very little lignin, the fiber is considered highly digestible.

Table 2. Effect of feeding peas on Holstein calf performance (de Boer et al., 1991).

Item	Control	Peas	Hay
Ingredients			
Barley, %	57.2	23.8	—
Peas, %	—	50.0	—
Wheat Shorts, %	15.0	15.0	—
Canola Meal, %	10.2	2.0	—
Soybean Meal - 48, %	10.2	2.0	—
Meat and Bone Meal, %	1.0	1.0	—
Molasses, %	3.0	3.0	—
Other, %	3.4	3.2	—
Nutrients			
Dry Matter, %	84.5	83.5	87.5
Organic Matter, % DM	92.3	93.5	93.8
Crude Protein, % DM	20.1	20.2	13.2
NDF, % DM	21.0	18.4	67.9
ADF, % DM	7.1	7.0	38.9
Starch, % DM	46.6	46.4	6.0
Performance			
Initial Body Wt, lb	154.0	147.0	—
Average Dairy Gain, lb	1.81	1.74	—
Dry Matter Intake, lb / da			
Concentrate	3.68	3.59	—
Hay	2.40	1.90	—
Total	6.08	5.49	—
Feed / Gain, lb DM / lb	3.36	3.15	—

diets of young calves. There does not appear to be an upper limit on the amount of peas that can be fed, except within practical ranges of dietary needs and environmental limits.

Unlike the pre-ruminant calf that depends greatly on the type of protein and the quantity and quality of amino acids for growth, the weaned ruminant calf relies more on the introduction of dry feed and the development of a functional rumen (Lalles et al., 1990). Peas can act as the sole protein source for young ruminants that have a functioning rumen with little or no effect on performance. Preweaned and weaned dairy calves were fed a grain starter containing field peas at 40% of the total DM (Marx, 2000). Calves fed the starter with field peas performed similarly to those fed starters with barley or corn (control) grain in the starter rations.

Lactating cows

Intake: Dry matter intake of oat hay and grain by four lactating Friesian cows was significantly higher when cows were given peas rather than barley grain (19 vs. 14.5 lb / d) (Valentine and Bartsch, 1987).

Milk Yield: There have been few studies on the effect of feeding peas to lactating dairy cattle and the results vary. Due to the lower effective degradability of crude protein in peas compared to soybean meal (12 vs. 28 RDP, % of DM) (Khorasani et al., 1992) and a lower undegradable protein content relative to soybean meal (22 vs. 35%), milk production may decrease in early lactation when the demand for rumen undegradable protein is high (Corbett et al., 1995). In some studies this finding has been confirmed, and the reduction in milk production is attributed to the greater degradation of pea protein in the rumen (Khasan et al., 1989). Results from feeding peas to a high-producing Holstein dairy herd (averaging 68.9 lbs per day) are shown in Table 3 (Corbett et al., 1995).

It is noteworthy that no differences were found in milk production for second lactation and older cows, while first lactation cows produced 17% less milk when given the diet which included field peas. Since the diets were equal for energy (NE_L) and protein, the requirement for growth among the younger first-calf cows may have precluded the availability of those nutrients for milk production. When actual milk yield was adjusted to fat-corrected milk (FCM) for 4% fat, there was no difference in FCM yield. Milk fat percentage was higher in early-, mid-, and late-lactation cows fed peas.

Table 3. Chemical composition of concentrate mixtures and milk production and composition of cows fed pea or SBM/CM supplemented diets (Corbett et al., 1995).

Chemical Composition	SBM/CM Based	Pea Based
DM %	**89.8**	**89.7**
	— (% of DM) —	
Crude Protein	18.5	18.5
Acid Detergent Fiber	7.3	7.4
Neutral Detergent Fiber	13.4	13.6
Crude Fat	5.2	4.5
Net Energy for Lactation, Mcal / lb	0.80	0.80

Performance of all cows (n = 155, 108, and 109 for cows in early, mid- and late-lactation, respectively).

Production	(lbs/day)	
Milk	70.6[a]	67.2[b]
Fat	2.14[a]	2.27[b]
Protein	2.12	2.07
FCM	60.4	61.3

Milk Composition	(%)	
Fat	3.13[a]	3.47[b]
Protein	2.99	3.10

[ab] Means in the same row with different letters are different (P<0.05)

The need for bypass protein is greatest during early lactation and declines as lactation progresses. Pea protein has been successfully substituted for soybean protein in late lactation cows in a study conducted at the University of Alberta (Khorasani et al., 1992). The soybean meal diet was formulated to satisfy the nutrient requirements of a Holstein cow weighing 1,300 lbs and producing 50 lbs of 3.5% fat milk at 200 days in lactation. A total mixed ration (TMR) consisting of 25% alfalfa silage, 25% brome grass silage, and 50% concentrate was fed ad libitum twice daily. Four different 18.6% crude protein concentrates were used in which pea protein replaced soybean protein at 0, 33, 67, and 100%, with barley as the major grain source. Daily milk production, 4% fat corrected milk (FCM) production and dry matter intake were not affected as the level of peas was increased (Table 4).

A field trial was initiated in Alberta in a high producing herd to see if practical rations could be formulated using peas as a protein source while maintaining peak milk yield as well as average production (Corbett et al., 1994). Two 18.5% crude protein concentrates were formulated to contain similar amounts of bypass protein using meat meal and distillers grains. Soybean meal and canola meal were used in the control ration while the treatment ration concentrate contained 25% peas.

The concentrates were fed through a computer controlled feeder according to level of milk production. A 50% alfalfa silage, 50% whole plant barley silage mixture was fed free choice along with 5 lbs of alfalfa hay per cow daily. Milk yield ranged between 70 and 75 lbs for the six-month duration of the experiment. Milk yield peaked at

Table 4. Effect of substitution of pea protein for soybean meal protein on milk production and dry matter intake in late lactation dairy cows (Khorasani et al., 1992).

	Pea Protein %			
Performance	**0**	**33**	**67**	**100**
Milk Yield, lbs / day	45.5	48.4	47.1	47.7
4% FCM, lbs / day	44.4	48.0	48.2	45.5
Dry Matter Intake, lbs / day	46.6	47.3	48.2	47.5

approximately 60 days and did not differ between the two concentrate groups. Persistency of milk production was not affected by concentrate source and there was a tendency for higher butterfat content in the milk of animals fed peas. The results of this trial indicate that peas can be fed to high producing animals when fed properly balanced rations. The use of peas would be limited only by the cost of providing adequate bypass protein.

