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SUPPLEMENTING GRAIN ENERGY SOURCES WITH FIELD PEAS AND FULL-FAT CANOLA SEED IN SWINE GROWING-FINISHING DIETS

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RESEARCH SUMMARY

Two growing-finishing experiments were conducted using feeder pigs from matings between PIC 326 boars and Camborough 22 females (Exp 1: n=75, Exp 2: n=84).

Experiment 1

The effects of dietary energy source on growth, carcass characteristics and feeding economics were evaluated when supplemented with field pea (*Pisum sativum* 'Profi'). Energy sources evaluated were: (1) barley (*Hordeum vulgare*)-pea, (2) corn (*Zea mays, indentata*)-pea, naked oat (*Avena sativa* 'Paul')-pea, barley/corn-pea, and barley/naked oat-pea. Compared to the other test grains, barley-fed pigs grew faster (P<.05), required less days on feed (P<.05), and were more efficient (P<.01). When corn and naked oats were compared to grain mixtures of barley and naked oats or barley and corn, no differences for any of the growth or efficiency criteria were identified. Hot carcass weight, percent yield, fat depth, loin depth, and fat free lean index (FFLI) did not differ due to dietary treatment. However, pigs fed either barley and naked oats or barley and corn had higher percent lean values (P<.02). An interaction for growth was identified such that when pigs were fed either corn or a mixture of barley and naked oats, there was a potential for greater (P<.10) feed consumption. Economically, whenever barley was included, its inclusion was associated with a reduction in feed cost per head (P<.01), and feed cost per pound of gain (P<.05). Highest returns over feed were identified where barley, barley and corn or barley and naked oats were fed.

Experiment 2

Barley-pea, corn-pea and naked oat-pea test diets were evaluated when fed to growing-finishing pigs with and without the inclusion of full-fat canola (*Brassica napus*). When compared to barley, feeding either corn or naked oats was associated with faster growth ($P<.05$) and less feed consumption per head ($P<.01$) . Compared to corn or barley, pigs fed naked oats consumed less feed per head per day ($P<.05$), and gain efficiency was markedly greater ($P<.001$). Loin depth was greater ($P<.10$) for pigs fed corn-based diets. Carcass yield and percent lean values were similar among the three test grains, but fat depth was greater ($P<.05$) for pigs fed naked oats as compared to pigs fed either barley or corn. Lower energy diets formulated with either barley or corn were associated with higher ($P<.10$) fat free lean index values.

Including 10% canola seed, as a supplemental source of methionine, in the first three dietary phases and 5% in the final finishing phase from 191-250 pounds yielded equal growth performance. Carcass quality associated with the use of canola seed was very acceptable. Including canola seed reduced fat thickness ($P<.05$) and resulted in higher fat free lean index values ($P<.05$). While favorable feeding results were obtained with raw canola seed, feed cost per head and feed cost per pound of gain were higher ($P<.05$), generating a lower return over feed. An interaction relating to the use of canola seed was identified such that when barley and canola seed are fed together, the potential for slower growth rate ($P<.05$) exists.

Results of these feeding experiments suggest that practical growing-finishing diets can be formulated with barley, corn, and naked oats when fortified with field peas as a principal protein/energy source and full-fat canola seed as a secondary source of energy and methionine. Diets formulated with either barley or naked oat and peas will meet dietary specifications without additional protein supplementation, however, the data suggests that when corn is supplemented with an upper limit of 35-40% peas, diet formulations will require an additional 8% soybean meal in the 1st grower phase, and 4% in the 2nd grower phase to replenish remaining amino acid deficiencies following pea supplementation. The data further suggests that the inclusion of 10% full-fat canola seed will contribute to meeting protein and energy needs while potentially enhancing carcass quality. Decisions as to which grain and supplements to feed will be based largely on ingredient availability and cost based on relative feed value.

INTRODUCTION

North Dakota farmers are increasing production of a number of crops that would be considered "alternatives" to small grain production. Among these new corps, a few are being grown for industrial purposes, but most have multiple human and livestock markets. Naked (hull-less) oats, field peas and un-processed (raw) full-fat canola seed are grains that hold considerable promise as livestock feed for swine in the cooler regions of the northern Great Plains.

