Director's Digest

FATS AND PROTEINS RESEARCH FOUNDATION, INC.

DR. GARY G. PEARL D.V.M.
Director Technical Services

16551 Old Colonial Road
Bloomington, Illinois 61704
Telephone: 309-829-7744 FAX: 309-829-5147
<www.fprf.org>

#341
October 2005

EVALUATING THE IMPACT UNDER COMMERCIAL CONDITIONS OF INCREASING DIET TALLOW CONTENT AND DIETARY ENERGY CONCENTRATION ON FROW-FINISH PERFORMANCE, CARCASS QUALITY AND RETURN OVER FEED COST

Tallow and Energy for Grow-Finish Pigs

J.F. Patience, A.D. Beaulieu, N.M. Rivard and D.A. Gillis

Prairie Swine Centre, Inc.
Saskatoon SK Canada

Evaluating the Impact Under Commercial Conditions of Increasing Diet Tallow Content and Dietary Energy Concentration on Grow-Finish Performance, Carcass Quality and Return Over Feed Cost

Tallow and Energy for Grow-Finish Pigs

J.F. Patience, A.D. Beaulieu, N.M. Rivard and D.A. Gillis

Monograph No. 05-07

Prairie Swine Centre Inc.
P.O. Box 21057- 2105 8th Street East
Saskatoon SK S7H 5N9 CANADA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Acknowledgements

The authors acknowledge with gratitude the financial support provided by PIC, Franklin, KY and by the Fats and Proteins Foundation, Bloomington, IL. We deeply appreciate the willingness of Community Pork Ventures, Regina, SK and St. Denis Stock Farm, St. Denis, SK for allowing us to use their facilities for the conduct of this experiment. The barn staff at St. Denis, under the leadership of Clint Keeler, and the production and administrative staff in Regina were particularly helpful in ensuring the successful completion of the experiment.

We received excellent support from the staff at Olymel, Red Deer, AB in the collection of the carcass data. We would like to acknowledge Federated Co-operatives Ltd. for provision of the experimental diets and Walbern Agri-Systems Sask (1996) Ltd. for the provision of the feed tanks and associated delivery augers. Bruce King and his staff at Saskatoon Processors provided us with excellent assistance and encouragement throughout the experiment. Thanks also to Dr. Neil Shantz for his delivery of herd health services.

Finally, we wish to acknowledge the continuing core financial support of the Prairie Swine Centre received from Sask Pork, Manitoba Pork Council and Alberta Pork.

■ EXECUTIVE SUMMARY

Energy is the most expensive nutrient in the diet of the pig, and yet, our understanding of energy metabolism, and more specifically, how the pig responds to changes in dietary energy concentration, is surprisingly limited. This experiment was conducted as a follow-up to a previous experiment conducted at the Prairie Swine Centre, which showed that pigs are able to achieve equivalent performance across diets of quite differing energy concentration. These results flew in the face of conventional wisdom, which suggests that increasing dietary energy concentration, notably through the additional of fat, will result in faster growth. This experiment was therefore conducted to re-evaluate this question, and determine if increasing dietary energy concentration would improve pig performance. The experiment was also designed to evaluate the impact of dietary energy concentration on carcass quality and on the uniformity of growth. The authors wondered if the level of feed intake of the pigs would impact on the response to energy, so a commercial farm was used; with a lower feed intake, it was considered a good model to evaluate the response of pigs to dietary energy concentration.

Experimental diets were formulated in a practical manner, such that energy concentration was elevated by using less barley and increasing amounts of wheat, soybean meal and tallow. The lowest energy diets contained 0.5% tallow and the highest energy diets contained 4% tallow. The actual DE content of the diets was determined by collecting faecal samples at the mid-point of each phase. On this basis, the mean dietary DE concentrations were 3.12 Mcal/kg (3.20), 3.30 Mcal/kg (3.35) and 3.43 Mcal/kg (3.50); values in parenthesis were the formulated DE targets.

Pigs performed very well on this experiment, with daily gain averaging 990 g/d across treatment. The higher energy diet supported higher weights up to first pull ($P<0.05$), but of course, market weights were constant across treatments because pigs were weighed prior to marketing to ensure they would fall within the packer's desired weight range. Average daily gain and feed efficiency were improved during the early phases of the experiment, up to about 80 kg ($P<0.05$); up to this point, there was no effect of diet on average daily feed ($P>0.10$), so increased dietary energy concentration resulted in increased daily energy intake ($P<0.05$). However, beyond about 80 kg, pigs tended to consume less of the higher energy diets, so growth rate was not affected by diet during this period. Of particular interest to commercial barn operators was the observation that the number of tail-end pigs, those that did not achieve the target shipping weight within the room turn period, was higher on the lower energy diets. We therefore concluded that higher energy diets make the most sense during the growout period below 80 kg, but not above 80 kg.

Interestingly, there were more pulls during the growout period on the higher energy diet, due either to mortality or serious health problems (prolapse, tail-biting, etc.). Thus, the portion of pulls was 3.75% on the two lower energy programs, and 5.4% on the highest energy program. If this observation is real, it has a significant impact on the economic value of the higher energy program.

Dietary energy did not affect carcass backfat thickness, lean yield, carcass index or carcass value ($P>0.10$). However, the higher energy diets tended to increase loin thickness ($P<0.10$), something we have seen in previous experiments. The dressing percentage of the pigs on the low energy diet tended to be lower than pigs on the other treatments ($P<0.10$).

The dietary energy concentration did not improve the uniformity of the pigs, nor the uniformity of their carcasses. Thus, producer should not increase diet energy concentration with the expectation that pigs will reach market in a more uniform manner, or produce more uniform carcasses. The latter will be much more dependent on selection practices at the time of shipping.

The economic analysis was conducted using longer-term average prices for pigs (1.45/kg) and ingredients: (wheat, \$130/t; barley, \$110/t; soybean meal, \$340/t; canola meal, \$204/t) were employed. A price of \$550/t for tallow, obtained from Saskatoon Processing, was also used.

The published Olymel (West) grid was applied to determine the value of pigs. Two possible scenarios for the adoption of these results on a commercial farm were considered. In scenario #1, pigs were shipped at the time the finishing room was turned over to the next group, and revenues reflected the associated lost value. Under this circumstance, the best return over growout feed cost was earned on the lowest energy diet, with an advantage in the range of $2.12 compared to the medium energy program, and $4.04 over the high energy program. In the second scenario, the tail-end pigs were held back until they reached the minimum market weight; this resulted in a higher gross income, since all pigs would be marketed within the optimum weight range, but the cost would be higher, since there would a considerable increase in the feed required. In this scenario, the advantage again fell to the lowest energy program, earning $1.26 more than the medium energy program, and $4.02 compared to the high energy program. In the latter scenario, no charge for housing was included, as it was assumed that hold-back pigs would be moved into an existing hold-back room, or would be placed with other pigs. However, a substantial feed penalty was applied to the hold-back pigs, an amount which we suspect is very conservative. We understand this scenario would not applied universally, but it is impossible to conducted an economic analysis that applies to all possible commercial circumstances. Sufficient information is presented herein to allow individual pork producers to conduct their own economic analsyis. Of course, the results of the economic analysis could change if differing packer settlement agreements were applied.

In conclusion, net income can be maximized by feeding lower energy programs. However, the results of individual phases within this experiment suggest that feeding higher energy diets up to 80 kg may be warranted, as this is the period when pigs would respond the most to the higher energy diets.

It is clear from this experiment, and from others conducted previously, that the response to dietary energy concentration is not easy to predict. We suspect, based on biology and not on experimental data, that the response of a group of pigs to dietary energy concentration may be determined by their normal feed intake. If pigs are able to consume sufficient quantities of feed to achieve excellent growth on lower energy diets, then feeding higher energy diets is unlikely to be beneficial. However, if feed intake is low, then there may be a benefit to feeding higher energy diets, to increase daily energy intake and thus support faster growth. Nonetheless, we caution producers from assuming that increasing dietary energy will universally increase pig performance; experimental data does not support such an assumption.

Finally, the deviation we observed between formulated DE values and determined DE values in the experimental diets confirms the importance of this measurement. The average deviation reported herein was 71 kcal/kg, or 2.1%, a significant amount in the context of practical swine diet formulation.

■ INTRODUCTION

Pork producers are continually seeking ways to reduce costs and improve net income. While increasing fat utilization has become popular in the United States, this practice has not achieved the same prominence in Canada. Producer resistance is based on concerns about carcass quality and a different economic environment in Canada, due to a more constraining carcass grading system that defines a narrow optimum carcass weight. This, in turn, places less value on rate of gain than in the U.S. Several studies in the literature, and a recent study conducted at PSCI, report no growth response to increased dietary energy concentration. However, all these studies have been conducted under conditions where feed intake was higher than that observed on many commercial operations. We hypothesized that a different result would occur if a similar experiment was conducted on a commercial farm where feed intake was lower, since it is expected that the response to dietary energy concentration would be dependent on feed intake.

This experiment is of interest to both pork producers and companies involved in the rendering business. Of great interest to pork producers is the definition of the response of growing and finishing pigs to dietary energy concentration, given that inadequate energy intake will impair growth and excess energy intake may increase costs and lower carcass value. In other words, when feed intake is limiting performance, to what extent can pork producers increase net income by increasing the energy concentration in the diet? A related question considers the impact of increasing dietary energy concentration on carcass quality.

An increasingly important question posed by pork producers is the impact of dietary energy concentration on the variability of pig performance. Although it is difficult to determine the cost of variability, we know that variation in growth imposes costs due to losses related to carcass grading and reduced barn utilization. In a recent review (Patience et al. 2003), it was estimated that variation cost Saskatchewan pork producers $3.41 per pig at market due to sort losses and an additional $1.25 per pig due to reduced barn utilization. Theoretically, variation in feed intake is a major contributor to the variability in growth; pigs with poorer appetites within a group will grow even slower due to inadequacy of the diet with respect to energy. Low appetite pigs may therefore be less affected on a higher energy diet. Even if increasing dietary energy did not reduce the absolute variability of pig performance, it could reduce the economic impact of variability, because with the expected faster growth, there would be fewer tail-enders in an all-in-all-out group. For example, for every 50 g/d increase in ADG, the number of tail-end pigs (those failing to reach the grading systems' core target weight within the available growout time cycle) is reduced by 50% (Patience, 2004a). Since pigs falling below the core earn $10 to $50 less than pigs reaching core weight, the financial benefit to pork producers is enormous.