Milk Composition: Milkfat percentage was higher (P<0.05) in cows fed a pea concentrate in all stages of lactation compared to cows fed a soy / canola concentrate (Corbett et al., 1995). This was attributed to the low degradation rate of non-structured carbohydrates in peas. Previous reports suggest this prevents a depression in rumen pH (Valentine and Bartsch, 1987). This maintains a more stable rumen, resulting in increased fiber digestion and a higher acetate:propionate ratio, leading to an increase in milkfat (Valentine and Bartsch, 1987). Robinson and McQueen (1989) reported low pea starch degradation rate of 3.9 to 5.3% per hour compared to barley starch (21.3 to 34.2% per hour) when peas were fed in a high concentrate:low forage diet. However, the University of Saskatchewan trials reported similar milkfat percentage and yield in dairy cattle fed soybean meal, micronized or raw peas (Christensen et al., 1998).

Protein: Milk protein percentage and yield were not affected by diet at any stage of lactation when peas were substituted for soy / canola meal in the concentrate and the diets were balanced for undegradable protein (Corbett et al., 1995). Because the concentrate portions of the diets were formulated to contain similar levels of undegradable protein, lack of differences in milk protein percentage and yield could be a reflection of a similar amino acid profile and supply to the small intestine of cows fed either peas or soy / canola meal. However, the formulation of the soy / canola meal and pea concentrate portions of the diet that contained equal amounts of undegradable protein could have masked any potential of the diets to influence milk protein percentage and yield.

Effects on the rumen

pH: Peas may support better production for cows fed hay-based diets by promoting a more stable rumen environment. Supplementing hay diets with high levels of barley grain in dairy cow diets causes major changes in ruminal fermentation. This leads to digestive disorders, reductions in hay intake, and losses in milk production due to the rapid fermentation of starch to volatile fatty acids and lactic acid. The result is a low rumen pH (below 5.8) and a severe inhibition of fiber digestion. Rumen bacteria normally associated with fiber digestion are almost eliminated when this occurs (Valentine and Bartsch, 1987; Bartsch and Valentine, 1986). Replacement of barley with peas (and other legumes) as 70% of the total ration fed twice daily to cows resulted in a ruminal pH that was significantly higher three to six hours after feeding. Ruminal pH did not fall below 6.0 in contrast to barley fed cows. When barley was supplemented, the rumen pH was below 6.0 for approximately seven hours of the 12-hour feeding period (Bartsch and Valentine, 1986).

Ammonia-Nitrogen Concentrations: Ammonia-nitrogen concentration in the rumen of the cows offered hammer-milled barley grain with 2% urea was below 5 mg per 100 ml for seven hours of the 12-hour feeding interval. Replacing barley with legume grains (including peas) resulted in higher ammonia-nitrogen concentrations from 0 to eight hours after feeding. Rumen ammonia-nitrogen concentrations below 5 mg per 100 ml are sub-optimal for maximum bacterial efficiency by the less competitive cellulolytic bacteria (Valentine and Bartsch, 1987).

Rumen degradability

Protein: Peas, like other legume seeds, are characterized by their highly degradable protein and slowly degradable starch. Much of the protein in peas is digested by ruminant animals. Pea protein is highly soluble with a low rumen escape or bypass protein content. NRC (1989) assigns a bypass protein content of 22%, based on four measurements. Peas contain approximately 40% soluble protein (Aguilera et al., 1992). Since pea protein is completely degraded by ruminants, this suggests that the non-soluble, slowly degradable fraction is about 38%. The initial degradation rate of the slowly degradable protein fraction appears to be much slower than for soybean meal (Aguilera et al., 1992). The pea protein disappearance rate was approximately 1.6% per hour compared to 4.5% for soybean meal after six hours of rumen incubation time. This relatively slow rate of degradation has been observed in other studies (Lindberg, 1981). Degradation rate from six to 12 hours appears to be similar to soybean meal. This may be advantageous in providing a more sustained release of nitrogen needed for rumen microbial growth.

Peas have been successfully substituted for soybean meal in situations where the need for undegradable protein has been modest, such as in late-lactation cows (Khorasani et al., 1992) and in a commercial dairy herd with modest milk production of 51 pounds per day (Ward et al., 1989). Alberta researchers (Corbett et al., 1995) studied the effects of substituting peas for a combined soybean meal (SBM) and canola meal (CM) supplement on milk producing dairy cows.

Two 18.5% crude protein grain concentrate diets were formulated based on the nutrient analyses of the forages available. The control grain mix contained standard protein sources, principally SBM / CM, while the test grain mix was formulated to contain approximately 25% field peas as the major source of protein. Both grain rations were formulated to the same nutrient specifications and balanced for undegradable protein (NRC, 1989). The duration of the trial was six months, during which grain feeding levels were adjusted monthly based on milk yield.
For cows in early lactation, 4% fat-corrected milk yield was higher for cows fed pea-based concentrates (69 lb / d) than for cows fed SBM / CM supplement (65.5 lb / d). Fat-corrected milk yield was not different for cows fed SBM / CM compared with cows fed the pea

supplement when cows across all stages of lactation were included in the analyses. Milk fat percent was significantly higher for early- and mid-lactation cows fed the pea supplement. These results suggest that peas can be substituted for SBM / CM as a protein source for high-producing dairy cows.

In situ research at North Dakota State University by M.L. Bauer and G.P. Lardy (Table 5, unpublished data) on four cultivars of field peas grown in North Dakota (Trapper, Profi, Carneval, and Arvika) was conducted to determine rumen degradable protein. Crude protein values for the four cultivars ranged from 19.4 to 26.1% on a DM basis. Nutrient Requirements for Dairy Cattle (NRC, 2001) shows N disappearance (A fraction) for raw field peas at 55.5%. All the cultivars used in this study were similar with the exception of Trapper. Trapper, however, had the most rapid degradation rate (16.3% / h), resulting in similar rumen degradable protein frations.