Growing-Finishing Research. Barley is a commonly grown feed grain for pigs in North Dakota (ND Agricultural Statistics, 1997). However, in 1994, North Dakota State University released a new high quality naked oat variety, 'Paul'. 'Paul' oat contains on average 16.5% crude protein, .65% lysine, .41% methionine, 9% fat, and 1.57 Mcal ME/ pound (McMullen et at., 1997). Investigations by Swantek et al. (1996) compared replacing 50 and 100% of the corn fraction in corn/soy diets with naked oats to determine the grain's substitution value. They determined that naked oats could replace all of the corn with respect to gain, feed intake, and feed efficiency, but that fat depth increased and percent muscling decreased with increasing levels of naked oats, indicating that proper nutrient:energy relationships needed to be maintained to avoid jeopardizing carcass quality. In a second study by Harrold et al. (1998), pelleted barley diets formulated with increasing levels of naked oats (0, 25, 50, 75 and 100%) were compared to a corn/SBM external control diet. Pigs receiving diets based on naked oats or corn had comparable daily gain, but pigs fed naked oats had superior feed efficiency. As naked oats replaced barley, gain ($P<.001$), feed:gain ($P<.001$), dressing percent ($P<.001$), and 10th rib fat depth ($P<.02$) improved. However, when the 100% naked oat-based diets were compared to the corn/SBM control, similar gain, dressing percent, carcass shrink, 10th rib fat depth, loin eye area, and fat free lean gain were reported.

Several experiments have been conducted to evaluate field peas as a substitute protein source for soybean meal in barley-based growing-finishing diets (Castell, 1990; Gatel and Grosjean, 1990; Matre et al., 1990; Castell and Cliplef, 1993; Landblom and Poland, 1997). Results have shown field peas to be a suitable replacement for soybean meal with respect to gain, feed intake, feed efficiency, and feed cost/pound of gain provided methionine deficiencies have been corrected.

Raw canola seed is not normally considered for direct feeding to swine because of its high-value potential as an oilseed for crushing. Raw canola seed contains an estimated 2,034 kcal of ME/Lb., 20.7% crude protein, 1.2%

lysine, .27% tryptophan, 1.0% threonine, .95% total sulfur-containing amino acids (TSAA) and 7% fiber (Patience et al., 1995). Thus, considering the energy, protein, and TSAA content of raw canola seed, it appears to be an ideal, naturally-occurring, source of methionine to offset a potential deficiency of this amino acid when diets are supplemented with field peas. Castell and Falk (1980) included 0, 3, 6, 9, 12 and 15% raw canola seed in pig growing-finishing diets at the expense of barley and soybean meal. Diets fed were isonitrogenous with a linear increase in energy, ether extracts and crude fiber. Differences in dietary nutrient content did not affect growth rates, feed intake, feed:gain or routine carcass measurements. However, carcass unsaturated fatty acid content increased ($P<.01$) with increasing level of canola seed.

Present objectives. The first objective of this investigation was to evaluate growth, carcass characteristics, and economics of growing-finishing pigs when fed varying grain energy sources (naked oats, corn, barley, naked oats and barley, and barley and corn) supplemented with field peas and crystalline amino acids (lysine and methionine). The second objective was to determine whether raw canola seed could be used cost-effectively as a natural source of the sulfur-containing amino acid methionine.

MATERIALS AND METHODS

General Procedures. Two experiments were conducted with growing-finishing pigs in replicated, sheltered, outdoor lots. After weaning, pigs were developed in a hot nursery using a common 4-phase dietary regimen. Pigs were allotted in a complete randomized design to growing-finishing test diets from nursery outcome groups. In Experiment 1, each pen consisted of 3 barrows and 2 gilts with three pen replicates per treatment. In Experiment 2, each pen consisted of 4 barrows and 3 gilts with two pen replicates per treatment. One, 6-hole, self-feeder and one frost-free fountain were provided in each pen. Experiment 1 was conducted in the summer (May - August), and Experiment 2 was conducted during the fall (September - December).

Animals. Crossbred pigs from matings between Pig Improvement Company (Franklin, KY) Line 325 boars and Camborough 22 females were used for both trials.

