Utilization of Wheat Screenings, Field Peas, and Canola Seed as Replacements for Corn and Soybean Meal in Growing-Finishing Pig Diets

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Abstract

Two performance experiments were conducted with growing-finishing pigs to determine the effects of adding various levels of wheat screenings to meal-type diets based upon corn and soybean meal when the diets also contained field peas and full-fat canola seed.

Under outdoor growing-finishing conditions, pigs that received a pelleted corn/soy external control diet gained faster (P<.01) and were more efficient than pigs receiving peas, canola, and screenings. Feeding a pea-corn control diet without wheat screenings was more efficient and promoted faster gain (P<.01)and improved efficiency (P<.001). Feed efficiency declined linearly as the level of screenings increased.

In confinement, pigs receiving the corn/soy external control diet also grew faster (P<.03) and were more efficient (P<.01) than pigs receiving peas, canola, and screenings. Rate of gain was comparable for all treatments containing field peas and full-fat canola seed (0, 20, 40, or 60% wheat screenings). However, substituting increasing levels of wheat screenings (up to 60% of the diet) increased the feed required per unit of gain (P<.05).

Meat color was the only carcass criteria influenced by diet (P<.01), which declined as dietary level of screenings increased.

Carcass measurements among outdoor pigs did not differ for most criteria. Control pigs that did not receive any level of screenings were higher yielding (P=.055). Loin depth was also greater among control pigs (P<.05), however, fat free lean index did not differ between treatments.

Digestibility analysis was conducted to determine test ingredient digestibilities. Relative to corn, digestibility values for wheat screenings, field peas, and canola seed were dry matter (87.1, 95.1, and 74.1%), acid detergent fiber (74.0, 101.4, and 83.6%), crude protein (97.8, 108.2, and 111.9%), and energy (92.1, 96.9, and 107.7%), respectively.

Economic analysis demonstrated that under certain ingredient price relationships wheat screenings inclusion can result in the highest gross return over feed. To assist pork producer risk management, a Microsoft Excel® ingredient forecasting model has been developed based on feed efficiency, ingredient pricing, lean meat carcass base price, yield value, percent lean value, and sort margin values obtained in this study. Click here to download that Excel file.

Introduction

The increasing number of crop production alternatives provides livestock producers with a greater number of options for energy and protein sources in diets or rations for their livestock. As these alternative feedstuffs become available, it is necessary to have as much information as possible about these feedstuffs as individual ingredients and in combination with other feeds.

Wheat screenings have been available for many years as an alternative energy feed that is usually higher in crude protein than the grains that they replace. Because screenings are expected to contain less energy than the grains that they replace, performance of growing-finishing swine may be reduced unless supplemental energy is added.

Field peas have the potential for replacing a portion of the soybean meal used in swine diets when a source of supplemental methionine is available.

Canola seed offers opportunities to provide supplemental energy when wheat screenings are included in swine diets and for providing some supplemental methionine when field peas are incorporated into swine diets.

The experiments reported here were conducted to determine the effectiveness of combinations of wheat screenings, field peas, and canola seed as partial replacements for corn and soybean meal in diets for growing-finishing pigs. And to develop an ingredient forecasting model.

Materials and Methods

General Procedures: Two experiments, one at each location, were conducted with growing-finishing pigs. One hundred five pigs were utilized at the Dickinson location while 160 pigs were used in the equivalent experiment conducted at Fargo. Average initial and final weights were 44 lb and 258 lb at Dickinson and were 40 and 240 lb, respectively, at Fargo.

Diets used in the growing-finishing experiment were:

1) A pelleted corn-soy reference diet;

2) A corn-soy diet base containing 20% field peas and 7.5% canola seed;

3) A corn-soy diet base containing 20% field peas, 20% screenings, and 15% canola seed;

4) A corn-soy diet base containing 20% field peas, 40% screenings, and 15% canola seed; and

5) A corn-soy diet base containing 20% field peas, 60% screenings, and 15% canola seed.

Diet formulations for the growing phase (40 to 120 pounds) are presented in Table 1. The composition of the diets fed during the development phase (120 to 190 pounds) and the finishing phase (190 pounds to market weight) were similar, but contained lower levels of crude protein, amino acids, calcium, and phosphorus.

Diet 1 was ground, mixed, and pelleted by the Northern Crops Institute at Fargo to serve as an internal control diet between, as well as within, each location. The remaining diets were fed in meal form and were ground and mixed locally. Single-source samples of wheat screenings, field peas, and canola seed were used for both locations.