Starch: The energy content of field peas is similar to corn and wheat. The starch content of peas ranges from 41 to 54% of the dry matter. The rumen degradable fraction is characterized by a slow degradation rate (Walhain et al., 1992; Robinson and McQueen, 1989). In high concentrate diets the ruminal degradation rate of pea starch is similar to corn and much slower than wheat, oats, or barley (Table 6). A slow starch degradation rate would help control rumen pH, especially in animals that are fed large amounts of grain. Fiber digestion is depressed at a rumen pH below 6.0, which contributes to reduced dry matter intake, butterfat depression, and increased digestive disturbances. This may also explain why high producing cows fed high grain diets tended to have higher butterfat percentage in their milk when peas comprised a significant proportion of the concentrate (Corbett et al., 1994).

Table 5. In situ rumen nitrogen degradation of field pea cultivars.

	Variety				
Item	**Profi**	**Arvika**	**Carneval**	**Trapper**	**SEM**
CP, % DM	22.6	26.1	22.6	19.4	—
N disappearance at 0 hour, %	58.4	56.5	53.3	40.2	7.0
Rate of CP digestion, % / hour	10.8[bc]	7.3[b]	15.4[bc]	16.3[c]	2.9
Rumen degradable protein[a], % of CP	82.2	76.9	83.5	79.0	4.8
Rumen undegradable protein[a], % of CP	17.8	23.1	16.5	21.0	—

[a] Passage rate of undegraded protein 8% / hr (Mathers and Miller, 1981).
[bc] Within a row, means without a common superscript letter differ ($P < 0.10$).

Table 6. Ruminal degradability characteristics of starches from selected feed ingredients (Robinson and McQueen, 1989).

		Rumen Degradation Rate (%/hour)		
		b Hay: a Conc	**a Hay: b Conc**	
	Total Starch		**Slow**	**Fast**
	(% DM)			
Barley	56.1	22.4	21.3	34.2
Oats	61.6	14.2	14.6	22.6
Corn	67.6	3.5	2.7	8.2
Wheat	66.6	22.6	17.2	23.2
Peas	41.8	13.4	3.9	5.3

Processing

Little research has been reported in the scientific literature on the influence of processing on the nutritive quality of peas for ruminant animals. Given the large kernel size of peas, it is questionable whether peas require processing before being fed. In spite of this lack of information, it would seem reasonable that peas be processed and that processing methods which minimize particle size reduction be used. Coarse grinding or rolling are the most common processing methods currently employed.

Inclusion of peas in pelleted concentrates generally improves pellet quality, resulting in more durable pellets with less fines produced with mechanical handling (de Boer et al., 1991). Steam flaking of peas has been shown to have no effect on degradability of protein or on gelatinization of starch.

Anti-nutritional factors

While it is not clear how high levels of field peas will affect milk yield and milk composition, current knowledge of ruminant nutrition suggests that peas can safely be fed with minor restrictions (Bond et al, 1989; Saini et al, 1989). Conservative recommendations generally suggest limiting peas to 15 to 20% of concentrate or 7 to 10% of a total mixed ration on a dry matter basis. The amount of peas used should be governed by the cost of competing protein sources and the cost of providing higher bypass protein supplements for highly productive animals.

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Field Pea in Swine Diets

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Peas have been used for food and feed for centuries. Research to evaluate their inclusion in swine diets has been conducted largely in Europe, Canada, as well as in the northern Great Plains and Pacific Northwest regions of the United States. Genetic advances in swine growth, feed efficiency, carcass yield and fat to lean ratios, and meat quality are putting increasingly greater demands on dietary requirements. Field peas are in demand to meet these requirements because they are low in fiber, serve as a good source of high quality protein, possess highly digestible energy, and are a good mineral source, as shown in Table 1.

Anti-nutritional factors (ANF) are common to seed from all pulse crops. Protease inhibitors are proteins with specific anti-trypsin and anti-chymotrypsin activity that decrease protein digestibility and cause pancreatic hypertrophy. However, spring seeded *(Pisum sativum*) peas resulting from white-flowered cultivars *(hortense*) that yield yellow and green seed are uniquely low in ANFs. European researchers reported trypsin inhibiting activity of raw peas to be from five to 20 times less than that reported for raw soybeans. Anti-nutritional factor levels are distinctly higher among winter pea *(Pisum sativum*) dark flowered cultivars (*arvense*) with respect to swine feeding and therefore are best suited for feeding to ruminants. While pigs can tolerate low ANF levels with good success, pig age and digestive tract development must be considered when formulating diets for very young early-weaned pigs. The good news, with the exception of early weaned pigs, is that practical pig diets formulated with field peas can be prepared and direct-fed without prior treatment to inactivate ANFs.

Protein in a diet consisting of a mixture of ingredients is referred to as crude protein and is defined as the nitrogen content X 6.25. This is based on the assumption that, on average, the nitrogen content is 16 g of nitrogen / 100 g of protein. Since the building blocks of proteins are amino acids, modern swine diets are formulated around an ideal protein concept that corresponds to the needs of the animal for 10 essential amino acids. Lysine has been determined to be the first limiting amino acid for swine, so four ideal amino acid ratios to lysine have been developed for maintenance, protein accretion, milk synthesis, and body tissue. Table 2 lists the amino acid composition of soybean meal and field peas, the true ileal digestibility of each amino acid, and each field pea amino acid digestibility expressed as a percentage of soybean meal. That field peas are an excellent source for high quality protein is illustrated by the

Table 1. Nutrient comparison of selected protein sources.

	Peas	Soybean Meal	Canola Meal
Crude Protein, %	22	44	38
ME Energy, kcal / lb	1430	1465	1225
Fiber: ADF, %	7.2	12.7	5.4
NDF,	8.9	17.2	21.2
Lysine, %	1.68	2.9	2.27
Methionine+Cystine, %	.52	1.24	1.05
Calcium, %	.11	.32	.63
Phosphorus, %	.41	.62	1.17

Table 2. Amino acid content and true ileal amino acid digestibilities of field peas expressed as a percent of soybean meal. (NRC, 1998).

	SBM A. Acid Cont.	Pea A. Acid	SBM Digest.	Pea Digest.	% of SBM
Lysine	2.83	1.50	89	88	99
Arginine	3.23	1.87	93	90	97
Histidine	1.17	.54	90	89	99
Isoleucine	1.99	.86	88	85	97
Leucine	3.42	1.51	88	86	98
Methionine	.61	.21	91	84	92
Cystine	.70	.31	84	79	94
Phenylalanine	2.18	.98	88	87	99
Threonine	1.73	.78	85	83	98
Tryptophan	.61	.19	87	81	93
Valine	2.06	.98	86	83	97

high true ileal digestibility values shown for each amino acid. Levels for the sulfur containing amino acids methionine and cystine are lower than desired. Necessary replenishment is accomplished through supplementation with either synthetic crystalline methionine or by including small amounts of a complementing protein source like canola meal.