Protocol and Design for Experiment 1. Pens of crossbred pigs (initial wt. = 64 lb.) were assigned, in a complete randomized design, to five grain energy sources supplemented with field peas. Energy sources included barley, corn, naked oats, a mixture of barley and naked oats and a mixture of barley and corn. The test diets (Table 1), fed in a 4-phase dietary regimen, were formulated to meet or exceed NRC nutrient requirements (NRC, 1988). The four phases were 50-80 pounds, 81-140 pounds, 141-190 pounds, and 191-250 pounds. Within phase, diets were formulated to contain lysine to energy densities of 3.3, 2.8, 2.6 and 2.6 grams of lysine/Mcal of ME for Phases 1 through 4, respectively. Since metabolizable energy of the test grains was variable, crystalline lysine was included to achieve the stated lysine:energy densities. Ratios of lysine to tryptophan, threonine, and the sulfur containing amino acids (methionine + cystine) were formulated to approximate those suggested by Chung and Baker (1992). When minimum levels for threonine and tryptophan could not be met with the test grains and field peas, soybean meal was included to achieve minimum levels. Corn diets supplemented with peas required the addition of soybean meal in Phases 1 and 2. All other amino acids were provided for by the test ingredients. Diet Phases 1 and 2 were formulated to contain 35% field peas. With declining lysine requirement in Phases 3 and 4, field peas were not held constant, but were included at levels necessary to meet dietary specifications.

Target dates for dietary changes through the four phases were pre-calculated. Beginning one week prior to the pre-calculated phase change, pen groups were weighed weekly until the target weight was achieved.

Protocol and Design for Experiment 2. Crossbred pigs (initial wt. = 56 lb.) were randomly assigned to field pea supplemented diets using a 3 x 2 factorial arrangement of treatments in which three primary grain energy sources (corn, barley and naked oats) were fed either with or without raw canola seed, as an additional protein and energy source. Four dietary phases were used (Table 2), as in Experiment 1, and formulated to meet or exceed nutrient requirements (NRC, 1988). Diets were balanced to provide lysine:energy ratios of 3.3, 2.8, 2.7 and 2.5 grams of lysine/Mcal of ME in phases 1 through 4, respectively. Raw canola seed was included at 10% of the diet in phases 1, 2 and 3, but was reduced to 5% across treatments in Phase 4 to maintain uniform protein and methionine + cystine levels across treatments. Diets with test grains that did not contain canola seed were formulated to contain methionine + cystine levels that were comparable to those containing canola seed.

Carcass Measurements. Once individual pigs reached target slaughter weight, they were shipped via commercial truck to John Morrell Packing Company, Sioux Falls, SD, and sold on a carcass merit basis. Carcass measurements and economic factors evaluated include: liveweight, hot carcass weight, fat depth, loin depth, percent yield, percent lean, and total carcass value. A fat-free lean index (FFLI) was calculated for each pig using the

National Pork Producer Council's FFLI formula for hot carcasses measured using Fat-O-Meter probe readings taken at the last rib, and 7 cm off the midline.

FFLI = 51.537 + (0.035 x Hot Carcass Wt.) - (12.260 x Fat-O-Meter Probe Hot Backfat Depth).
Backfat Depth is adjusted using the following adjustment:
BF = 0.11 + (0.98 x Fat-O-Meter Probe Hot Backfat Depth).
Percent yield was calculated by dividing hot carcass weight by the Sioux Falls live BW x 100.

Statistical Analysis. Data from both experiments were analyzed as completely randomized designs using SAS software (SAS Rel. 6.12, TS020, 1989-1996, SAS Institute, Inc., Cary, NC). Growth and feed efficiency data were analyzed using pen as the experimental unit, while animal represented the experimental unit for carcass data. Four orthogonal contrasts were used to describe significant ($P < .10$) treatment effects in Experiment 1. Contrasts were: 1) barley vs all others, 2) corn vs naked oats, 3) corn and naked oats vs mixture of corn or naked oats and barley, 4) interaction between pure grains (corn and naked oats) and their use in combination with barley. In Experiment 2, significant treatment effects were described using a factorial analysis (Steel and Torrie, 1980). Main effects were represented by base grain (n=3; barley, corn, and naked oats) and inclusion of full-fat canola seed (n=2; 0 or 10%). Slaughter weight was used as a covariate in the analysis of slaughter data. An interaction between base grain and canola seed was also considered. A Bonferroni t-test (using P diff option of SAS) was used to describe differences among base grains.