The screenings used in these experiments contained 32.82% wheat, 8.72% chaff and straw, 7.84% wild oats, 3.13% wild buckwheat, and 47.49% miscellaneous weed seeds (primarily green and yellow foxtail).

Dietary treatments were randomly assigned to pens within weight replicates and individual pigs were assigned at random to pens within outcome groups based on weight, gender, and ancestry.

Carcass data from pigs in the experiment conducted at Dickinson were obtained from pigs slaughtered at John Morrell Packing, Sioux Falls, SD. Carcass information from pigs used in the experiment at Fargo was obtained from pigs processed at the NDSU abattoir.

In addition to the growth experiments conducted at each location, a digestibility experiment was conducted at Fargo to determine the digestibility of selected nutrients in the wheat screenings, field peas, and ground canola samples. Each test ingredient was added as a percentage of the body weight of individual pigs to supplement a basal diet formulated to meet the requirements of growing pigs for all nutrients except energy. Nutrient digestibility was calculated on a dry matter basis. The digestibility of nutrients in the test ingredients was determined by the difference between total excretion of undigested nutrients and the excretion of undigested nutrients provided by the basal diet.

Economic analysis to identify the value of replacing corn with wheat screenings was conducted using ingredient sensitivity analysis. Based on feed efficiency, ingredient pricing, carcass base price, yield value, percent lean value, and sort margin an ingredient forecasting model was prepared.

Results and Discussion

Animal performance from the experiment conducted at Dickinson: Combined data (Table 2) for pigs grown to market weight in outdoor facilities revealed that pigs fed the pelleted corn-soy and mash-type corn-pea control diets grew faster (P<.01) than pigs fed diets containing screenings. Pigs fed the pelleted control diet, however, were more efficient than any of the pigs receiving peas and screenings (P<.01). Diets in which peas and canola were fed with 0 to 60% wheat screenings had significant variation. Pigs receiving the corn-pea control diet (mash-type) diet grew faster (P<.01) and were more efficient (P<.001) than pigs fed any of the test levels of wheat screenings. Feed efficiency in the presence of screenings declined linearly as screenings level increased (P<.001).

While feed efficiency declined with increasing level of screenings, only minimal differences were recorded with respect to carcass characteristics. Percent lean, fat depth, and fat-free lean index did not differ. Carcasses from pigs fed the control diets (pelleted or mash) had greater loin depth (P<.10) than those receiving screenings, however fat depth was similar.

Animal performance from the experiment conducted at Fargo: For the complete period of the experiment, pigs receiving the pelleted corn-soy diet gained more rapidly and had lower feed:gain values than pigs fed the meal-type diets. Within the diets containing field peas and canola but with varying levels of wheat screenings, rate of gain values did not differ significantly (P>.05). However, the pigs receiving the diet containing 60% screenings were less efficient than pigs fed the diets containing either 20% screenings or no screenings (P<.05).

There were minimal differences in most carcass measurements (hot or cold carcass weight; carcass length; backfat at the first rib, tenth rib, or last rib; muscle pH, or area of the loin muscle). For backfat depth measured at the last lumbar vertebrae, fat depth increased linearly as percentage of screenings in the diet was increased (P<.05). No explanation for this effect is immediately apparent.

There were no differences in subjective color, firmness, or marbling scores due to dietary treatment (P>.05). However, diet influenced color values determined objectively (Minolta) (P<.01).

Digestibility Study: Digestibility analysis of corn, wheat screenings, field peas and whole canola seed is shown in Table 4. Compared to corn, dry matter digestibility for screenings, peas, and canola seed was 87.1, 95.1, and 74.1%, respectively; for acid detergent fiber, digestibility was 74.0, 101.4, and 83.6%, respectively; for crude protein, digestibility was 97.8, 108.2, and 111.9%, respectively; and for energy (kcal/kg), digestibility compared to corn was 92.1, 96.9, and 107.7%, respectively. Considering all criteria, field peas are the most desirable ingredient followed by whole canola seed. While digestibility results for wheat screenings suggest less desirable growth and efficiency performance can be expected, economic analysis identified certain ingredient pricing situations when wheat screenings are economically the best option.

Economic analysis: Price sensitivity analysis revealed contrasting results. In the first analysis, ingredients were priced as follows: corn - $2.856/bu., soybean meal - $207/ton, peas - $5.40/cwt., screenings - $35/ton, and canola seed - $150/ton. Using these pricing relationships, feeding a 60% wheat screenings diet priced at $35/ton resulted in the highest gross return. The following price changes would have to occur before diet 1(20% peas, no screenings) would yield the highest gross return: The price of corn would have to fall from $2.856 to $2.267/bu., screenings would have rise to $54.00/ton, peas would have to rise to $8.40/cwt., soybean meal would drop to $140/ton, and canola would have to increase to $230/ton. This particular set of price relationships is very stable, as it would take a significant change in any one of the major ingredients to effect a change in the highest gross margin to another diet.