■ HYPOTHESIS

That increasing the concentration of energy in the diet will increase pig growth with no adverse effect on carcass quality.

■ OBJECTIVES

The objectives of this experiment were:

1. To determine the response of growing and finishing pigs to increasing dietary energy concentration on a commercial farm.

2. To determine the most efficacious energy level that can be adopted in diets for growing and finishing swine housed in a commercial facility based on performance, carcass composition and return over feed.
3. To determine if increasing dietary energy concentration will help to reduce variation in pig performance, by allowing pigs with poor appetites to grow at rates closer to their higher appetite counterparts.
4. To improve the net income of pork producers through the development of feeding programs that best balance cost of feed and gross income per pig.

■ MATERIALS AND METHODS

Barn and Room Preparation

This experiment was conducted at St. Denis Stock Farm, located at St. Denis, SK, about 50 km east of Saskatoon, SK. It is a single site, 600-sow farrow-to-finish operation constructed about 15 years ago. It operates as a strictly commercial entity, and is not normally used for research. However, it provided an excellent opportunity to conduct this experiment under conditions that differ from that of a dedicated research unit. Of course, there were challenges associated with carrying out research in a barn designed strictly for commercial production. However, the staff of the barn, under the leadership of Mr. Clint Keeler, and the staff at Community Pork Ventures, operators of the barn and in particular, Mr. Adrian Hubbard, allowed the experiment to be completed with very few problems.

The experiment was conducted in 3 grower and 3 finisher rooms at St. Denis Stock Farm, St. Denis, SK. Each room consisted of 12 pens, with 20 pigs per pen. This provided an overall total of 36 pens and 720 pigs on test, or 6 pens and 120 pigs per gender per treatment. The pens measured 2.44 m × 4.57 m (11.25 m^2) and 2.44 m x 6.10 m (14.88 m^2) in the grower and finisher barn, respectively.

The barn was designed with one feeder supplying feed to two pens; therefore, prior to the experiment, feeders were modified to separate feed delivery to individual pens. Feeder extensions were also required, to ensure that each feeder could accommodate 80 kg of feed or the predicted daily maximum intake per pen; thus, feeders would only need to be filled once per day. Six 3-tonne bulk feed bins were installed outside the barn to hold 2 phases of each of the 3 experimental diets.

A platform feed scale was purchased to weigh feed into feed tubs (plastic garbage tubs) at the feed augers; tubs and feed carts were constructed to move the feed from the feed auger area to the animal rooms.

Animal Selection, Identification and Care

Animal flow in this particular barn involves the removal of the bottom 15% of the pigs at the time of nursery exit, to an off-site location. This is necessary because the productivity of the sow herd exceeds the housing capacity of the barn. Therefore, it is important to note that this experiment involved the heaviest 85% of the pigs leaving the nursery.

Otherwise, all available pigs were employed in this experiment, according to standard commercial practice in the St. Denis barn. There were 2 pens per gender per dietary treatment per room. Pigs were blocked by bodyweight within gender to attain a "heavy" and a "light" block within each gender/treatment combination in each room. The objective of the selection process was to provide the most uniform pens of barrows and of gilts within a replicate (room). Once pigs were allocated to a pen, they remained with the same pen mates when the pigs moved from the grower to the finishing room.

Feed and water were available ad libitum, the former using existing wet/dry shelf-style feeders (Crystal Springs Hog Equipment, St. Agathe, MB) and the latter using existing nipple drinkers mounted on the rear wall of the pen.

This experiment qualified under the Prairie Swine Centre's animal care protocol #19970019, "Standard experimental trials using grower or finisher pigs for nutritional, reproductive or behavioural trials".

Treatments

Three dietary energy levels were employed: 3.20, 3.35 and 3.50 Mcal DE/kg or 2.21, 2.32 and 2.42 Mcal NE/kg. Pigs remained on the same energy level throughout the experiment; diets were phased according to the lysine:energy ratio, as explained below. This range in energy was selected as it represented the reasonable expected range of energy used in typical commercial diets in western Canada. Ingredient and calculated nutrient composition are presented in Tables 1 and 2, respectively. The diets were formulated according to commercial practice, such that increasing the energy content of the diet resulted in increased use of wheat, soybean meal and tallow, and less barley. The upper limit of tallow levels in the highest energy diets was determined by the handling capacity of most mills, especially during the winter months. Diets were formulated, such that the low energy diets within each phase contained 0.5% tallow, and the high energy diet contained 4% tallow. Four percent meat and bone meal was included in Phases 1 and 2, and 3% in Phase 3. NE was estimated according to CVB (1994).

A constant dlysine:DE ratio was maintained across energy levels; thus, the level of lysine increased proportionate to the increase in dietary energy. Other amino acids were formulated to a constant minimum ratio to lysine. The diets differed in apparent ileal digestible lysine:DE ratios across phases, as follows: 2.95, 2.60 and 2.10 g/Mcal for phase 1, 2 and 3, respectively. These ratios were selected to ensure that amino acid intake did not limit the response of the pigs to dietary energy. As a further safeguard, factorial estimates of lysine requirements were calculated for each energy level at the end of the experiment, to confirm that lowering the DE content of the diet did not result in inadequate lysine intake. It was important to ensure that any response observed in performance could be attributed to energy levels, and not to any other dietary nutrient.

Feed requirements were tendered to local commercial feed manufacturers; Co-op Feeds (Federated Co-operatives Ltd., Saskatoon, SK) was awarded the contract. Feed was delivered in 2-tonne or 3-tonne batches when required. Feed was provided as a mash, as per the farm's normal practice.

The tallow used in these diets was supplied by Saskatoon Processing Company, a member of the Fats and Proteins Research Foundation, one of the sponsors of this experiment. Tallow composition and quality was monitored during the course of the experiment.

Males remained on Phase 1 for 4 weeks, on Phase 2 for 4 weeks and on Phase 3 for the remainder of the experiment, about 5 weeks. Females remained on Phase 1 for 6 weeks, on Phase 2 for 4 weeks and on Phase 3 for the remainder of the experiment, or about 3 weeks. This allowed us to adopt split-sex feeding without the need for additional feed storage bins.

Experimental Design

The experiment was designed as a complete randomized block design with a factorial arrangement of treatments (3 energy levels by 2 genders). The experiment was conducted in 3 rooms of 12 pens each. Therefore, each room contained 2 pens of each gender/ dietary treatment combination. The pigs were blocked and divided into two weight groups at the initiation of each replication.

Table 1. Ingredient composition of the low, medium and high energy diets.

	Phase I			Phase II			Phase III		
Ingredient	**3.20**	**3.35**	**3.50**	**3.20**	**3.35**	**3.50**	**3.20**	**3.35**	**3.50**
Barley	61.422	41.761	22.100	63.419	45.760	28.100	54.905	35.303	15.700
Wheat	16.423	32.924	49.425	15.411	29.638	43.865	25.181	41.666	58.150
Soymeal	15.300	16.600	17.900	14.800	16.450	18.100	13.800	15.150	16.500
Meat meal	4.000	4.000	4.000	4.000	4.000	4.000	3.000	3.000	3.000
Tallow	0.500	2.250	4.000	0.500	2.250	4.000	0.500	2.250	4.000
Dicalcium phosphate	0.550	0.550	0.550	0.300	0.275	0.250	0.750	0.725	0.700
Limestone	0.200	0.250	0.300	0.200	0.225	0.250	0.650	0.675	0.700
Salt	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
Mineral premix[a]	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
Vitamin premix[b]	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
l-lysine HCl	0.290	0.320	0.350	0.160	0.180	0.200	0.015	0.033	0.050
l-threonine	0.075	0.093	0.110	0.010	0.023	0.035	------	------	------
dl-methionine	0.040	0.053	0.065	------	------	------	------	------	------
Oxytetracycline 200[c]	0.075	0.075	0.075	------	------	------	------	------	------
Tylan 40[d]	-----	-----	-----	0.050	0.050	0.050	------	------	------

[a] Provides per kg of diet: 0.64 mg Fe, 80 mg Zn, 20 mg Mn, 40 mg Cu, 0.4 mg I and 0.08 mg Se.

[b] Provides per kg of diet; 6600 IU Vitamin A, 660 IU Vitamin D_3, 32 IU Vitamin E, 3.2 IU Vitamin K_3, 0.02 mg Vitamin B_{12}, 4 mg riboflavin, 12 mg pantothenic acid, 28 mg niacin, 1.6 mg folacin, 0.8 mg thiamine, and 0.16 mg biotin.

[c] Provided 330 gm/t activity of oxytetracylcine HCl. Initially, the Phase 1 diets did not contain medication, but oxytetracycline was added by the third delivery (February 3, 2005) due to diarrhea.

[d] Provided 44 gm/t activity of tylosin phosphate.

Table 2. Nutrient composition of the low, medium and high energy diets.