RESULTS AND DISCUSSION

Experiment 1

Growth and Feed Efficiency

Results of Experiment 1 have been summarized in Table 3. Pigs fed the barley control diet grew faster ($P<.05$), required less days on feed ($P<.05$), and were more efficient ($P<.10$) than pigs fed the other diets. Pig response of this magnitude to sole barley-based diets was not observed by Harrold et al. (1998), who reported improved gain ($P<.001$) and feed:gain ($P<.001$) with increasing level of naked oats. Contrasts between feed grains (naked oats and corn) and the mixed grains (barley and naked oats vs. barley and corn) did not differ for any of the growth or feed efficiency criteria measured. However, there was an indication that daily feed intake (P=.07) and total feed intake (P<.05) were greater in pure corn and mixed naked oat-barley diets compared to pure naked oat and mixed corn-barley diets.

Effect on Carcass Characteristics

When carcass data was analyzed, variation in slaughter weight resulted from significant treatment effects, therefore slaughter weight was used as a covariate. When slaughter weight was adjusted, hot carcass weight, percent yield, fat depth, loin depth, and fat free lean index did not differ due to dietary treatment, which does not agree with the findings of Harrold et al. (1998), who reported higher dressing percent (P<.001), less carcass shrink (P<.05), and greater fat depth (P<.02) with increasing level of naked oats. Contrasts for fat depth between diets formulated with either corn or naked oats, in which no difference was measured in the present study, is in agreement with the findings of Harrold et al. (1998). These data do not agree with Swantek et al. (1996) who reported fatter carcasses when naked oats and corn-based diets were compared. Percent lean values for pigs fed barley and naked oats or barley and corn were higher (P<.02), however FFLI values for the tested grain bases were similar.

Economic Comparisons

Differences were identified with respect to the cost of feeding the various test grains. Feed cost per pound of gain was lowest (P<.01) for the barley control diet compared to all other grains. Feeding either corn or naked oats alone was markedly more costly (P<.01) than formulating with the test grain mixtures. When corn and naked oats were contrasted with diets prepared using mixtures of barley and corn or barley and naked oats, the inclusion of barley was associated with a reduction in feed cost per head (P<.01) and per pound of gain (P<.05). Total carcass value differences were minimal between treatments. Highest returns over feed were obtained when barley, or barley and corn or barley and naked oats were fed.

Experiment 2

Comparison of Grain Energy Sources

Results of pig performance comparing three test grains (corn, barley and naked oats) when supplemented with peas are summarized in Table 4. Pigs fed either naked oats or corn grew faster (P<.05) and consumed less total feed per head (P<.01) than pigs fed barley. Pigs fed naked oats consumed less feed per head per day (P<.05) and were more efficient (P<.001), while pigs fed barley consumed the most feed per head per day (P=.001) and were the least efficient (P=.001). Corn fed pigs were intermediate with respect to daily feed intake and feed efficiency. The performance measured agrees with the results reported by Harrold et al. (1998) in which pigs fed corn or naked oats grew comparably, but compared to barley, naked oats yielded superior feed efficiency.

Effect on Carcass Characteristics

Faster growth among naked oats fed pigs resulted in heavier slaughter weight, however, when slaughter weight was used as a covariate in the analysis, hot carcass weight did not differ. Carcass yield and percent lean were similar among the three grains tested, but, fat depth was greater (P<.10) for pigs fed naked oats measuring .81 in. as compared to .72 and .74 in. for pigs fed barley and corn, respectively. This is in agreement with Harrold et al. (1998) who reported increasing fat depth with increasing level of naked oats. Naked oat fed pigs also had lower fat free lean index values (P<.10) compared to barley fed pigs. Corn fed pigs were intermediate with respect to fat free lean index. Loin depth was greatest for pigs fed corn (P<.10) and did not differ between naked oat and barley fed pigs.

Canola Seed as a Supplemental Source of Sulfur Containing Amino Acids

Including 10% canola seed in the 1st three dietary phases and 5% in the final finishing phase, as a source of supplemental methionine, yielded equal growth performance, and is summarized in Table 5. With respect to carcass characteristics, including canola seed resulted in very acceptable carcass quality. In fact, pigs receiving test grain diets formulated with canola seed yielded carcasses with reduced fat thickness (P<.05) and higher fat free lean index values (P<.05).