In the second analysis, ingredients priced as follows: corn - $2.05, soybean meal - $178/ton, peas -$3.834/cwt., screenings - $25/ton, and canola seed - $160/ton. Using this price grouping, the control diet that contained no screenings yielded the highest gross return. In order for the 60% screenings diet to displace the control diet the following would have to occur: corn would have to rise $.03/bu., screenings would have to decrease $1/ton, peas would have to rise to $4.25/cwt., soybean meal would have to increase to $183/ton, and canola seed would have to decrease $5/ton.

The two scenarios analyzed demonstrate that as ingredient prices fluctuate quite different outcomes occur. Being able to forecast gross return over feed costs involves not only animal response to the different dietary levels of screenings, but also carcass returns as influenced by base carcass price and premium and discount adjustments that arise from sort margin, carcass yield, and carcass percent lean. To better address the user's needs, a downloadable ingredient forecasting model spreadsheet (Microsoft Excel®) has been developed and can be accessed by clicking the forecast model button at the end of this report. Users of the ingredient forecasting model can modify both ingredient and base lean meat carcass prices to determine an estimate of net return less feed costs over an infinite range of ingredient and carcass prices.

Implications

Data from these experiments suggest that combinations of wheat screenings, field peas and canola seed can be used effectively by growing-finishing swine, and that daily gain likely will not be effected appreciably by increasing levels of wheat screenings from 0 to 60%. However, feed efficiency can be expected to decline. While efficiency of feed utilization was impacted, the data further suggests that economically important carcass characteristics would not be expected to differ appreciably when wheat screenings are included as a significant portion of the diet. Objective muscle tissue color was influenced negatively as wheat screenings level increased.

Price sensitivity analysis demonstrated that ingredient price fluctuations for the feeds evaluated in this study impact economic returns. Being able to forecast gross return over feed costs prior to pigs being put on feed is a useful tool for managing risk. To aid pork producers' risk management and establishment of "Put Option Basis" with the test ingredients (field peas, corn, full-fat canola seed, wheat screenings, and soybean meal), an ingredient forecasting model has been prepared in Microsoft Excel® format. By inputting current feed placement costs and estimated base lean meat carcass price (based on John Morrell Packing, Sioux Falls, SD) the user can rank the test diets evaluated to determine the most economically viable dietary formulation over an infinite number of feed and lean meat carcass prices. Application of the model's power is maximized when producers determine gross return over feed with the ingredients evaluated before feeder pigs are placed on feed. The model's flexibility allows users to make price changes within three commonly accepted weight categories of 50-120 lbs, 120-190 lbs., and 190-240 lbs., which will be useful for tracking estimated economic returns as ingredient prices change during the feeding process.

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Literature Cited

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Table 1. Composition of Experimental Diets for the Growing Phase (40 - 120 pounds).

Description of Special Dietary Composition					
Level of Screenings:	External	Control	20% Screenings	40% Screenings	60% Screenings
Level of Peas	Reference	20% Peas	20% Peas	20% Peas	20% Peas
Level of Canola	(Control)	7.5% Canola	15% Canola	15% Canola	15% Canola
Physical form:	Pelleted	Mash (Meal)	Mash (Meal)	Mash (Meal)	Mash (Meal)
Ingredient (% of diet):	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Corn	69.02	52.55	33.63	20.15	1.66
Wheat screenings	0.00	0.00	20.00	40.00	60.00
Soybean meal, 44%	27.60	16.70	7.93	1.20	0.00
Field peas	0.00	20.00	20.00	20.00	20.00
Ground canola seed	0.00	7.50	15.00	15.00	15.00
L-lysine HCl	0.20	0.12	0.30	0.47	0.45
DL-Methionine	0.10	0.12	0.14	0.17	0.17
L-Threonine	0.03	0.05	0.12	0.20	0.17
L-Tryptophan	0.00	0.01	0.03	0.06	0.05
Dicalcium phosphate	1.45	1.40	1.35	1.20	0.95
Limestone	0.80	0.75	0.70	0.75	0.75

Salt	0.35	0.35	0.35	0.35	0.35
Vitamin & t.m. premix	0.30	0.30	0.30	0.30	0.30
Antibiotic	0.15	0.15	0.15	0.15	0.15
Total	100.0	100.0	100.0	100.0	100.0

Table 2. Growing-finishing pig response to increasing levels of wheat screenings in 3-Phase corn-pea diets fed outdoors (Dickinson Research Extension Center).