Starter (Weanling) Pig Diets

In modern swine production, pigs are commonly weaned from 14 to 21 days of age, weighing from 11 to 16 pounds, and are fed highly nutrient-dense diets. During the first two to three weeks of life, a pigs digestive enzymes are only capable of digesting lactose (milk sugar), glucose, casein (milk proteins), and certain fats. Enzyme physiology changes occur between two and seven weeks of age such that the pig becomes increasingly more capable of efficiently digesting starch, sugars, non-milk proteins, and fats. By three weeks of age, enzyme turnover has progressed sufficiently such that a milk-based diet can be replaced with dry feedstuffs consisting of some milk co-products (whey, dried skim milk, etc.), cereal grains, and high quality proteins.

Research in Europe, Canada, and North Dakota with starter diets have evaluated both raw and extruded pea replacements for soybean meal and corn ranging from 20 to 50%. Extruding is a process whereby feeds are forced through a small orifice in the end of a heavy steel barrel by an auger-like device. Clearance between the heavy steel auger flighting and flighting on the wall of the barrel is narrow. When feed, and an appropriate amount of water or steam is forced through the device at high RPM friction heat is created in the range of 250-290 °F. European investigators have shown that extrusion decreases ANF and significantly increases ileal starch digestibility. When varying levels of raw or extruded peas (15, 30, and 45%) were fed to pigs from 15.4 to 55 pounds, adding raw peas tended to depress growth rate and efficiency at all levels fed. However, following extrusion, growth and efficiency among pigs fed either 30 or 45 percent peas was comparable to performance of pigs fed a wheat / soy control diet.

The swine industry has adopted earlier weaning as a common practice in which pigs are weaned between 14 and 16 days of age. Successful weaning programs with pigs of this age rely on precise nutrient balance and phase feeding adjustments that allow the nutritionist to reduce nutrient density as pigs mature. Field pea research at the Dickinson Research Extension Center has focused on the use of peas in nutrient dense, 4-phase, early-weaned pig diets. In the first of three investigations, starter diets for 14.5 day old pigs weighing 10.8 pounds were prepared with raw or extruded peas that replaced either 30 or 50% of the diet. Overall pig performance was not improved compared to the corn / soy control diet. Within pea treatments, extrusion heat treatment did improve pig performance at the 30% replacement level. In a second investigation (Table 3), pigs weaned weighing 16 pounds were studied in which raw and extruded peas replaced 20 and 40% of the diet. Overall, the 40% replacement level depressed growth and efficiency.

Within pea replacement, extrusion improved pig performance at both the 20 and 40% levels. Replacing 20% of the diet with either raw or extruded peas resulted in nearly comparable performance to that of the corn / soy control diet.

A third evaluation (Table 4) was conducted to determine timing for introduction of extruded peas in an early weaning program. Fourteen day old pigs weighing 11.8 pounds were fed a nutrient dense 4-phase starter program over 35 days. Pigs received either a corn / soy control diet, a 20 percent extruded pea diet initiated at weaning, or a combination diet in which pigs received the corn / soy control diet for the first two weeks post weaning followed by the 20% extruded pea diet for the remaining three weeks of the 35 day starter period. At the time the pigs were switched

Table 3. Early-weaned pig response to raw and extruded field peas (Landblom and Poland, 1997).

	Corn/Soy	20% Raw	20% Extruded	40% Raw	40% Extruded
Start Wt., lb.	16.3	16.2	16.2	16.3	16.2
28 Day Wt., lb.	37.0	35.1	36.2	30.6	34.0
Gain / Hd., lb.	20.7	18.9	20.0	14.3	17.8
ADG, lb.	.73	.68	.71	.51	.64
ADFI, lb.	1.25	1.18	1.30	1.02	1.18

Table 4. Timing of pea application for pigs weaned at 14 days of age (Landblom and Poland, 1997).

	Corn/Soy	20% Extruded Pea at Weaning	Corn/Soy Wks 1 & 2; Extruded Pea 20% Wks 3-5
Start Wt., lb.	11.3	11.2	11.2
35 Day Wt., lb.	35.0	32.5	36.6
Gain, lb.	23.7	21.3	25.4
ADG, lb.	.68	.61	.73
ADFI, lb.	1.14	1.09	1.20
Feed:Gain, lb.	1.68	1.79	1.65

from the control diet to the extruded pea regime, they were 28 days of age and weighed 25 pounds. Thirty-five day pig growth and efficiency favored the time delayed combination method.

In practical, nutrient dense, phase-fed, pig starter programs it is suggested that pea replacement in the total diet not exceed 20% for extruded peas and 15% for raw peas. Data has shown that peas can be fed to very young pig immediately after weaning; however, best performance and efficiency will be obtained using a 20 / 20 rule in which peas are withheld from pigs until they have attained 20 days of age and 20 pounds body weight.

Growing-Finishing Pig Diets

Worldwide, the majority of all peas are fed to growing-finishing pigs for several reasons: 1) It is a time during the pig's growth profile when digestive enzyme turnover is complete. 2) Growing pigs over 10 weeks of age are more tolerant to low levels of ANF. 3) Feed intake is greatest during the finishing period. 4) Peas have frequently been used to lower growing-finishing diet cost / unit of gain. As stated, peas are deficient in sulfur-containing amino acids, which are not generally considered to be a dietary problem in protein dense starter diets, but must be replenished in growing-finishing diets if other protein sources are being completely replaced with peas. Pig performance reported in Canadian research with 44 - 132 lb. pigs was depressed when peas replaced soybean meal; however, once methionine shortages were replenished performance was equivalent to control diets. Numerous studies with pea replacement for soybean meal in growing-finishing diets have shown, when amino acid balance is correct, peas can replace all of the protein and a portion of the basal feed grain.