	Phase I			Phase II			Phase III		
Ingredient	**3.20**	**3.35**	**3.50**	**3.20**	**3.35**	**3.50**	**3.20**	**3.35**	**3.50**
DE, Mcal/kg	3.20	3.35	3.50	3.20	3.35	3.49	3.20	3.35	3.50
ME, Mcal/kg	3.02	3.15	3.28	3.02	3.15	3.27	3.01	3.15	3.28
NE, Mcal/kg	2.20	2.31	2.42	2.21	2.32	2.42	2.21	2.32	2.43
Crude fat, %	2.19	3.86	5.53	2.20	3.89	5.54	2.21	3.87	5.54
dLys/DE; g/Mcal	2.94	2.96	2.94	2.59	2.63	2.64	2.09	2.12	2.11
dLys/NE, g/Mcal	4.27	4.29	4.26	3.76	3.79	3.79	3.80	3.06	3.05
dLysine, %	0.94	0.99	1.03	0.83	0.88	0.92	0.67	0.71	0.74
dThreonine, %	0.57	0.60	0.63	0.51	0.54	0.56	0.47	0.48	0.49
dTSAA, %	0.54	0.57	0.59	0.49	0.51	0.53	0.48	0.50	0.51
dTryptophan, %	0.16	0.17	0.18	0.16	0.17	0.18	0.15	0.16	0.17
dTHR:LYS	0.61	0.61	0.61	0.61	0.61	0.61	0.70	0.68	0.66
dTSAA:LYS	0.57	0.57	0.57	0.60	0.59	0.57	0.48	0.50	0.51
dTRP:LYS	0.17	0.17	0.17	0.19	0.19	0.19	0.23	0.23	0.23
Ca, %	0.69	0.70	0.71	0.66	0.66	0.65	0.81	0.81	0.80
P, % (total)	0.58	0.58	0.55	0.55	0.55	0.55	0.60	0.60	0.60
Crude fat (analyzed[c]), %	2.3	4.8	5.0	-----	-----	-----	-----	-----	-----
Crude fat (analyzed[d]), %	2.41	4.08	5.34	1.95	3.51	4.94	1.88	3.18	4.99
Crude protein (analyzed[d]), %	19.3	20.2	21.9	18.4	19.7	20.3	18.1	18.9	19.3

[a]Provides per kg of diet: 0.64 mg Fe, 80 mg Zn, 20 mg Mn, 40 mg Cu, 0.4 mg I and 0.08 mg Se.
[b]Provides per kg of diet; 6600 IU Vit A, 660 IU Vit D_3, 32 IU Vit E, 3.2 IU Vit K_3, 0.02 mg Vit B_{12}, 4 mg riboflavin, 12 mg pantothenic acid, 28 mg niacin, 1.6 mg folacin, 0.8 mg thiamine, and 0.16 mg biotin.
[c]Analyzed at experiment initiation, SGS Canada Inc. Vancouver, BC.
[d]Analyzed pool samples at experiment conclusion, Norwest Labs, Lethbridge, AB.

Table 3. Composition of the tallow used at St. Denis and compared to the composition of tallow from the Saskatoon Processing Company for the 3 months of 2005 during which the experiment was conducted and the average of the previous 2 years.[a]

Item	Tallow used at St. Denis	Saskatoon Processing Co., Averages 2005 March	February	January	2004	2003	Specification[b]
Titre, °C[c]	41.2	41.6	41.8	41.8	41.8	41.0	40.5
Free fatty acids (as oleic)	5.12 %	3.95	5.15	5.01	3.76	4.36	4.00 (as FFA)
Moisture and volatilities	0.05 %						
Insoluble impurities	0.01 %						
Unsaponifiable matter	0.42 %						
Total M.I.U.	0.48 %	0.71	0.86	0.47	0.49	0.48	1 (max)
Iodine value	52.4	56.5	53.0	59.9	52.8	56.7	
Peroxide value	1.0 meq/kg						
Fat stability	15.2 meq/kg						
FAC Color	19 (not darker than)	19	19	11C	11B	11B	None
Calories	9240 kcal/kg						

[a]All analysis conducted at SGS Canada Inc., Vancouver, BC. Canada.
[b]Specifications from the US Renderers Association for bleachable fancy tallow.
[c]Titre is the solidification point of the fatty acids. Trade practice is to designate animal fats with titres of 40 °C and up as tallow, those below as grease (www.renderers.org)

Animal and Pen Allocation

Prior to the start of the experiment, the smallest half of the female pigs were visually identified, marked and moved to the "small (light-weight)" female block of pens. The remaining females were placed in the large block of female pens. The process was repeated for the male pigs. Prior to the final randomization, pigs were weighed to obtain the day 0 body weight.

Pens within each room were randomly allocated to gender and treatment. However, pairs of pens sharing a feeder were assigned to the same dietary treatment. Even though the feeders were split, both in the hopper and in the feeding trough, the risk of cross contamination between feeder sides was avoided by maintaining common diets in pen pairs sharing a common feeder.

Data Collection

All raw data were entered into the computer located on the farm within one day of collection to ensure regular backups were maintained. Electronic copies of data were removed from the site daily as a further protection against inadvertent loss of data.

The bodyweight of individual pigs was recorded at the start of the experiment. Average pig weights within pens were recorded every three weeks thereafter, until the first pig was marketed within a block (1st pull). Individual bodyweights were again recorded at first pull, as a means of evaluating variation in bodyweight among treatments.

All animals were maintained on experimental diets and feed intake was measured until all pigs within the pen were marketed, or when non-experimental pigs entered those pens. The normal practice within this commercial barn was to hold back pigs from one finishing room that were too light to market, and place them in the following finishing room; these hold-back pigs were placed in empty pens, if available, but otherwise, were placed in pens with other pigs. Whenever possible, holdback pigs were put in pens receiving the same experiment diet, so that carcass information could still be collected. If pigs were placed on different diets, they were considered to have been removed from the experiment, and carcass information was not collected. For the purpose of performance information, data collection was terminated 1) when the pig went to market, or 2) when the pig was removed from its pen and moved to a different finishing room as a holdback pig or, 3) during room emptying, and it was necessary to mix pigs from different treatments.

At the time of marketing, pigs were tattooed with a unique tattoo number by pen to preserve statistical analysis of the carcass data on a pen basis. Pigs were chosen for market according to the standard operating procedure of the barn; thus, any pig which weighed at least 116 kg on selection day, corresponding to a shipping weight of ~118 kg, was shipped to Olymel LP, Red Deer, AB.

Individual weights were recorded on the day prior to shipping. Dressed weight, fat thickness, loin thickness and estimated percent lean yield were collected at the time of slaughter as per the normal practise of the abattoir. The value of carcass quality incentives was also recorded. From these data, carcass index and dressing percentage were calculated.

Daily rate and efficiency of gain, as well as daily feed intake, were calculated for the total growout period and for each 3-week weigh period. Daily NE and DE intakes are recorded by treatment, gender, weight block and phase. Feed conversion was estimated on the basis of total feed consumption, as well as on the basis of DE and NE intake.

Faecal samples were collected at the mid-point of each phase to determine actual DE content of the experimental diets. A minimum of one fresh sample was required from each pen; samples were frozen and stored until freeze-dried. Freeze-dried samples were ground, and pooled within phase, gender and diet for analysis of gross energy and acid insoluble ash. Feed samples were assayed for crude protein, gross energy, acid insoluble ash and crude fat.

Economic Analysis

The outcome of the experiment included both performance analysis and economic analysis. Obviously, higher energy diets have a greater cost, and this cost was evaluated in the context of revenues from the sale of stock. Two scenarios were considered. In the first scenario, the impact of lightweight pigs on gross revenues was determined on the basis of their being marketed at the close of the room, irrespective of their weight; thus, the cost of slower growth would be reflected in the penalties received for marketing lightweight pigs. In the second scenario, the lightweight pigs would be held back, such as in special holdback facilities, or in growout rooms not yet closed out. In this case, the cost of slower growth would be borne by added feed costs required to attain market weight. Neither added labour cost of handling tail-end pigs, nor the added housing costs, other than feed, were included in this economic analysis.

Long term prices for market hogs ($1.45/kg) and feed ingredients (wheat, $130/t; barley, $110/t; soybean meal, $340/t; canola meal, $204/t) were employed. A price of $550/t for tallow, obtained from Saskatoon Processing, was also used. The published Olymel (West) grid was used to determine the value of pigs. The value of pigs will obviously be influenced by the marketing grid applied; consequently, differing packer settlement agreements could result in different dietary DE optimums. Furthermore, the price of tallow could vary among locations; the price reported herein is applicable for the Saskatoon area at the time of the completion of the experiment (June, 2005).

Statistical Analysis.

Pen was the experimental unit for all analysis, and main effects of energy, gender, weight group and their interaction were determined using the PROC MIXED option in SAS (Version 8.2; SAS Institute Inc. Cary, NC). The initial analysis included all possible interactions; since none of the interactions were significant ($P>0.05$) for performance data, they were removed from the model. However, some of the interactions approached significance for the carcass data, and thus were kept in the model. Initial body weight (day 0) and market weight were used as covariates for the performance and carcass data, respectively. A separate analysis, without covariate adjustment was performed to compare the response to initial starting weight. Room (block) was considered random throughout. Selected carcass parameters were compared using the PROC CORR option in SAS.

■ RESULTS AND DISCUSSION

Barn modification and installation of the bins commenced in December, 2004 and were completed in early January, 2005. Pigs were assigned to the first block (room) on January 13, 2005. Blocks 2 and 3 commenced on January 20 and January 27, 2005, respectively. Pens were randomly assigned to treatment within a room.

Diets

Table 3 describes the composition of the tallow used in this experiment and the quality control samples of the tallow from the plant compared to standards set by the National Renderers Association Inc. As indicated by the comparison with the National Renderers Association's specifications for bleachable fancy tallow, the product obtained from Saskatoon Processing Co. was of a high quality. There was also a high degree of consistency of the product, both within the time frame of this experiment and when compared with the product manufactured by the supplier over the past 3 years.

Faecal samples were collected at the mid-point of each feeding phase, in order to determine the actual DE content of the diet. The results of these analyses are presented in Table 4. It can be seen that, averaged across all phases, the low energy diets, formulated to contain 3.2 Mcal DE/kg, actually contained 3.12 Mcal DE/kg. The medium energy diets, formulated to contain 3.35 Mcal DE/kg, actually contained 3.30 Mcal DE/kg, and the high energy diets, formulated to contain 3.5 Mcal DE/kg actually contained 3.43 Mcal DE/kg. The deviation in dietary energy concentration, as compared to the formulated levels, averaged 2.1%, or 71 kcal/kg. This amount of variation from expected falls within the range reported previously (Figure 1).

Table 4. Formulated treatment digestible energy values compared to measured[a].

Gender	Phase	Treatment (DE, Mcal/kg)	Actual DE (Mcal/kg)	Treatment Average (Mcal/kg)	Diffrence kcal/kg
Female	1	Low (3.20)	3.11	3.13	71
	2		2.98		
	3		3.30		
	1	Medium (3.35)	3.28	3.31	40
	2		3.26		
	3		3.39		
	1	High (3.50)	3.47	3.42	76
	2		3.39		
	3		3.42		
Male	1	Low (3.20)	3.10	3.11	89
	2		3.03		
	3		3.20		
	1	Medium (3.35)	3.27	3.28	74
	2		3.20		
	3		3.36		
	1	High (3.50)	3.46	3.43	73
	2		3.37		
	3		3.45		

[a]DE was determined by collecting faecal samples at the mid-point of each phase. Endogenous acid-insoluble ash was used as a indigestible marker.