An interaction was identified (Table 6) such that pigs fed test diets containing barley and canola seed can be expected to grow slower (P<.05), be lighter at slaughter (P<.01) and have lighter hot carcass weight (P<.05). Although not significant, there was a numerical trend toward reduced feed efficiency when barley and canola were fed together.

Based on these limited results, the data suggests that raw canola seed can be considered as a source of supplemental sulfur containing amino acids (methionine and cystine).

Economic Comparisons

While pig performance in the presence of naked oats was superior, feeding naked oats also was more expensive (Table 4). The naked oat test diet was the most costly with respect to feed cost per head (P<.01), and feed cost per pound of gain (P<.10). A trend toward higher percent yield when naked oats were fed, resulted in a numerically higher total carcass value. Corn-based diets yielded the highest return over feed of $59.53, as compared to $58.69 and $53.29, respectively, for the barley and naked oat test diets.

Including canola seed, as shown in, was more expensive resulting in higher feed cost per head (P<.01), and higher feed cost per pound of gain (P<.01). As a result, and due to the higher acquisition cost for canola seed, return over feed from pigs grown without canola was $4.06 higher ($59.19 vs $55.13).

IMPLICATIONS

Practical growing-finishing diets can be formulated using field peas as a source of supplemental protein when barley, corn and naked oats are the principal feed grain bases. Achieving acceptable animal performance, however, will require specific amino acid formulation adjustments based on the quantity of amino acids resident in the feed grains and supplements being considered. It appears that when corn is supplemented with an upper limit of 35-40% peas, diet formulations will require an additional 8% soybean meal in the 1st grower phase, and 4% in the 2nd grower phase to replenish remaining amino acid deficiencies following pea supplementation. Barley and naked oats will not require additional protein from soybean meal, but the quantity of protein to be supplied by peas will be greater for barley diets than for naked oat diets.

Canola seed appears to be a suitable source of supplemental methionine, but currently is too expensive for inclusion in swine diets. Factors that lower market value for canola seed such as over production, reduced demand, and crop damage may create situations in which canola seed becomes an attractive alternative protein source for swine.

Based on the results reported here, decisions as to which of the test ingredients to feed would be based largely on availability and cost based on relative feed value (Pork Industry Handbook, Fact Sheet #112; Stevermer et al. 1987).

Table 1. Ingredient levels and calculated nutrient analysis of the four-phase diets fed in Exp. 1

		Ingredients, %								Analysis, %								
		Naked Oats	Peas	Barley	SMB	Corn	Methionine	Lysine	Vit/Min Premix	Crude Protein	Lysine	Tryptophan	Threonine	Meth + Cyst	Calcium	Avail. Phos.	Mcal ME/lb	Lysine, g/Mcal ME
Phase I	Barley/Pea	0	35	62.17	0	0	.28	.25	2.3	16.2	1.01	.18	.56	.58	.68	.29	1.39	3.30
	Naked Oat/Pea	62.35	35	0	0	0	.25	.25	2.15	18.1	1.07	.20	.60	.58	.67	.27	1.47	3.30
	Corn/Pea	0	35	0	8	54.32	.20	.18	2.30	16.2	1.07	.18	.66	.59	.68	.27	1.47	3.32
	Barley/N-Oat/Pea	20	35	42.23	0	0	.27	.25	2.25	16.8	1.03	.19	.57	.58	.67	.29	1.42	3.30
	Barley/Corn/Pea	0	35	42.06	0	20	.27	.32	2.35	15.4	1.04	.17	.54	.56	.68	.30	1.42	3.30
Phase II	Barley/Pea	0	35	62.57	0	0	.20	.08	2.05	16.0	.88	.18	.56	.51	.64	.27	1.40	2.87
	Naked Oat/Pea	62.70	35	0	0	0	.20	.05	2.05	18.0	.91	.20	.61	.53	.63	.27	1.48	2.81
	Corn/Pea	0	35	0	7	55.73	.20	.02	2.05	15.7	.92	.18	.65	.58	.60	.24	1.47	2.83
	Barley/N-Oat/Pea	20	35	42.70	0	0	.20	.05	2.05	16.6	.88	.19	.58	.52	.61	.27	1.42	2.80
	Barley/Corn/Pea	0	35	42.63	0	20	.20	.12	2.05	15.2	.88	.17	.56	.52	.59	.25	1.42	2.81
	Barley/Pea	0	11	86.60	0	0	.13	.33	1.95	14.0	.79	.16	.43	.48	.55	.25	1.40	2.58