Two options for replenishing sulfur containing amino acids include the addition of synthetic crystalline methionine and feeding a complementing pea / canola meal blend. Canadian research has shown that pea / canola meal blends can replace all of the soybean meal and sulfur containing amino acids in growing-finishing diets. The two protein sources complement each other because peas are a rich source of the amino acid lysine and are also high in digestible energy. Canola meal, on the other hand, is high in methionine and cystine but lower in digestible energy. Growing-finishing research conducted by Landblom et al. (2001) evaluated a pea / canola meal blend that was further enhanced with the enzyme additives phytase and xylanase (Table 5). A pelleted corn / soy control diet was compared to ground meal-type pea / canola meal diets prepared with either of the enzymes alone and in combination. Pelleting improved growth and efficiency for pigs receiving the control diet. All pigs performed very well using pea / canola diets and adding phytase and xylanase enzymes enhance d growth and feed efficiency further.

The energy content of canola meal is approximately 14.3 percent lower than peas. Therefore, a balanced amino acid profile using a peas and canola meal, that doesn't compromise total dietary energy is essential to obtain optimum growth performance. Table 6 shows an example of typical levels for peas and canola meal in barley and corn diets that do not compromise dietary energy.

Review of a number of studies show pea inclusion levels range from 35 to 40% of the diet during the grower phase and from 10 to 43% during the finishing phase. Variations in the level of peas added in diet formulations is based on the targeted growth phase and protein supplementation needs of the basal grain. For example, wheat and hull-less oat growing-finishing

Table 5. Growing-finishing performance of a pea/canola meal blend and enzyme enhancement.

	Corn/Soy	Pea /CM	Pea /CM + Xylanase	Pea/CM + Phytase	Pea/CM + Xylanase & Phytase
Physical Form	Pel	Meal	Meal	Meal	Meal
Start Wt., lb.	67.22	66.3	67.3	67.3	67.8
Final Wt., lb.	292.5	260.2	268.4	268.6	274.2
Gain, lb.	225.3	193.9	201.1	201.3	206.4
ADG, lb.	2.56	2.20	2.29	2.29	2.35
Fd / Hd, lb.	490.8	557.5	550.6	577.4	560.8
ADFI, lb.	5.58	6.34	6.26	6.56	6.37
Feed:Gain, lb.	2.18	2.87	2.74	2.86	2.71

(Landblom et al., 2001)

diets require less supplemental protein from pea than lower protein grains such as corn. Four-phase growing-finishing diet formulations, such as those shown in Table 7, illustrate how the nutritionist adjusts pea levels to match basal feed grains. The table also summarizes growth performance and carcass measurements resulting from the diets shown.

Table 6. Pea and canola meal inclusion levels in barley and corn grain-bases.

	Stage 1 (50-80 lb)	Stage 2 (81-140)	Stage 3 (141-190)	Stage 4 (191-250)
Barley	64%	66%	71%	73%
Peas	22%	23%	22%	20%
Canola Meal	12%	9%	5%	5%
Corn	50%	53%	57%	59%
Peas	36%	34%	31%	30%
Canola Meal	12%	11%	10%	9%

Table 7. Pea inclusion levels in four-phase diets prepared with barley, corn, and naked oats. (Landblom and Poland, 1998).

Phase 1 (50-80 lb)	Diet 1	Diet 2	Diet 3	Phase 2 (81-140 lb)	Diet 1	Diet 2	Diet 3
Peas	35	35	35	Peas	10	25	40
SBM	—	—	8	SBM	—	—	4
Corn	—	—	54.3	Corn	—	—	53.8
Barley	—	62.2	—	Barley	—	72.5	—
Naked Oats	62.4	—	—	Naked Oats	87.4	—	—
Phase 3 (141-190 lb)				**Phase 4 (191-250 lb)**			
Peas	10	15	43	Peas	10	10	40
Corn	—	—	55.1	Corn	—	—	58.0
Barley	—	82.8	—	Barley	87.8	—	—
Naked Oats	87.8	—	—	Naked Oats	—	87.9	—

Growing-finishing performance resulting from the four-phase diets.

	Barley/Pea	Corn/Pea	Naked Oat/Pea
Start Wt., lb.	56	56	57
Final Wt., lb.	253	256	261
Gain, lb.	197	200	204
ADG, lb.	1.81	1.95	2.02
ADFI, lb.	6.35	6.03	5.59
Feed:Gain, lb.	3.51	3.0	2.77

Carcass measurements resulting from the four-phase diets.

	Barley/Pea	Corn/Pea	Naked Oat/Pea
Hot Carcass Wt., lb.	184	183	185
Percent Yield, lb.	74.8	74.4	75.3
Percent Lean, lb.	53.7	54.2	52.9
Fat Depth, in.	.72	.74	.80
Loin Depth, in.	2.07	2.23	2.04
Fat Free Lean Index	49.1	48.9	48.2

Carcass Quality of Pigs Finished With Peas

Research data relating to carcass quality is not nearly as extensive as that for growth and efficiency. However, data available indicates that feeding peas has no effect on backfat thickness but may increase intra-cellular fat (marbling). Carcass measurements shown in Table 7 are typical of lean growth resulting from diets formulated with peas.

Feeding Peas With Wheat Screenings

Peas are a versatile feedstuff that can be fed in dietary formulations with a variety of feed grains and by-products. A study at the Dickinson Research Extension Center looked into pig response when wheat screenings replaced 20, 40, and 60% of the corn. The level of peas was held to 20% of the diet. When corn was replaced with either 40 or 60% screenings growth performance and efficiency were depressed. However, as the price of competing ingredients increased the pea supplemented diets with either 40 or 60% screenings became cost effective choices. Thus, peas can be used in cost conserving approaches that utilize by-products like screenings.

Effect of Feeding Peas to Lactating Swine

Available data suggests peas can replace a portion of the soybean meal in sow lactation diets. Research at the Dickinson REC evaluated replacement of up to 30% of the soybean meal in lactation diets. Daily feed intake and metabolizable energy consumption were similar across treatments, suggesting pea replacements for up to 30% of the soybean meal did not compromise dietary energy consumption. Sow performance was unaffected by the level of pea grain in the lactation diet, and as such, lactation sow weight change from farrowing to weaning and days to first estrous did not differ. Sow milk composition sampled mid-lactation on day 14 for total milk solids, protein, and fat was similar to that of control sows. Sow body condition based on ultrasound backfat depth measurement was also not effected by pea replacement. Sows receiving a 10% replacement for soybean meal weaned more and heavier pigs than the other treatments and tended toward greater pig survival than the control and other levels of pea replacement. These data suggest that pork producers can replace up to 30% of the soybean meal in lactation diets with peas without compromising sow performance, milk composition, return to estrous, litter performance, and litter survival rate. Concerns raised relative to potential antigenic responses to the proteins (legumin and vicilin) in litters from sows fed pea diets are unwarranted and should not be of concern.