Growth Performance

Overall performance of the pigs was very good. The pigs assigned to the experiment were from weekly farrowing outcomes of approximately 280 pigs. The barn routinely sends about 40 lightweight pigs per week (15%) from the nursery to another facility. As per normal barn procedure, pigs that were growing poorly in the grower barn were sent to an off-site barn for finishing. These pigs were removed from the experiment at the discretion of the barn manager.

During the course of the experiment, mortalities and total removals averaged 4.4%; the actual mortality rate was a very acceptable 1.5% (Table 5). Total removals averaged 3.75% on both the low energy and the medium energy programs. Interestingly, the removal rate on the high energy program was higher, at 5.4%. Mortality was 3 pigs or 1.25% on the low energy program, 2 pigs or 0.8% on the medium energy program and 5 pigs, or 2.1%, on the high energy program.

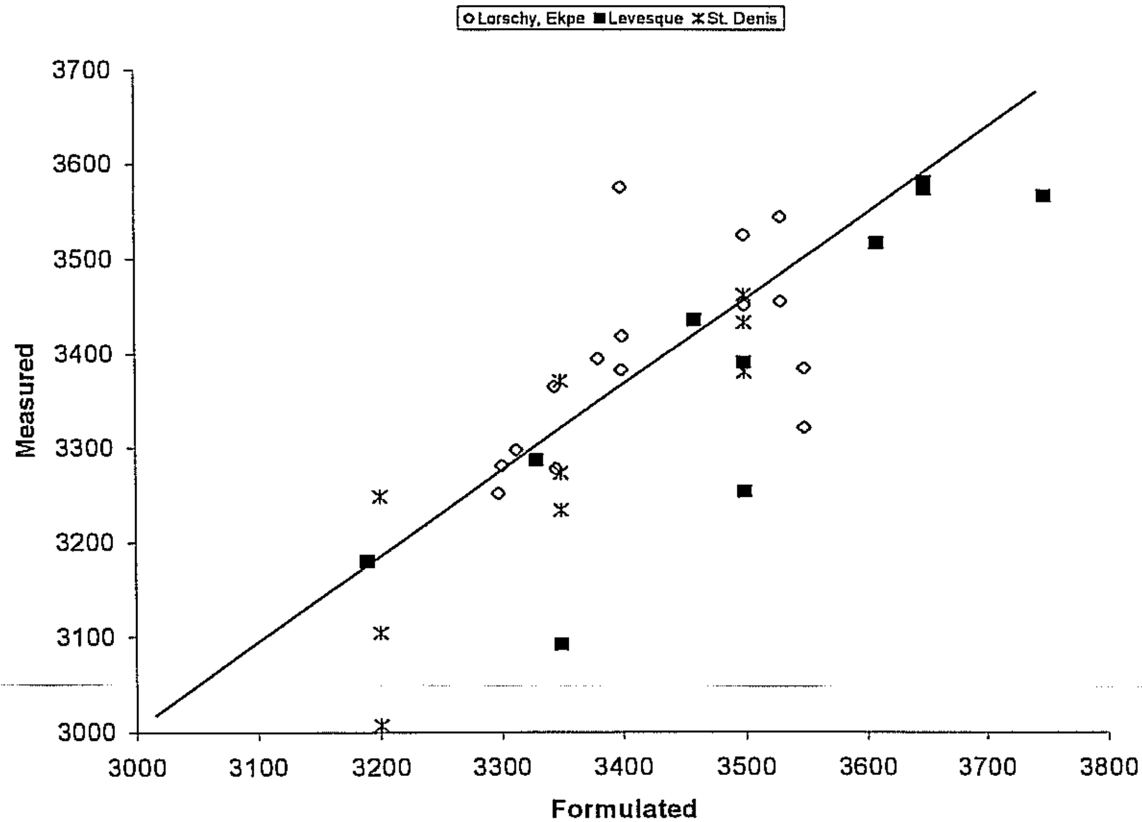


Figure 1. A comparison of the formulated versus measured DE (kcal/kg). Data from other experiments conducted at PSCI are shown for comparison.

The effect of dietary energy concentration on overall pig performance is described in Table 6. The overall average starting weight for the experiment was 36.8 kg; pigs assigned to the low energy treatment were 800 g heavier at the start of the experiment than those assigned to the medium or high energy treatments ($P = 0.02$). Nonetheless, at first pull, the pigs on the lowest energy diet were 1.0 kg and 2.2 kg lighter than the pigs on the medium and high energy programs, respectively. Of course, market weight was the same across treatment, because pigs were shipped to market within a relatively narrow window, to achieve the barn's goals of maximizing the number of pigs within the packer core. Across all treatments, about 19% of the pigs did not reach the minimum target shipping weight of 118 kg, and thus were considered tail-enders. A total of 48 pigs – 20.8% - were tail-enders on the low energy program out of the 231 pigs that reached market weight. A total of 45 pigs – 19.5% - were tail-enders on the medium energy program out of the 231 pigs that reached market weight. A total of 37 pigs – 16.3% - were tail-enders on the high energy program out of the 227 pigs that reached market weight.

Dietary treatment was significant for ADG during all periods up to day 42 of the experiment; as the pigs reached heavier weights, the impact of dietary energy concentration declined. This would suggest that in terms of growth rate, higher energy diets would be most beneficial until the pigs reach weights between 75 and 95 kg; thereafter, the benefit of higher dietary energy appears to be negligible, or non-existent.

ADG responded to energy in a linear fashion for both the first and second weigh periods, i.e. days 0 to 21 and 22 to 42 ($P<0.05$). However, ADG was not affected by dietary energy during the final weigh period, i.e. from d43 to first pull.

Table 5. Animals removed from the experiment[a]

	Treatment	Gender	Removal[b] Day	Removal[b] Weight (kg)	Removal[b] Reason
Block 1	3.20	M	47	90	Prolapse
	3.20	F	6	31	Ill-thrift
	3.20	F	81	78	Dead
	3.35	F	23	23	Dead
	3.35	F	84	50	Ill-thrift
	3.35	M	30	55	Ill-thrift
	3.35	M	46	68	Prolapse
	3.35	M	81	78	Dead
	3.50	F	84	94	Ill-thrift
	3.50	M	63	84	Dead
	3.50	M	68	72	Dead
	Block 1 removal rate = 11 pigs / 240 = 4.6 %				
Block 2	3.20	F	27	52	Ill-thrift
	3.20	F	77	78	Ill-thrift
	3.20	M	74	70	Dead
	3.20	M	56	54	Tail-bite
	3.20	M	74	82	Dead
	3.35	M	77	57	Ill-thrift
	3.35	F	42	25	Ill-thrift
	3.35	F	77	50	Ill-thrift
	3.50	M	77	59	Ill-thrift
	3.50	M	87	94	Ill-thrift
	3.50	M	66	124	Dead
	3.50	F	57	84	Tail-bite
	3.50	F	57	87	Tail-bite
	3.50	F	65	83	Arthritis
	Block 2 removal rate = 14 pigs/ 240 = 5.8%				
Block 3	3.20	M	41	72	Prolapse
	3.35	F	70	101	Lame
	3.50	M	9	43	Dead
	3.50	M	28	58	Ill-thrift
	3.50	M	81	85	Ill-thrift
	3.50	F	88	79	Dead
	3.50	M	83	80	Dead
	Block 3 removal rate = 7 pigs/ 240 = 2.9 %				

[a] Animals were euthanized or removed from the experiment as per normal barn procedure and typically following consultation with barn production personnel. As per normal barn procedure, animals considered "poor-doers" were sent to a different finishing barn.

[b] Of the total animals removed, only 4 came from the "heavy" block of pigs. The rest, 28 pigs, came from the "light" block

Table 6. **Effects of feeding diets formulated to contain 3.20, 3.35 or 3.50 Mcal/kg DE on the performance of growing/finishing pigs in a commercial barn**[a]

	Digestible energy (Determined Mcal/kg)				
Item	**3.12**	**3.30**	**3.43**	**SEM**	**P**
No. pigs	240	240	240		
Body weight, kg					
d 0	37.4	36.6	36.5	0.87	0.02
d 21	56.1	56.9	57.7	1.17	0.03
d 33	66.4	68.9	70.2	0.94	0.02
d 42	74.9	78.2	79.3	1.76	0.02
1st pull (d 57)	93.5	94.5	95.7	1.66	0.14
Market weight	118.61	117.97	118.98	0.29	0.05
Average daily gain, kg/d					
d 0-21	0.91	0.96	1.00	0.06	0.02
d 22 - 42	0.96	1.01	1.07	0.05	0.02
d 0 - 42	0.93	0.98	1.03	0.05	0.001
d 43 - 1st pull (d 57)	1.08	1.08	1.05	0.03	0.41
d 0 - 1st pull (d 57)	0.99	1.01	1.03	0.03	0.14
d 57 - market	0.98	0.91	0.94	0.02	0.08
d 0 – end	0.99	0.98	1.00	0.02	0.31
Average daily feed intake, kg/d					
d 0 - 21	2.09	2.11	2.08	0.07	0.74
d 22 -42.	2.75	2.72	2.67	0.08	0.21
d 0 -42	2.42	2.41	2.37	0.06	0.41
d 43 - 1st pull (d 57)	3.48	3.33	3.21	0.09	0.10
d 0 - 1st pull (d 57)	2.69	2.66	2.59	0.07	0.12
d 57 - market	3.53	3.34	3.20	0.08	0.02
d 0 – end	2.94	2.85	2.77	0.04	0.01
Feed efficiency, gain/feed					
d 0 - 21	0.44	0.46	0.48	0.01	<0.001
d 22 - 42	0.36	0.37	0.40	0.01	0.003
d 0 - 42	0.40	0.41	0.43	0.01	<0.001
d 43 -1st pull (d 57)	0.32	0.33	0.33	0.02	0.34
d 0 -1st pull (d 57)	0.37	0.38	0.40	0.01	0.002
d 57 - market	0.28	0.27	0.29	0.01	0.17
d 0 – end	0.34	0.34	0.36	0.01	0.002
Tail-enders[b]	48	45	37	------	------
No. marketed[c]	183	186	187	------	------
Days to market (average)[d]	79.9	80.7	79.0	------	------

[a]Model included effects of dietary treatment, gender, weight block and d 0 bodyweight which was used as a covariate. Room was considered a random effect.
[b] Number of pigs not reaching market weight during the allotted experimental period.
[c] Number of pigs reaching minimum market weight; excludes tail-enders, mortalities and pulls.
[d] Of those pigs reaching the minimum market weight.