Phase III	Naked Oat/Pea	97.51	0	0	0	0	.08	.46	1.95	16.1	.85	.19	.43	.47	.59	.26	1.51	2.55
	Corn/Pea	0	41	0	0	56.86	.16	.03	1.95	14.0	.82	.15	.59	.48	.56	.21	1.47	2.54
	Barley/N-Oat/Pea	10	8	79.56	0	0	.13	.36	1.95	14.1	.79	.16	.42	.48	.56	.25	1.41	2.56
	Barley/Corn/Pea	0	22	55.71	0	20	.14	.20	1.95	14.1	.79	.16	.49	.48	.56	.23	1.42	2.51
Phase IV	Barley/Pea	0	8	89.80	0	0	.08	.37	1.75	13.8	.79	.16	.41	.44	.49	.22	1.40	2.56
	Naked Oat/Pea	97.71	0	0	0	0	.08	.46	1.75	16.1	.85	.19	.43	.47	.54	.23	1.52	2.55
	Corn/Pea	0	37.5	0	0	60.52	.12	.11	1.75	13.6	.83	.15	.57	.45	.50	.18	1.48	2.55
	Barley/N-Oat/Pea	12	4	81.75	0	0	.08	.42	1.75	13.8	.79	.16	.40	.45	.50	.22	1.41	2.55
	Barley/Corn/Pea	0	18	59.87	0	20	.10	.28	1.75	13.8	.81	.15	.46	.45	.50	.21	1.43	2.57

Table 2. Ingredient levels and calculated nutrient analysis of the four-phase diets fed in Exp. 2

		Ingredients, %									Analysis, %								
		Naked Oats	Peas	Barley	SMB	Corn	Canola	Methionine	Lysine	Vit/Min Premix	Crude Protein	Lysine	Tryptophan	Threonine	Meth + Cyst	Calcium	Avail. Phos.	Mcal ME/lb	Lysine, g/Mcal ME
	N-Oat/Pea	62.35	35	0	0	0	0	.25	.25	2.15	18.1	1.1	.20	.60	.58	.67	.27	1.47	3.30
	Barley/Pea	0	35	62.17	0	0	0	.28	.25	2.3	16.2	1.01	.18	.56	.58	.68	.29	1.39	3.31

Phase I	Corn/Pea	0	35	0	8	54.32	0	.20	.18	2.3	16.2	1.07	.18	.61	.59	.68	.27	1.47	3.32
	N-Oat/Pea/Canola	60.65	27	0	0	0	10	0	.20	2.15	18.1	1.01	.21	.57	.42	.69	.29	1.52	3.02
	Barley/Pea/Canola	0	28	59.45	0	0	10	0	.25	2.3	16.3	1.01	.19	.56	.40	.70	.31	1.45	3.2
	Corn/Pea/Canola	0	28	0	7	52.70	10	0	.15	2.15	16.1	1.02	.19	.66	.46	.66	.26	1.52	3.10
Phase II	N-Oat/Pea	87.36	10	0	0	0	0	.04	.45	2.15	16.6	.95	.19	.48	.42	.66	.28	1.50	2.80
	Barley/Pea	0	25	72.53	0	0	0	.08	.24	2.15	15.2	.89	.17	.51	.42	.63	.27	1.40	2.89
	Corn/Pea	0	40	0	4	53.75	0	.05	.05	2.15	15.2	.93	.17	.53	.42	.64	.23	1.47	2.87
	N-Oat/Pea/Canola	77.50	10	0	0	0	10	0	.35	2.15	17.2	.94	.20	.51	.44	.68	.29	1.54	2.78
	Barley/Pea/Canola	0	17	70.57	0	0	10	0	.28	2.15	15.4	.90	.18	.64	.41	.65	.28	1.45	2.84
	Corn/Pea/Canola	0	40	0	0	47.78	10	0	.07	2.15	15.2	.94	.17	.64	.39	.65	.25	1.51	2.81
Phase III	N-Oat/Pea	87.87	10	0	0	0	0	0	.38	1.75	16.6	.90	.19	.48	.40	.53	.24	1.51	2.71
	Barley/Pea	0	15	82.83	0	0	0	0	.32	1.75	14.3	.84	.16	.45	.40	.53	.23	1.40	2.71
	Corn/Pea	0	43	0	0	55.10	0	0	.07	1.75	14.2	.88	.15	.53	.40	.52	.19	1.48	2.71
	N-Oat/Pea/Canola	77.93	10	0	0	0	10	0	.32	1.75	17.2	.92	.20	.45	.44	.55	.26	1.55	2.70
	Barley/Pea/Canola	0	5	82.84	0	0	10	0	.41	1.75	14.4	.87	.17	.60	.43	.51	.25	1.45	2.71
	Corn/Pea/Canola	0	33	0	0	55.09	10	0	.16	1.75	14.3	.91	.16	.60	.40	.52	.21	1.53	2.72
Phase IV	N-Oat/Pea	87.89	10	0	0	0	0	.06	.30	1.85	16.6	.84	.19	.48	.44	.53	.24	1.51	2.50
	Barley/Pea	0	10	87.78	0	0	0	.05	.32	1.85	13.9	.78	.16	.42	.41	.52	.25	1.40	2.50
	Corn/Pea	0	40	0	0	58.02	0	.09	.04	1.85	13.9	.82	.15	.50	.42	.52	.21	1.48	2.51
	N-Oat/Pea/Canola	82.99	10	0	0	0	5	0	.26	1.85	16.8	.84	.20	.42	.42	.54	.25	1.53	2.50