Effect of Feeding Peas to Breeding Swine

Specific data relative to feeding peas to breeding boars, sows, and gilts is limited. Although documented studies are not available, the large body of existing data for all other classes of swine would not cause concern among nutritionists desiring to formulate with peas. Developing formulations for breeding swine using peas would be appropriate and justified when peas are competitively priced compared to other feedstuffs.

Conclusion

Information available pertaining to feeding peas to swine encompasses all phases of production. In the past, peas have been an economical source of high quality protein and energy. However, if producers of peas are to continue growing the crop they must be adequately compensated for their production efforts. Therefore, peas of the future will likely demand a higher value in the marketplace. While there are limitations to the level of peas that can be fed to the various production classes of pigs, virtually all classes are capable of consuming some quantity of peas in their diet.
For best results, starter pigs should not consume diets containing more than 15% raw peas or 20% extruded peas. It is further suggested that early weaned pigs be at least 20 days of age and weigh a minimum of 20 pounds before receiving starter diets with peas included.
For growing-finishing pigs, substantial evidence exists demonstrating that peas can replace all of the soybean meal and a portion of the basal grain in wheat, barley, and hull-less oat grain bases, and that 4 to 8% soybean meal or other protein source will need to be added to pea / corn grower pig diets due to the low protein content of corn.
Strong supporting evidence clearly supports the use of peas and canola meal as complementing protein, energy, and mineral sources.
Lactating sows also benefit from partial replacement of 30% of the soybean meal in sow lactation diets.
All things considered, peas are an excellent feedstuff for swine.

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Field Pea in Poultry Diets

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Field peas are considered to be a relatively problem-free ingredient in poultry diets when peas are included at recommended levels. Field peas contain relatively low levels of trypsin inhibitors and spring-seeded cultivars contain less than one-half of the inhibitor levels in winter-seeded varieties. White-flowered cultivars are usually preferred for feeding to animals.

Protein content is influenced by a number of factors and amino acid content may be predicted using linear equations when crude protein (nitrogen) content is known.

Two extensive reviews of the literature on feeding peas to poultry are available (Castell et al., 1996; Fleury, 1998) and relatively little new information is available. As a result of these two reviews, information in this review has been typically limited to references containing publication dates of 1997 or more recent.

Introduction

The short digestive tract of poultry and the sequence in which ingesta is exposed to enzymatic processes and to mastication (reduction in particle size) are unique among the species discussed in this publication. The short transit time (short residence time in the digestive tract) places a premium on feedstuffs that are rapidly digested to permit absorption of the nutrients that are released.

The production of table eggs brings an emphasis on external and internal visual quality of the product. Examples of desirable visual characteristics for table eggs include color of the yolk and albumin, absence of inclusion bodies in the albumin, durable shells, and shells devoid of undesired pigmentation. When diets are fed to breeder hens, fertility of the egg becomes the major factor.

Pigmentation of body fat, skin, and shanks in broilers is a consideration that is influenced by the region where the product is consumed. Yellow pigmentation is preferred in the U.S. while other regions may prefer non-pigmented broiler products.

Skeletal soundness is desired in broilers and in turkeys to maintain value of the product. Turkeys, however, are often fed diets containing a number of ingredients that would not typically be present in the diets of broilers of laying hens. Nutritional management of broilers and turkeys may include moderate limitation of rate of gain during early growth to promote skeletal soundness. Early restriction of protein content of diets to permit subsequent compensatory growth is more widely practiced with turkeys than with broilers.

More is known about the nutritional requirements of poultry than other species. As a result, large breeding companies may provide information on recommended nutrient allowances or nutrient concentrations for birds of the various strains that they produce. If available, these nutritional recommendations should be consulted in formulating diets for poultry.

Laying hens

Yellow-, green-, and brown-seeded peas were fed at levels of 0%, 20%, 40% and 60% of the diet as substitutes for wheat and soybean meal by Igbasan and Gunter (1997a). When peas were fed at 20% of the diet, egg production, production of egg mass and feed conversion were increased relative to the wheat-soy control diet. At 40% of the diet, diets containing peas produced performance similar to that of the control diet. When diets contained 60% peas (total replacement of soybean meal), egg production, production of egg mass, and feed conversion were not equivalent to the control diet. Egg yolk color was improved as the level of peas was increased in these wheat-based diets. Shell quality was reduced by increasing levels of yellow- and brown-seeded peas but not by green-seeded peas. These authors concluded that yellow-, green-, or brown-seeded peas could be included at levels up to 40% of the diet without influencing production performance.

These authors (Igbasan and Gunter, 1997b) have reported that micronization, an infrared heat treatment, improved the feeding value of peas for laying hens but that dehulling or a crude pectinase enzyme supplement were not effective in improving hen performance. Perez-Maldonado et al (1999) reported that the viscosity of intestinal contents from hens fed diets containing 25% field peas was higher than when 25% faba beans or chickpeas were fed but lower than when the diets contained 25% lupins.

Broilers

Richter et al. (1999) reported that enzyme mixtures improved weight gain by 2.5% when broiler starter and finisher diets contained 29% peas. In contrast, Igbasan et al. (1997) reported that pectinase or a combination of pectinase and alpha-galactosidase enzymes did not significantly improve growth rate, feed intake, or feed conversion in a two-week study. Nimruzi (1998) reported that fig powder acted as a source of enzymes that reduced intestinal viscosity and improved digestibility when diets containing peas were fed to broilers.

Apparent ileal digestibility of protein from “coarse” peas was less than that of “fine” peas (70.2% vs 89.5%, respectively), although a decrease in protein digestibility between the ileum and excreta was noted for diets containing peas of the smaller particle size (Crevieu et al., 1997a). Crevieu et al. (1997b) detected small amounts of proteins that were resistant to hydrolysis but concluded that these represented only a small amount of the material present in the terminal ileum. Incorporation of dehulled peas at 70% of the diet resulted in acceptable performance of broilers (Daveby et al., 1998) and a response to alpha-galactosidase was observed with a small particle size produced by grinding. No response to the enzyme addition was obtained with the larger particle size of crushed peas.