The reduction in the impact of dietary DE concentration on pig growth may be explained by the feed intake data. Whilst there was little impact of DE concentration on average daily feed during the early part of the experiment, this changed as the pigs grew heavier; during the 1st period, there was no impact of diet on feed intake, but by the second phase (d22 to 42), a tendency for feed intake to decline as dietary energy concentration increased could be observed ($P = 0.21$). By the third phase (d43 to 1st pull), this effect was approaching significance ($P = 0.10$), and by the final phase, from day 57 to market, the effect of diet on feed intake was statistically significant ($P=0.01$). Because the bulk of the feed was consumed beyond d43, there was a significant effect of diet on feed intake ($P<0.05$) for the overall experiment. The fact that diet had little effect on feed intake during the early part of the experiment, and that the effect of diet increased as the pigs grew heavier, helps to explain why diet had its greatest effect on growth in smaller pigs. When diet had no effect on feed intake, daily energy intake would increase as the energy content of the diet increased. This increased supply of energy would, at least theoretically, support faster growth. Later, when pigs ate less of the higher energy than the lower energy diet, their daily supply of energy would not be improved by the higher energy diet, and growth rate would be less likely to change.

As expected, feed efficiency improved as the dietary DE concentration increased for all periods except d43 to 1st pull and from d57 to market ($P<0.05$). Interestingly, whereas dietary DE concentration increased by about 9% from the lowest to the highest treatment, feed efficiency improved by about the same amount.

The impact of starting weight on performance is presented in Table 7. The pigs in the heavier block were heavier at first pull than their lighter weight counterpart; indeed, while there was a 8.4 kg difference in body weight at the start of the experiment, this increased to 12.3 kg at first pull. Overall, the pigs in the heavier block grew faster (1.04 versus 0.94 kg/d; $P<0.05$), ate more feed (2.96 versus 2.75 kg/d) but presented no difference in feed efficiency. About 3 times as many pigs in the light block were tail-enders, as compared to pigs in the heavier block. Heavier pigs were more efficient during the first weigh period, but not during the second or the third.

The impact of gender on performance is presented in Table 8. Barrows and gilts weighed approximately the same at the start of the experiment, but by first pull, barrows were 1.3 kg heavier (Table 8). We would not expect barrows and gilts to be this close in weight, but it is advantageous in terms of barn throughput. This observation was an unexpected finding, and confirms that amino acid intake was not limiting performance; generally, differences in performance between sexes is increased when amino acid nutriture is most limiting.

Barrows consumed more feed than gilts in every period, but also presented a poorer feed conversion, especially in the heavier growth phases ($P<0.05$). Feed efficiency was identical in barrows and gilts for all except the last weigh period, when barrows exhibited a better feed efficiency than gilts ($P<0.05$). This was an unexpected finding, and again confirms that amino acid intake was not limiting performance; generally, differences in performance between sexes is increased when amino acid nutriture is most limiting.

Carcass

The number of animals for which carcass data was obtained is presented in Table 9, according to dietary treatment and gender. Overall, carcass data was collected on 163 pigs on the low energy diet, on 164 pigs on the medium energy diet and 126 pigs on the high energy diet.

Table 7. Effect of initial body weight on the performance of pigs in a commercial barn[a]

	Initial weight group			
	Heavy	Light	SEM	P
No. pigs	360	360		
Bodyweight, kg				
d 0	41.0	32.6	0.87	<.0001
d 21	62.1	51.7	0.88	<0.001
d 33	73.5	63.5	1.17	<.0001
d 42	82.8	72.0	1.35	<.0001
1[st] pull (d 57)	100.7	88.4	3.10	<.0001
Market weight	117.05	120.00	0.56	0.01
Average daily gain, kg/d				
d 0 -21	1.00	0.91	0.06	<.0001
d 22 - 42	1.04	0.98	0.04	0.05
d 0 - 42	1.02	0.94	0.05	0.0003
d 43 -1[st] pull (d 57)	1.10	1.05	0.04	0.02
d 0 - 1[st] pull (d 57)	1.05	0.97	0.03	0.0003
d 57 - market	0.95	0.93	0.04	0.43
d 0 – market	1.02	0.96	0.05	0.0001
Average daily feed intake, kg/d				
d 0 - 21	2.28	1.90	0.06	0.0001
d 22 - 2	2.84	2.59	0.06	0.0001
d 0 -42	2.57	2.24	0.06	0.0001
d 43 -1[st] pull (d 57)	3.48	3.20	0.09	0.02
d 0 -1[st] pull (d 57)	2.81	2.49	0.06	0.0001
d 57 - market	3.42	3.30	0.20	0.16
d 0 – market	2.96	2.75	0.12	0.0001
Feed efficiency, gain/feed				
d 0 - 21	0.74	0.48	0.02	0.0001
d 22 - 42	0.37	0.38	0.006	0.13
d 0 -42	0.40	0.42	0.008	0.002
d 43 -1[st] pull (d 57)	0.32	0.33	0.02	0.17
d 0 -1[st] pull (d 57)	0.38	0.39	0.01	0.15
d 57 - market	0.30	0.26	0.02	0.42
d 0 – market	0.35	0.35	002	0.43
Tail-enders[b]	32	96	------	------
No. marketed[c]	322	229	------	------
Days to market (average)[d]	75.7	84.1	------	------

[a] Model included effects of dietary treatment, gender and weight block. For this comparison the d0 covariate was removed from the model. Room was considered a random effect.
[b] Number of pigs not reaching market weight during the allotted experimental period.
[c] Number of pigs reaching minimum market weight; excludes tail-enders, mortalities and pulls.
[d] Of those pigs reaching the minimum market weight.

Table 8. Effect of gender on performance of pigs in a commercial barn[a]

	Male	Female	SEM	P
No. pigs	360	360		
Bodyweight, kg				
d 0	36.9	36.8	0.87	0.75
d 21	57.2	56.6	1.15	0.14
d 33	69.1	67.8	0.76	0.21
d 42	79.0	75.9	1.64	0.01
1st pull (d 57)	95.2	93.9	1.59	0.11
Market wt	118.59	118.45	0.23	0.66
Average daily gain, kg/d				
d 0 - 21	0.97	0.94	0.05	0.12
d 22 - 42	1.02	1.00	0.05	0.54
d 0 - 42	0.99	0.97	0.05	0.26
d 43 - 1st pull (d 57)	1.07	1.07	0.04	0.94
d 0 - 1st pull (d 57)	1.02	1.00	0.03	0.12
d 57 - market	0.97	0.92	0.02	0.05
d 0 – market	1.01	0.98	0.02	0.03
Average daily feed intake, kg/d				
d 0 - 21	2.13	2.05	0.07	0.03
d 22 - 42	2.77	2.66	0.08	0.004
d 0 - 42	2.45	2.36	0.07	0.003
d 43 - 1st pull (d 57)	3.57	3.11	0.09	0.0003
d 0 - 1st pull (d 57)	2.74	2.55	0.06	<0.0001
d 57 - market	3.56	3.15	0.06	<0.0001
d 0 – market	2.97	2.74	0.04	<0.0001
Feed efficiency, gain/feed				
d 0 - 22	0.46	0.46	0.02	0.94
d 22 - 42	0.38	0.38	0.006	0.84
d 0 - 42	0.41	0.41	0.008	0.66
d 43 - 1st pull (d 57).	0.30	0.35	0.02	<0.0001
d 0 - 1st pull (d 57)	0.37	0.39	0.004	0.004
d 57 - market	0.27	0.29	0.007	0.04
d 0 – market	0.34	0.36	0.005	0.001
Tail-enders[b]	46	82	------	------
No. marketed[c]	297	254	------	------
Days to market (average)[d]	79.1	80.7	------	------

[a]Model included effects of dietary treatment, gender and weight block. Room was considered a random effect.
[b] Number of pigs not reaching market weight during the allotted experimental period.
[c] Number of pigs reaching minimum market weight; excludes tail-enders, mortalities and pulls.
[d] Of those pigs reaching the minimum market weight.

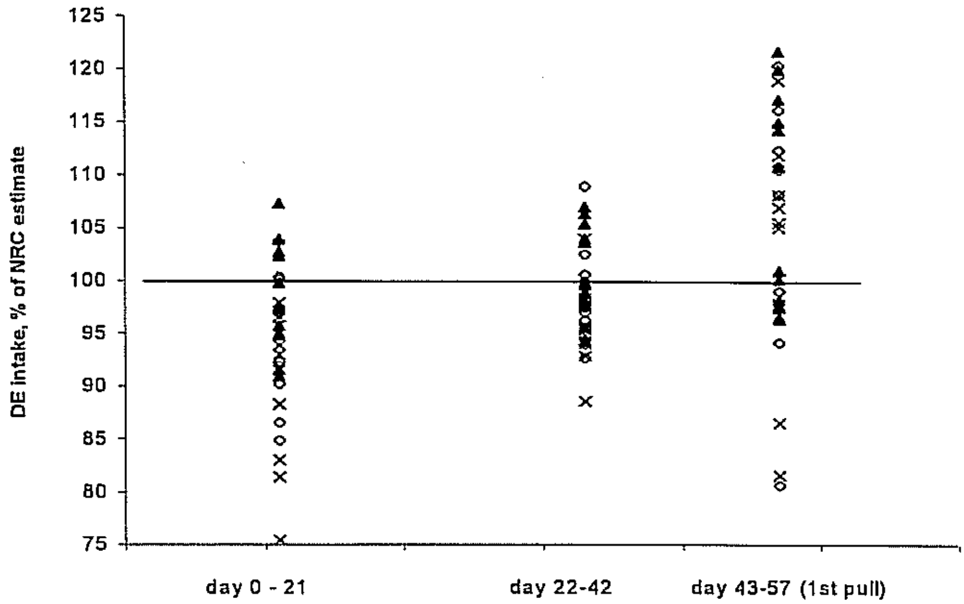


Figure 2. Digestible energy intake (kcal/.day) expressed as a percentage of the expected intake according to NRC (1998).