	Barley/Pea/Canola	0	5	87.79	0	0	5	0	.36	1.85	13.9	.79	.16	.58	.40	.53	.26	1.42	2.51
	Corn/Pea/Canola	0	35	0	0	58.06	5	0	.09	1.85	13.8	.84	.15	.59	.40	.53	.22	1.50	2.52

Table 3. Growing/finishing pig response to grain energy sources supplemented with field peas (Exp. 1)

	Control	Pure Grain		Mixed Grains		P-Values				
	Bly-Pea	**Noat-Pea**	**Corn-Pea**	**Bly-NOat-Pea**	**Bly-Corn-Pea**	**Barley vs Others**	**Pure Gr. vs. Mix**	**Corn vs. Noat**	**Interact**	**SE**
Growth										
Initial Wt., lbs.	64	63	64	64	62					
Final Wt., lbs.	261	252	257	250	243					
Days Fed	93.7	98.4	98.4	98.4	98.4	.04	NS	NS	NS	1.81
Gain/Head, lbs	197	189	193	186	181	NS	NS	NS	NS	5.95
ADG, lbs	2.10	1.92	1.96	1.89	1.84	.04	NS	NS	NS	.073
Feed/Hd/lbs	545	543	607	607	548	NS	NS	NS	.04	26.76
Feed/Hd/Day, lbs	5.83	5.52	6.17	6.17	5.58	NS	NS	NS	.07	.315
Gain : Feed, lbs	.36	.35	.32	.31	.33	.08	NS	NS	NS	.017

Carcass										
Slaughter Wt., lbs	256	251	249	251	236	.04	NS	.06	NS	
Hot Carcass Wt., lbs	177	180	177	181	179	NS	NS	NS	NS	1.382
Percent Yield	71.5	72.6	71.4	72.9	72.2	NS	NS	NS	NS	.562
Percent Lean	51.8	51.6	51.0	53.0	53.4	NS	.02	NS	NS	.804
Fat Depth, in	.81	.82	.82	.77	.75	NS	NS	NS	NS	.045
Loin Depth, in	1.89	1.95	1.91	1.94	1.99	NS	NS	NS	NS	.055
Fat Free Lean Index	47.7	47.7	47.7	48.4	48.6	NS	NS	NS	NS	.564
Economics										
Feed Cost/Head, $	34.89	44.19	45.93	41.02	36.91	.007	.009	NS	NS	1.88
Feed Cost/lb Gain, $	.1786	.2334	.2379	.2197	.2038	.003	.04	NS	NS	.01
Total Carc. Value, $	143.97	145.79	142.84	145.70	146.42	NS	NS	NS	NS	1.38
Return Less Feed, $	109.08	101.60	96.91	104.68	109.51	-	-	-	-	

[a]Ingredient cost: Naked Oats, $140/T; Peas $133.33/T; Barley, 597.92/T; SBM, $320/T; Corn, $108.92/T; Methionine, $3,800/T; Lysine, $3,600/T; Vit/Min Premix (Vit/Tr. Min, $2,327/T; Cal. Carb., $108/T; Dical Phos., $360/T; Salt, $82/T).