Combining equal parts, by weight, of whole canola seeds with peas resulted in a linear reduction in weight gain of broilers (0 - 20 days or 20 - 40 days) when levels of 0%, 10%, 20%, or 30% were fed (Fasina and Canpbell, 1997b). This effect was presumably due to a curvilinear decrease in intake with increasing levels of the whole canola / pea blend. Pelleting the whole canola / pea blend improved performance (Fasina et al., 1997). Farrell et al. (1999) reported that steam pelleting of field peas improved growth rate and feed conversion of broilers and recommended an upper inclusion rate of 30% of the diet for broilers.

Turkeys

Czech workers (Mikulski et al., 1997) reported that 20 - 24% peas could be used to replace part of the soybean meal in diets for growing turkeys without adversely affecting performance, dressing percentage, or meat quality. These values are similar to the recommendations of Castell et al. (1996) of the use of peas as 25% of the diet for turkeys.

Practical experience

Field peas may be considered to be an energy source containing moderately high levels of crude protein rather than a protein feedstuff because the protein content approximates the protein requirement for most classes of poultry, except laying hens.

The use of high levels of field peas (20% - 30%) may result in a slight increase in viscosity of the digesta, but this increase is considerably lower than that associated with feeding several other feedstuffs. Some commercial enzyme supplements containing xylanases and beta-glucanases have been reported to reduce the viscosity of intestinal contents and increase protein digestibility when diets containing high levels of peas have been fed. At the highest levels of recommended use, litter in the poultry house may contain slightly more moisture than when conventional feedstuffs are fed without enzyme supplementation. Management practices may dictate whether or not this is a factor to be considered in individual poultry enterprises.

Levels Recommended in Diets for:

Layers

Diets for layers frequently contain up to 10% field peas as a slight decrease in the rate of lay (typically 2.5% to 3%) is observed when higher levels of peas are fed. Dietary levels of peas greater than 10% may be used when economic conditions favor the use of lower cost diets and the slight reduction in rate of lay results in comparable or reduced feed cost per dozen eggs produced. Under favorable economic conditions, layer diets may contain up to 30% peas (Castell et al., 1996).

Broilers

Diets for broilers often contain up to 30% field peas without effect on performance when equivalent nutrient concentrations are fed. However, an upper limit of 20% field peas in diets for broilers was suggested by Castell et al. (1996).

Turkeys

Diets for turkeys may contain higher levels of field peas as the birds mature and approach market weights. Little research is available on feeding field peas to turkeys. Birds weighing more than 12 to 16 pounds could receive diets containing at least 30% field peas when economic conditions are favorable, although Castell et al. (1996) suggested an upper limit of 25% of the diet. Upper limits of inclusion may be influenced by management conditions if moist droppings are encountered.

Variations in Energy Available Compared to Other species

The energy content of field peas for poultry, as for other ingredients, is lower than that of other species discussed in this publication because of the shorter length of the digestive tract and the more rapid rate of passage. As a point of reference, field peas contain available energy levels comparable to those of barley and cottonseed meal.

Variations in energy content have been attributed to color of inflorescence, color of seed, season of seeding (spring vs winter) and variety. The available literature suggests that white-flowered, yellow-seeded cultivars may be preferred, when available. Smooth-seeded varieties contain more digestible or metabolizable energy but less crude protein and amino acids than wrinkled-seeded varieties.

When field peas are fed in combination with feedstuffs containing restricted levels of energy, supplementation with fats or oils is suggested to increase the energy content of the diets and produce improved feed conversion ratios.

Amino Acid Supplementation

Field peas, like other legume seeds, are first-limiting in methionine and the sequence of limiting amino acids in diets containing peas will be influenced by the other ingredients in each diet. When formulating diets for poultry, the use of diet formulation software or a spreadsheet containing analytical information for all amino acids required by poultry is suggested to avoid neglecting or ignoring consideration of all amino acids required by poultry. In the absence of accurate analytical information for the field peas to be fed to poultry, standard reference tables (NRC, 1994) may be used to provide estimated analyses.

Processing

Feed intake in poultry is acutely influenced by particle size and the production of "fines" is to be avoided during grinding unless the diets are to be pelleted. Field peas are a low-fiber ingredient and should be easily ground in well-maintained equipment and at moisture levels where storage is not a problem. Grinding to an extremely small particle size is not economical and may lead to interference with feed intake due to buildup of material in the beak. Beak necrosis has been suggested to be one result of impaction of small particles in the beak.

Some reports have suggested that attention should be given in the feed mill when diets containing more that 20% field peas are pelleted. In contrast, formulations containing peas as the major source of energy and protein have been pelleted without difficulty (K.B. Koch, personal communication, May 11, 2001).

The experience of the pellet mill operator, operating conditions, and particle size of the ingredients may be factors in successful pelleting of diets containing peas.

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Field Pea in Sheep Diets

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Field pea production in North Dakota is increasing as growers realize the agronomic benefits of field peas as a legumious crop in rotation systems. Field peas are grown primarily for the human food market, but surplus grain or grain which does not make human food grades can and is used in livestock rations. Field pea grain is high in crude protein (CP) (Table 1) and high in rumen degradable protein (NRC, 1989). The starch content is 54% (McLean et al., 1974) and the net energy for gain (NE_g) is 0.67 Mcal/lb (NRC, 1989).

Previous research has focused on using field pea as a protein source in diets for nonruminants (Gatel, 1994) and dairy cattle (Corbett et al., 1995). Field pea has been shown to be an effective replacement for 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 nonruminant diets have been suggested to be 25.0 to 33.3% (Castanon and Perez-Lanzac, 1990; Perez-Maldonado et al., 1999; and 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 0.71 Mcal / lb (calculated from Bock et al., 2000).

Three studies have been conducted at North Dakota State University using field peas in sheep diets. All three research projects have focused on the use of field peas in diets for growing and finishing lambs.

Experiment One

One hundred Columbia crossed lambs (74.7 ± 2.9 lb initial body weight, BW) were fed for 89 days to evaluate the energy value and optimal inclusion level of field peas in diets fed to feedlot lambs (Loe et al., 2001). Four dietary treatments were fed where dry-rolled field pea (cv. Profi) replaced dry-rolled corn (DRC) at 0, 15, 30, or 45% of the diet on a dry matter (DM) basis. Diets contained 75% DRC or field pea, 10% alfalfa hay, 5% concentrated separator by-product (CSB), and 10% supplement. Field pea was cracked in half by processing through a single stage roller mill. Diets were formulated to contain a minimum 15% CP, 0.7% Ca, 0.36% P, 1.22% K, 1.74 Ca:P, and 12 mg / lb lasalocid. Performance data is reported in Table 1. Calculated net energy values are presented in Table 2.