Dietary energy treatment had very little impact on carcass quality (Table 9). There was a tendency for pigs from the low energy diet to have a slightly lower dressing percentage (P<0.10), but carcass weights were very similar in weight across treatment. There was a tendency for loin thickness to increase as dietary energy increased; this is consistent with previous results (P<0.10; Patience et al., 2004). However, there was no impact of diet on backfat thickness or on carcass lean yield. These findings support our hypothesis that feeding higher energy diets will not impair carcass quality, provided the diets are formulated correctly and the genetics of the herd is of sufficient quality, in terms of body composition.

As a result, the gross revenue per pig was the same across treatment (Table 9). It is important to remember that this carcass value reflects that of the pigs marketed within the normal shipping weight range, and does not include the value of pigs marketed late. This will be dealt with later under the economic analysis of the experiment.

There was no effect of diet on the uniformity of the carcasses, as expressed by standard deviation for index, yield, backfat and lean (Table 9). However, since pigs were shipped according to a target live weight, this is not a surprising observation.

Pigs from the heavy blocks presented a slightly greater market weight than pigs from the lighter blocks, but interestingly, there was no difference in dressed weight (Table 10). Otherwise, there were no differences in carcass parameters, due to weight block, although there was a tendency for the pigs from the heavier block to be slightly fatter (P<0.15) but to also have a larger bonus (P<0.10).

It was not surprising to see differences in carcass quality between barrows and gilts (Table 11). The barrows had a lower dressing percentage and thus were slightly lighter on the rail (P<0.05). There was no difference in index, but the gilts were leaner (14.7 versus 17.3 mm), had larger loins (64.2 versus 61.0 mm) and higher estimated lean yield (62.6 versus 61.2 mm). Consequently, gilt carcasses were slightly more valuable than barrow carcasses, but the difference was smaller than expected. There were no differences in the uniformity of carcasses, although there was a tendency for gilts to be slightly more uniform in terms of index (P<0.10) and backfat thickness (P<0.20).

Table 9. **Effects of feeding diets formulated to contain 3.20, 3.35 or 3.50 Mcal DE/kg to growing/finishing pigs on carcass quality[a]**

	Digestible energy (Determined Mcal/kg)				
Item	**3.12**	**3.30**	**3.43**	**SEM**	**P[a]**
Number of pigs	240	240	240	-------	-------
Number of pens	12	12	12	-------	-------
Market weight, kg	118.9	117.9	118.8	0.60	0.02
Dressing percent, %	78.5	79.3	79.0	0.20	0.07
Carcass weight, kg	93.4	93.5	94.1	0.22	0.16
Index[b]	112.2	113.0	112.4	0.46	0.81
Lean yield, %	62.0	61.8	62.0	0.20	0.55
Fat, mm	15.8	16.2	16.0	0.40	0.53
Lean, mm	61.8	62.5	63.5	0.71	0.08
Incentive, $/carcass[c]	1.57	1.70	1.52	0.43	0.98
Value, $/pig[d]	148.33	149.57	149.59	0.80	0.19
St. dev. index[e]	3.64	3.26	3.78	0.61	0.79
St. dev. lean yield	1.69	1.51	1.65	0.14	0.62
St. dev. fat	3.26	2.93	3.24	0.31	0.68
St. dev lean	5.81	5.65	6.33	0.47	0.57

[a]The statistical model contained the effects of dietary treatment, initial block weight, gender and all possible 2- and 3-way interactions. No interactions were significant, P>0.05. Except for market weight, the model included market weight as a covariate. All data presented as simple arithmetic means.

[b]Taken from the Olymel West grid.

[c]Deductions for less than 57.9 mm lean and incentives (up to $6.00/carcass) for 58 to 69.9 mm lean. Only deductions applied for hogs over 99.9 kgs dressed weight or under 12 mm fat.

[d]Based on Spring 2005, 3 month average price of $140.00/ckg.

[e]Standard deviations on a pen basis. These were determined primarily because the numbers of pigs per pen for which we had carcass data varied. The standard deviation showed that this did not skew the data (no apparent outliers which would affect the mean).

Table 10. The effect of initial body weight on carcass quality[a]

Item	Heavy	Light	SEM	P
Number of pigs	360	360	-------	------
Number of pens	18	18	-------	------
Market weight	119.4	117.6	0.58	0.02
Dressing percent, %	78.8	79.1	0.18	0.21
Carcass weight, kg	94.2	93.1	0.20	0.99
Index[b]	112.5	112.6	0.46	0.95
Lean yield, %	61.8	62.1	0.20	0.56
Fat, mm	16.2	15.7	0.34	0.14
Lean, mm	62.5	62.7	0.72	0.67
Incentive, $/carcass[c]	1.86	1.33	0.43	0.10
Value, $/pig[d]	150.21	148.12	0.81	0.18
St. dev. index[e]	3.33	3.79	0.52	0.48
St. dev. lean yield	1.58	1.66	0.11	0.60
St. dev. fat	3.10	3.20	0.25	0.78
St. dev. lean	5.48	6.38	0.38	0.11

[a, b, c, d, e] Please refer to Table 10.

Table 11. The effect of gender on carcass quality[a]

Item	Male	Female	SEM	P
Number of pigs	360	360	-------	-------
Number of pens	18	18	-------	-------
Market weight, kg	118.6	118.4	0.58	0.54
Carcass weight, kg	93.4	93.9	0.18	0.01
Dressing percent, %	78.6	79.3	0.16	0.003
Index[b]	112.5	112.6	0.38	0.88
Lean yield, %	61.2	62.7	0.17	<0.001
Fat, mm	17.3	14.7	0.34	<0.001
Lean, mm	61.0	64.2	0.62	<0.001
Incentive, $[c]	1.41	1.78	0.38	0.28
Value, $/pig[d]	148.44	149.88	0.69	0.04
St. dev. index[e]	4.11	3.01	0.52	0.10
St. dev. lean yield	1.70	1.53	0.11	0.29
St. dev. fat	3.39	2.90	0.25	0.17
St. dev. lean	5.63	6.24	0.38	0.27

[a, b, c, d, e] Please refer to Table 10.

Simple correlation analysis was carried out on the carcass data, with the results presented in Table 12. There was, of course, a strong negative correlation between backfat thickness and lean yield (P<0.05), and a positive correlation between loin thickness and lean yield (P<0.05). There was a significant negative correlation between carcass index and carcass weight (P<0.05) and a positive correlation between quality incentive bonus and loin thickness; since the latter is paid out on the basis of loin thickness, this was a completely expected correlation.

Table 12. Simple correlation coefficients for carcass characteristics.

	Weight	Yield	Fat	Lean	Incentive
Index	**-0.35**[a]	0.31	**-0.36**	0.16	0.16
Weight		-0.05	0.08	0.17	0.14
Yield			**-0.99**	**0.76**	0.27
Fat				**-0.68**	-0.22
Lean					**0.47**

[a]Numbers in bold indicate a significant correlation (P < 0.05) n = 36.

Economic Analysis

An economic analysis of the outcome of this experiment was carried out, using two different scenarios, as described in the Materials and Methods, above. In all instances, the data were normalized to 1,000 head. A market price of $1.45/kg was used to generate a value for the pigs; this was considered to be a reasonable long-term average market price. The value of carcasses considered the market weight, index and bonuses paid, according to the results obtained in this experiment. The portion of pigs sold in different weight categories, as observed in the experiment. Feed costs were determined on the basis of a 4-phase feeding program, and feed usage was adjusted for the animals that were sold light.

In scenario #1 (Table 13; Appendix VII), the tail-end or hold-back pigs (those which did not reach the target market weight) were sold "as is" and the penalty for marketing lightweight pigs was absorbed as lost revenue. Less than 20% of the pigs were marketed as "lights" so the cost was not as great as it might have been otherwise. In this scenario, the most economical program, that is the one that maximized return over feed, was the lowest energy program, with a $2,118 advantage over the medium energy program and a $4,045 advantage over the high energy program. The economic disadvantage of the high energy feeding program, relative to the other two program, would be higher if canola oil, a much more expensive fat source, was used in place of tallow. Greater detail of this analysis is presented in Appendix VII, including actual diet costs and actual feed usage by phase.

In scenario 2 (Table 14; Appendix VIII), all of the tail-end pigs were kept in the barn until they reached their target market weight. On some farms, this would be impossible, but on others, such pigs may be moved to a special room maintained for this purpose. Another option employed on some farms is to move pigs "back" in the growout cycle, mixing the pigs with those scheduled to be marketed 1 or 2 weeks later. Additional feed was required to bring all of the pigs to market weight, but of course, revenues also increased because all pigs were marketed with an average live weight of 118kg. In this scenario, the lower energy program retained its advantage over the other two programs. The medium energy program lowered returns over growout feed by $1,253 while the high energy program reduced returns over growout feed by $4,015. Additional details of this scenario are presented in Appendix VIII.

Table 13. Projected returns over growout feed cost accruing from the use of low, medium or high energy feeding programs: Scenario #1[1]

	Diet DE Content, Mcal/kg		
	3.12	3.30	3.43
Total pigs start	1,000	1,000	1,000
Total pig end	963	963	946
Entry weight, kg	37.0	37.0	37.0
Shipping weight, kg	114.8	115.1	115.6
Dressed wt., kg	90.7	90.9	91.3
Feed usage, tonnes[2]	219.6	217.6	204.3
Feed usage, kg/pig	228	226	216
Feed conversion	2.93	2.89	2.75
Total feed cost, $	$38,090	$40,847	$41,078
Feed cost, $/pig sold	39.55	42.42	43.42
Gross revenues, $[3]	$144,381	$145,020	$143,324
Gross revenues, $/pig sold	149.93	150.59	151.51
Return over growout feed, $	$106,291	$104,173	$102,246
Return over growout feed, $/pig started	106.29	104.17	102.25
Return over growout feed, $/pig sold[4]	110.37	108.18	108.08

[1] All animals are sold when the rooms is closed out; thus, the penalty of marketing lightweight carcasses is fully absorbed in this scenario, and no attempt is made to mitigate this cost.

[2] Feed costs include a processing charge of $20/t. A 4-phase feeding program was employed as follows: Phase 1: 37 to 60 kg; Phase 2: 60 to 80 kg; Phase 3: 80 to 95 kg; Phase 4: 95 to 118 kg. Details of feed costs are presented in the Appendix.

[3] The number of animals sold adjusted for mortalities and "pulls" due to health or other problems. No cost or revenue was assigned to these animals, as it was assumed that the modest revenues from these animals would only cover their feed utilized. The Olymel West grid was applied for this economic analysis.