Table 4. Growing/Finishing Pig Response to Grain Energy Sources (Exp. 2)					
	Barley	**Corn**	**Naked Oats**	**P-Value**	**SE**
Growth					
Initial Wt., lbs	56	56	57		
Final Wt., lbs	253	256	261		
Days Fed	109	103	101		
Gain/Head, lbs	197	200	204	.002	1.08
ADG, lbs	1.81	1.95	2.02	.015	.036
Feed/Head, lbs	691	600	566	.001	12.89
Feed/Head/Day, lbs	6.35	6.03	5.59	.036	.15
Gain:Feed, lbs	.285	.323	.363	.001	.007
Carcass					
Slaughter Wt., lbs	241	244	251	.017	1.84
Hot Carcass Wt., lbs	184	183	185	NS	1.20
Percent Yield	74.8	74.4	75.3	NS	.54
Percent Lean	53.7	54.2	52.9	NS	.48
Fat Depth, in.	.72	.74	.80	.059	.02
Loin Depth, in.	2.07	2.23	2.04	.057	.04
Fat Free Lean Index	49.1	48.9	48.2	.074	.24

Economics[a]					
Feed Cost/Head, $	$41.54	$40.85	$47.03	.006	.91
Feed Cost/lb of Gain, $	$.212	$.211	$.230	.056	.005
Total Carcass Value, $	$100.23	$100.38	$103.32	NS	1.33
Return over feed	$58.69	$59.53	$53.29	--	
[a]Ingredient costs: Naked Oats, $140/T; Peas, $133.33/T; Barley, $96.66/T; SBM, $291/T; Corn, $147.40/T; Canola Seed, $287/T; Methionine, $4.03/T; Vit/Min Premix (Vit/Tr. Min, $2,220/T; Cal. Carb., $104/T; Dical Phos., $385/T; Salt, $111,T).					

Table 5. The effect of adding full-fat canola seed to grain energy sources supplemented with field peas (Exp. 2)				
	0%	**10%**	**P-Value**	**SE**
Growth				
Initial Wt., lbs	56	56		
Final Wt., lbs	259	254		
Days Fed	104	105		
Gain/Head, lbs	203	198	NS	.88
ADG, lbs	1.92	1.89	NS	.03
Feed/Head, lbs	626	625	NS	10.53
Feed/Head/Day, lbs	6.03	5.96	NS	.13
Gain:Feed, lbs	.328	.318	NS	.006

Carcass				
Slaughter Wt., lbs	248	243	.095	1.51
Hot Carcass Wt., lbs	184	185	NS	1.02
Percent Yield	74.7	75.01	NS	.44
Percent Lean	53.2	54.0	NS	.39
Fat Depth, in.	.78	.73	.047	.016
Loin Depth, in.	2.11	2.10	NS	.035
Fat Free Lean Index	48.3	49.1	.038	.19
Economics[a]				
Feed Cost/Head, $	$40.73	$45.54	.004	.74
Feed Cost/lb of Gain, $	$.2053	$.2300	.005	.004
Total Carcass Value, $	$99.92	$100.67	NS	1.07
Return over Feed, $	$59.19	$55.13	--	

[a]Ingredient costs: refer to Table 4.

Table 6. Interactions Associated with growing/finishing pigs fed barley, corn or naked oats supplemented with peas and full-fat canola seed (Exp. 2)

	Barley	**Corn**	**N-Oat**	**Barley & Canola**	**Corn & Canola**	**N-Oat & Canola**	**P-Value**	**SE**

Growth								
Initial Wt., lbs	56	56	57	56	55	56		
Final Wt., lbs	259	260	259	246	252	263	.007	2.68
Days Fed	106	103	102	112	104	100		
Gain/Head	203	204	202	190	197	207	.008	1.53
ADG	1.92	1.99	1.98	1.70	1.89	2.07	.048	.05
Feed/Head	711	574	551	671	625	580	NS	18.23
Feed/Head/Day	6.7	5.6	5.4	6.0	6.0	5.8	.098	.22
Gain:Feed	.285	.33	.37	.285	.315	.355	NS	.01

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