Treatments:	**Corn/Soy (Pelleted)**	**Corn/Pea (Meal)**	**Corn/Pea20% Scrn (Meal)**	**Corn/Pea40% Scrn (Meal)**	**Corn/Pea60% Scrn (Meal)**	**Control vs Pea**	**Control vs Screen**	**Scrn. vs Linear**	**SE**
Growth:									
Initial Wt., lbs	42.0	42.5	44.0	43.7	47.0				
Final Wt., lbs	259.8	258.8	252.0	256.5	260.8				
Days Fed	106.3	108.6	109.6	115.4	112.4	NS	.009	.046	1.67
Gain/Head, lbs	217.8	216.3	208.0	212.8	213.8	NS	NS	NS	NS
ADG, lbs	2.05	1.99	1.90	1.84	1.90	NS	.004	.085	.039
Feed/Head, lbs	568.8	651.6	673.6	725.1	778.8	.002	.0001	.0001	14.1
Feed/Head/Day, lbs	5.35	6.0	6.15	6.28	6.93	.006	.0001	.0006	.133
Feed:Gain, lbs	2.61	3.01	3.24	3.41	3.64	.003	.0001	.0001	.071
Carcass:									
Slaughter Wt., lbs.	253	250	244	248	253				
Hot Carcass Wt., lbs	180	184	176	179	179	NS	NS	NS	2.87
Percent Yield	71.2	73.4	71.9	72.4	70.9	.043	NS	.055	.477
Percent Lean	53.8	53.9	54.0	53.6	53.9	NS	NS	NS	.60
Fat Depth, in	.69	.73	.68	.70	.69	NS	NS	NS	.033

Loin Depth, in	2.08	2.10	1.99	2.03	1.96	NS	.061	.054	.031
Fat Free Lean Index	49.3	49.0	49.3	49.2	49.4	NS	NS	NS	.394

Table 3. Growing-finishing pig response to increasing levels of wheat screenings in 3-Phase corn-pea diets fed in confinement (Fargo).

Level of Screenings: Diet Base:	None Corn/Soy	None Corn/Pea	20% Corn/Pea	40% Corn/Pea	60% Corn/Pea	
Growth:						
ADG, lb.	1.98	1.87	1.84	1.88	1.82	P<0.03
ADFI, lb.	4.89	4.81	4.78	5.01	5.16	N.S.
F/G	2.48	2.58	2.60	2.67	2.84	P<0.01
Carcass:						
Hot carc. wt, lb.	187.4	187.3	191.6	185.9	187.3	N.S.
Cold carc. Wt, lb.	182.3	182.0	186.5	180.7	182.6	N.S.
1^{st} rib fat, in.	1.68	1.74	1.83	1.75	1.75	N.S.
10^{th} rib fat, in.	0.82	0.88	0.92	0.87	0.97	N.S.
Last rib fat	0.95	0.95	1.00	0.96	1.05	N.S.
Muscle pH	5.62	5.61	5.64	5.58	5.61	N.S.
LEA, sq. in.	6.61	6.45	6.75	6.58	6.46	N.S.
Color, subjective	2.00	2.31	2.18	2.06	2.37	N.S.
Firmness	2.37	2.37	2.18	2.25	2.56	N.S.
Marbling	2.00	2.25	2.00	2.06	2.43	N.S.
Color, Minolta L1	58.68	56.62	55.43	56.81	55.06	P<0.01
Color, Hunter 1	51.81	49.56	48.31	49.62	48.00	P<0.01

Table 4. Selected nutrient digestibility for corn, wheat screenings, field peas, and full-fat canola seed used in these experiments (Fargo Samples).

	Corn	Wheat Screen.	% of ***Corn***	Field Pea	% of ***Corn***	Whole Canola Seed	% of ***Corn***
Dry matter dig., %	87.85	76.54	***87.1***	83.56	***95.1***	65.09	***74.1***
Acid-detergent fiber dig., %	68.01	50.31	***74.0***	68.93	***101.4***	56.88	***83.6***
Crude protein dig., %	66.77	65.28	***97.8***	72.23	***108.2***	74.73	***111.9***
Digestible energy,	3.701	3.410	***92.1***	3.585	***96.9***	3.987	***107.7***

Click Here for ingredient forecasting model in Microsoft Excel® format