[4] All items expressed on a "per pig" basis are reported on a per pig *sold* basis, with the exception of return over feed, which is presented as both per pig started and per pig sold

Table 14. Projected returns over growout feed cost accruing from the use of low, medium or high energy feeding programs: Scenario #2[1]

	Diet DE Content, Mcal/kg		
	3.12	3.30	3.43
Total pigs start	1,000	1,000	1,000
Total pig end	963	963	946
Entry weight, kg	37.0	37.0	37.0
Shipping weight, kg	118.0	118	118
Dressed wt., kg	93.2	93.2	93.2
Feed usage, tonnes[2]	230.4	228.0	211.7
Feed usage, kg/pig	239	237	224
Feed conversion	2.95	2.93	2.77
Total feed cost, $	$39,851	$42,683	$42,484
Feed cost, $/pig sold	41.38	44.32	44.91
Gross revenues, $[3]	$147,378	$148,957	$145,996
Gross revenues, $/pig sold	153.04	154.68	154.33
Return over growout feed, $	107,527	$106,274	$103,512
Return over growout feed, $/pig started	107.53	106.27	103.51
Return over growout feed, $/pig sold[4]	111.66	110.36	109.42

[1] All animals are sold at the target weight of 118 kg; thus, additional feed was required to carry the holdback pigs to the target market weight. No charge for additional housing was included for simplicity, but also recognizing that in most costs, existing facilities are used to house holdback pigs.

[2] Feed costs include a processing charge of $20/t. A 4-phase feeding program was employed as follows: Phase 1: 37 to 60 kg; Phase 2: 60 to 80 kg; Phase 3: 80 to 95 kg; Phase 4: 95 to 118 kg. Details of feed costs are presented in the Appendix.

[3] The number of animals sold adjusted for mortalities and "pulls" due to health or other problems. No cost or revenue was assigned to these animals, as it was assumed that the modest revenues from these animals would only cover their feed utilized. The Olymel West grid was applied for this economic analysis.

[4] All items expressed on a "per pig" basis are reported on a per pig *sold* basis, with the exception of return over feed, which is presented as both per pig started and per pig sold

The return over feed cost under scenario 2 was on average $1.53 per pig higher than under scenario 2, illustrating the penalty of marketing lightweight pigs under most Canadian grading grids.

Like any economic analysis, this one requires that certain assumptions be made. The application of the Olymel West grading grid was appropriate in this instance, as it was the packer receiving the test pigs. However, it must be recognized that different results could accrue from the economic analysis if a different grid was applied. The economic analysis also reflects the results of this experiment conducted on this farm; results on other farms could differ. For example, the economic "value" of the high energy program was reduced by the higher pull rate (5.4% versus 3.75% on the other two programs). Since we do not know the exact feed intake or feed efficiency of the hold-back pigs, as they grow to market weight after their contemporaries have been marketed, we recognize that scenario #2 may underestimate the economic advantage of the low energy program. We conservatively estimated growth rate to be reduced by 10%, as compared to the treatment average, and the additional feed required to achieve market weight, after the contemporary pigs had gone to market, was assumed to be in the order of one-third.

Variability

Variability in bodyweight was determined for each dietary treatment on a room basis. At the beginning of the experiment, the coefficient of variation for bodyweight was a very respectable 15.9% (Table 15). At first pull, the latest time at which variation can be estimated, it was 12.0%. These CV's need to be considered in light of the fact that 20% of the smaller pigs were removed from the contemporary group prior to the start of the experiment; this would obviously lower variation. Nonetheless, these CV's are considered to be quite good for commercial conditions (Patience, 2004).

Table 15. The effect of dietary DE concentration on the CV[a] of body weight.

Formulated DE, Mcal/kg	3.12	3.30	3.43
		Room 1	
Day 0 CV, %	15.6	14.0	15.2
Day 57 (1st pull) CV, %	11.4	13.4	11.7
		Room 2	
Day 0 CV, %	19.2	15.1	16.8
Day 57 (1st pull) CV, %	13.4	12.7	13.6
		Room 3	
Day 0 CV, %	17.4	14.4	15.8
Day 57 (1st pull) CV, %	11.8	8.3	11.2
		Overall	
Day 0 CV, %	17.4	14.5	15.9
Day 57 (1st pull) CV, %	12.2	11.5	12.2

[a]The Coefficient of Variation or CV (std dev/mean * 100) was calculated on the bodyweights within a room (block) on a treatment basis (bodyweight of all pigs on the same treatment regardless of gender or weight block), therefore n ≈ 80 pigs.

Energy intake and efficiency

Daily energy intake, according to dietary treatment, initial weight and gender, is presented in Tables 16 through 18, respectively. It is clear from these data that during the early stages of growth, energy intake increased with increased dietary energy concentration. However, the advantage of the higher energy diets disappeared later in the finishing period. This phenomenon was present when either the DE or NE system was employed. It reflects very well our observations on feed intake (Table 6).

Despite the increased energy intake on the higher energy diets, there was no advantage in terms of the efficiency of energy utilization for growth. Indeed, during the last phase of the experiment, the lowest energy diet had the advantage in terms of the energetic efficiency of gain.

The heavier pigs consumed more energy per day than the lighter pigs. There were inconsistent responses statistically, in terms of the efficiency of energy utilization for growth; when they existed, they favoured the lighter pigs. This would be expected, because heavier pigs would have a higher maintenance requirement for energy, so a lower portion of the daily energy intake would be used for growth.

Similarly, barrows consumed more energy than gilts; this existed for all periods and was expected since barrows consumed more total feed than gilts. However, the gilts were more efficient in the use of their daily energy intake, especially in the later phases of growth. Again, this was expected. Gilts are leaner than barrows, and used overall feed more efficiently than barrows as well.

These data suggest that the higher energy diets are most effectively used in the early stages of growth, perhaps up to about 80 kg bodyweight. As the pig grows, the benefit of the higher energy diet declines, and becomes a greater cost burden on the farm. Since a major portion of feed is consumed after the pig reaches 80 kg, the cost of feeding pigs to market could be optimized by feeding lower cost, lower energy diets for the finishing phase.

■ CONCLUSIONS

The results of this experiment, conducted on a commercial piggery, confirmed that higher energy diets can be successfully fed without an adverse effect of carcass quality. Despite the fact that the DE content of the diet increased by 10%, there was no impact on backfat thickness, lean yield or carcass index. Indeed, the higher energy diet tended to increase loin thickness.

Based on performance, carcass quality and financial return, the lower energy feeding program was once again equal to, or superior to, the higher energy programs. In this experiment, the same energy level was fed throughout; it would appear from the data that the most effective feeding program would be one that employs higher energy levels in the growing and early finishing phases, perhaps up to 80 kg, with lower energy levels used thereafter. This would take advantage of the improved growth on the higher energy diets observed during the first 6 weeks in this experiment, and save money by lowering energy during the final phase of growout, when energy did not elicit a growth response. Since 56% of the feed consumed by pigs on this experiment occurred beyond 80 kg bodyweight, substantial savings could accrue from feeding the lower energy diets after 80 kg.

Increasing dietary energy concentration did not reduce variability in growth. This particular experiment may not have been the best model to test such an hypothesis, since the "bottom" 15% of the pigs were removed from the contemporary group prior to the start of the experiment. While this may have lowered the chances of seeing a difference, or more likely lowered the differences observed, the results reported herein are very clear – increasing dietary energy does not alter the variability of pig growth.

We can draw other conclusions from this experiment, as well. For example, it was once again confirmed that the energy content of experimental diets must be determined, rather than use book values. Determining DE is not a difficult or expensive practice, and deviations of significant magnitude are common in our experience. In this experiment, the deviation between the formulated and determined DE values averaged 71 kcal/kg or 2.1%.

Table 16. Effects of feeding diets formulated to contain 3.20, 3.35 or 3.50 Mcal/kg DE to growing/finishing pigs in a commercial barn on energy intake and efficiency of the use of energy for growth.

Item	Treatment (DE, Mcal/kg) 3.12	3.30	3.43	SEM	P value
DE intake, Mcal/d[a]					
d 0-21	6.49	6.89	7.19	0.22	0.0005
d 22 - 42	8.51	8.92	9.27	0.31	0.0001
d 0 – 42	7.49	7.91	8.23	0.25	0.0001
d 43 - 1st pull (d 57)	10.51	10.95	10.98	0.33	0.53
d 0 - 1st pull (d 57)	8.35	8.74	9.02	0.29	0.003
d 57 - market	11.24	11.16	10.97	0.26	0.72
d0- end	9.14	9.34	9.58	0.14	0.06
NE intake, Mcal/d[b]					
d 0-21	4.60	4.86	5.02		
d 22 – 42	6.03	6.30	6.48		
d 0 – 42	5.31	5.58	5.75		
d 43 - 1st pull (d 57)	7.67	7.69	7.76		
d 0 - 1st pull (d 57)	5.92	6.14	6.28		
d 57 – market	7.76	7.70	7.76		
d0- end	6.48	6.59	6.69		
Energetic efficiency, kg gain/Mcal DE [a]					
d 0-21	0.14	0.14	0.14	0.004	0.60
d 22 – 42	0.11	0.11	0.12	0.003	0.82
d 0 – 42	0.13	0.12	0.13	0.003	0.35
d 43 - 1st pull (d 57)	0.11	0.10	0.10	0.008	0.01
d 0 - 1st pull (d 57)	0.12	0.12	0.12	0.002	0.33
d 57 – market	0.09	0.08	0.09	0.003	0.19
d0- end	0.11	0.10	0.10	0.002	0.11
Energetic efficiency, kg gain/Mcal NE[b]					
d 0-21	0.20	0.20	0.20		
d 22 - 42	0.16	0.16	0.16		
d 0 - 42	0.18	0.18	0.18		
d 43 - 1st pull (d 57)	0.14	0.14	0.14		
d 0 - 1st pull (d 57)	0.17	0.16	0.17		
d 57 - market	0.13	0.12	0.12		
d0- end	0.15	0.15	0.15		

[a]LSMeans. Digestible energy determined on a pen basis.
[b]Means. Net energy calculated for each diet using CVB (1998).

Table 17. Effects of initial body weight of growing/finishing pigs in a commercial barn on energy intake and efficiency of the use of energy for growth.