Table 1. Effect of treatment on feedlot performance in Experiment 1.

	Field pea in diet, % DM basis					Contrast		
Item	**0**	**15**	**30**	**45**	**SEM[a]**	**Linear**	**Quadratic**	**Cubic**
Weight, lb								
Initial	73.9	75.6	72.3	77.2	2.87	0.61[b]	0.56	0.33
Final	135.2	141.8	138.3	144.9	3.53	0.14	0.99	0.24
Dry matter intake								
lb / day	3.51	3.66	3.42	3.57	0.07	0.97	0.99	0.02
% of BW	3.35	3.36	3.26	3.23	0.07	0.15	0.81	0.51
ADG, lb	0.68	0.75	0.75	0.75	0.04	0.25	0.63	0.65
Gain:Feed, lb / lb	0.197	0.205	0.218	0.213	0.010	0.22	0.52	0.63

[a] n = 5.
[b] Probability of greater F.

Experiment Two

One hundred Columbia crossed ram lambs (86.2 ± 0.5 lb initial BW) were blocked by weight and allotted randomly to dietary treatment (five pens / treatment and four lambs / pen; Loe et al., 2001). 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 were similar to Exp. 1; however, an additional treatment was added where dry-rolled field pea replaced DRC and all SBM (45–SBM). This diet was added to evaluate if RDP was overfed in the 45% field pea diet, limiting performance. Performance data is reported in Table 3. Calculated net energy values are presented in Table 4.

Experiment Three

Two hundred and forty lambs (wethers and ewes) were used to evaluate the use field peas as a replacement for soybean meal and barley in lamb diets (Poland and Faller, 1998). Lambs were allotted by weight and sex into eight pens (2 pens / treatment). The control diet contained 81% concentrate (72.6% barley and 8.4% soybean meal). Peas replaced barley and soybean

Table 2. Effect of treatment on dietary net energy in Experiment 1.

	Field peas, % DM basis					Contrast		
Item	0	15	30	45	SEM[a]	Linear	Quadratic	Cubic
NE_m[b], Mcal / lb	0.94	0.98	1.01	1.02	0.03	0.10[c]	0.73	0.95
NE_g[d], Mcal / lb	0.63	0.67	0.70	0.69	0.03	0.10	0.69	0.90

[a] n = 5.
[b] Net energy for maintenance.
[c] Probability of greater F.
[d] Net energy for gain.

Table 3. Effect of treatment on feedlot performance in Experiment 2.

	Field peas, % DM basis			45	45		Contrast			
Item	0	15	30	+SBM	–SBM	SEM[a]	Lin	Quad	Cub	± SBM
Weight, lb										
Initial	86.2	87.8	86.2	86.2	86.0	0.44	0.98[b]	0.73	0.66	0.81
Final	135.2	137.4	137.2	133.2	137.2	2.01	0.50	0.14	0.93	0.18
Dry matter intake										
lb / day	3.48	3.66	3.46	3.48	3.44	0.11	0.52	0.28	0.86	0.86
% of BW	3.19	3.28	3.12	3.17	3.10	0.09	0.76	0.26	0.61	0.61
ADG, lb	0.78	0.81	0.81	0.74	0.83	0.031	0.49	0.15	0.85	0.15
Gain:Feed, lb / lb	0.223	0.223	0.233	0.217	0.237	0.008	0.82	0.35	0.32	0.10

[a] n = 5.
[b] Probability of greater F.

Table 4. Effect of treatment on dietary net energy in Experiment 2.

	Field peas, % DM basis			45	45		Contrast			
Item	0	15	30	+SBM	–SBM	SEM[a]	Lin	Quad	Cub	± SBM
NE_m[b], Mcal / lb	1.05	1.04	1.09	1.01	1.10	0.03	0.63[c]	0.25	0.24	0.05
NE_g[d], Mcal / lb	0.73	0.73	0.77	0.70	0.78	0.03	0.62	0.24	0.24	0.05

[a] n = 5.
[b] Net energy for maintenance.
[c] Probability of greater F.
[d] Net energy for gain.

meal in incremental levels at 0, 8.8, 17.7, and 26.5% peas were included in the diets (DM basis). Lambs were fed of 90 days. Performance data is reported in Table 5.

Results and Recommendations

Peas appear to have a net energy value at least equal to corn in most research conducted in North Dakota. Based on lamb performance (Exp. 1) there was 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 45% - SBM compared with 45% +SBM.

Average calculated NE_m and NE_g for field pea were 1.25 and 0.92 Mcal / lb, which was 14% greater than corn. Field pea is a suitable replacement for corn in lamb finishing diets.

Peas appear to be an excellent source of energy, protein, and other nutrients. Use in sheep diets is likely dictated by cost of nutrients in other available feedstuffs. To our knowledge no research has investigated the use of field peas in diets for gestating or lactating ewes. However, based on these data sets in growing and finishing lambs, and data generated in other species, no problems would be anticipated with their use in ewe diets.

Table 5. Effect of treatment on feedlot performance in Experiment 3.

	Field pea in diet, % DM basis				
Item	**0**	**8.8**	**17.7**	**26.5**	**SEM**
Weight, lb					
Initial	75.4	71.2	72.3	72.1	0.93
Final	104.3	107.6	110.0	111.6	6.53
Dry matter intake, lb / day	3.57	3.73	3.70	3.74	0.05
ADG, lb	0.33	0.40	0.42	0.44	0.07
Gain:Feed, lb / lb	0.092	0.109	0.113	0.119	0.015

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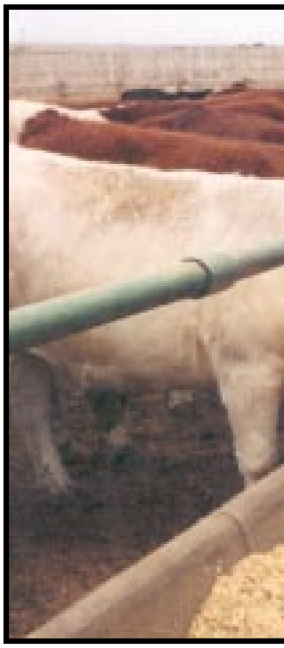

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