Item	Heavy	Light	SEM	P value
DE intake, Mcal/d[a]				
d 0-21	7.50	6.22	0.19	0.0001
d 22 - 42	9.31	8.48	0.20	0.0001
d 0 - 42	8.41	7.34	0.19	0.0001
d 43 - 1st pull (d 57)	11.26	10.37	0.35	0.01
d 0 - 1st pull (d 57)	9.23	8.18	0.23	0.001
d 57 - market	11.34	10..91	0.27	0.12
d0- end	9.71	9.00	0.10	0.0001
NE intake, Mcal/d[b]				
d 0-21	5.24	4.41		
d 22 - 42	6.05	6.49		
d 0 - 42	5.62	5.48		
d 43 - 1st pull (d 57)	8.57	6.84		
d 0 - 1st pull (d 57)	6.31	5.92		
d 57 - market	7.38	8.11		
d0- end	6.83	6.35		
Energetic efficiency, kg gain/Mcal DE[a]				
d 0-21	0.13	0.16	0.01	0.0001
d 22 - 42	0.12	0.11	0.002	0.17
d 0 - 42	0.12	0.13	0.003	0.30
d 43 - 1st pull (d 57)	0.10	0.10	0.006	0.10
d 0 - 1st pull (d 57)	0.11	0.12	0.001	0.005
d 57 - market	0.08	0.09	0.003	0.56
d0- end	0.11	0.11	0.001	0.57
Energetic efficiency, kg gain/Mcal NE[b]				
d 0-21	0.20	4.41		
d 22 - 42	0.16	6.49		
d 0 - 42	0.18	5.48		
d 43 - 1st pull (d 57)	0.13	6.84		
d 0 - 1st pull (d 57)	0.16	5.92		
d 57 - market	0.13	8.11		
d0- end	0.15	6.35		

[a]LSMeans. Digestible energy determined on a pen basis.
[b]Means. Net energy calculated for each diet using CVB (1998).

Table 18. Effects of gender of growing/finishing pigs in a commercial barn on energy intake and efficiency of the use of energy for growth.

Item	Male	Female	SEM	P value
DE intake, Mcal/d[a]				
d 0-21	6.97	6.74	0.22	0.04
d 22 - 42	9.06	8.74	0.30	0.004
d 0 - 42	8.01	7.74	0.25	0.003
d 43 - 1st pull (d 57)	11.45	10.18	0.28	0.001
d 0 - 1st pull (d 57)	8.98	8.43	0.28	0.0001
d 57 - market	11.85	10.39	0.22	0.0001
d0- end	9.73	8.98	0.12	0.0001
NE intake, Mcal/d[b]				
d 0-21	4.92	4.82		
d 22 - 42	6.39	6.26		
d 0 - 42	5.65	5.54		
d 43 - 1st pull (d 57)	8.24	7.83		
d 0 - 1st pull (d 57)	6.33	6.14		
d 57 - market	8.21	7.77		
d0- end	6.86	6.62		
Energetic efficiency, kg gain/Mcal DE[a]				
d 0-21	0.14	0.14	0.003	0.88
d 22 - 42	0.12	0.11	0.007	0.44
d 0 - 42	0.12	0.13		
d 43 - 1st pull (d 57)	0.09	0.11	0.007	0.0001
d 0 - 1st pull (d 57)	0.11	0.12	0.001	0.02
d 57 - market	0.08	0.09	0.002	0.02
d0- end	0.10	0.11	0.002	0.003
Energetic efficiency, kg gain/Mcal NE[b]				
d 0-21	0.20	0.20		
d 22 - 42	0.16	0.16		
d 0 - 42	0.18	0.18		
d 43 - 1st pull (d 57)	0.13	0.14		
d 0 - 1st pull (d 57)	0.16	0.16		
d 57 - market	0.12	0.12		
d0- end	0.15	0.15		

[a]LSMeans. Digestible energy determined on a pen basis.
[b]Means. Net energy calculated for each diet using CVB (1998).

■ REFERENCES

C.V.B. 1994. Table of Feedstuffs. Information about composition, digestibility and feeding values. Centraal Veevoederbureau, Lelystad, The Netherlands.

Patience, J.F. 2004. Managing variation in the nursery and growout barn. Prince Agri-Products, Des Moines, IA. August 18.

Patience, J.F., A.D. Beaulieu, R.T. Zijlstra, N. Williams and D. A. Gillis. 2004. Response of growing and finishing pigs to dietary energy concentration. Monograph No. 03-05. Prairie Swine Centre Inc., Saskatoon, Canada. 24 pp.

Appendix I. Effects of dietary energy level, initial weight and gender on body weight and average daily gain of pigs in a commercial barn.[a]

Initial weight group	Heavy						Light					
Gender	Male			Female			Male			Female		
Formulated DE.Mcal/kg	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**
Bodyweight, kg												
d 0	41.2	40.3	41.3	41.7	40.9	40.9	33.4	32.9	32.1	33.2	32.3	31.8
d 21	58.3	58.3	60.5	57.7	58.8	58.6	54.9	55.6	55.7	53.6	54.7	56.1
d 28[b]	68.5	66.8	71.0	.	.	.	59.0	59.5	58.8	.	.	.
d 33	67.1	66.3	69.1	60.4	68.7	67.5	70.0	70.3	72.0	67.5	70.2	72.4
d 42	76.4	76.5	78.8	68.3	77.0	75.7	79.3	80.3	82.9	75.2	79.3	79.9
d 56	95.3	95.0	98.2	.	.	.	92.0	92.3	93.3	.	.	.
1st pull (d 57)	95.6	95.2	98.0	95.3	96.5	96.1	93.8	94.0	94.9	89.6	92.2	93.7
d 57 – market	117.5	116.9	116.8	117.1	116.2	117.9	120.3	119.3	120.7	119.5	119.5	120.6
Average daily gain, kg/d												
d 0 - 21	1.02	1.03	1.13	0.99	1.04	1.03	0.86	0.90	0.90	0.79	0.86	0.92
d 22-28	0.95	0.82	0.98	.	.	.	0.98	1.01	1.00	.	.	.
d 0 - 28	0.97	0.95	1.06	.	.	.	0.91	0.95	0.96	.	.	.
d 22 - 42	0.90	0.97	1.01	0.96	0.98	1.00	0.99	1.06	1.18	0.98	1.01	1.07
d 0 - 42	0.94	0.98	1.04	0.95	1.00	1.00	0.94	1.00	1.05	0.90	0.96	1.02
d 43 - 56	1.09	1.12	1.12	.		.	1.11	1.08	1.02	.	0.96	.
d 0 - 56	1.04	1.03	1.09	.	.	.	0.99	0.99	1.01	.	.	.
d 43 - 1st pull (d 57)	1.06	1.07	1.05	1.11	1.09	1.06	1.12	1.10	1.04	1.06	1.05	1.06
d 0 - 1st pull (d 57)	1.03	1.02	1.07	1.02	1.04	1.03	1.00	0.96	1.02	0.93	1.01	1.01
d 57 - market	1.03	0.98	0.94	0.98	0.98	0.97	1.00	0.92	0.92	0.91	0.86	0.91
d 0 – market	1.05	1.03	1.07	1.04	1.02	1.04	0.99	0.96	0.95	0.91	0.90	0.95

[a]No interactions were significant ($P > 0.10$). Significance of main effects described in previous tables. d0 was used as a covariate
[b]Male weigh day only (change from phase I to phase II)

Appendix II. Effects of dietary energy level, initial weight and gender on feed intake and feed efficiency of pigs in a commercial barn.

Initial weight group	Heavy						Light					
Gender	Male			Female			Male			Female		
Formulated DE, Mcal/kg	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**
Average daily feed intake, kg/d												
d 0 – 21	2.34	2.28	2.34	2.17	2.26	2.21	1.98	1.92	1.91	1.88	1.95	1.83
d 22 – 28	2.85	2.59	2.61	.	.	.	2.39	2.32	2.31	.	.	.
d 0 – 28	2.49	2.37	2.45	.	.	.	2.11	2.04	2.04	.	.	.
d 22 – 42	2.75	2.69	2.62	2.56	2.55	2.54	2.92	2.77	2.86	2.74	2.89	2.69
d 0 – 42	2.53	2.48	2.47	2.35	2.40	2.37	2.45	2.35	2.40	2.33	2.43	2.27
d 43 – 56	3.76	3.83	3.59	.	.	.	3.65	3.42	3.38	.	.	.
d 0 – 56	2.94	2.89	2.86	.	.	.	2.66	2.52	2.53	.	.	.
d 43 - 1st pull (d 57)	4.02	3.98	3.76	3.65	3.46	3.40	3.51	3.12	3.05	2.76	2.75	2.61
d 0 - 1st pull (d 57)	2.89	2.84	2.77	2.65	2.64	2.60	2.76	2.59	2.61	2.47	2.56	2.40
d 57 – market	3.68	3.49	2.96	3.05	2.89	3.12	3.98	3.63	3.64	3.40	3.33	3.11
d 0 – market	3.18	3.10	2.91	2.89	2.82	2.85	3.03	2.81	2.80	2.68	2.68	2.50
Feed efficiency, gain/feed												
d 0 – 21[b]	0.45	0.46	0.49	0.41	0.47	0.48	0.42	0.46	0.46	0.47	0.43	0.50
d 22- 28	0.33	0.31	0.38	.	.	.	0.42	0.44	0.43	.	.	.
d 0 – 28	0.39	0.40	0.43	.	.	.	0.43	0.47	0.47	.	.	.
d 22 – 42[c]	0.35	0.35	0.38	0.37	0.37	0.39	0.37	0.39		0.37	0.36	0.41
d 0 – 42	0.40	0.40	0.43	0.41	0.42	0.43	0.39	0.42	0.43	0.38	0.38	0.44
d 43 – 56	0.29	0.29	0.31	.	.	.	0.31	0.32	0.31			.
d 0 – 56	0.35	0.36	0.38	.	.	.	0.37	0.39	0.40	.	.	.
d 43 - 1st pull (d 57)	0.29	0.29	0.32	0.34	0.35	0.35	0.29	0.32	0.30	0.35	0.34	0.35
d 0 - 1st pull[d] (d 57)	0.35	0.35	0.38	0.38	0.39	0.39	0.37	0.40	0.40	0.39	0.39	0.44
d 57 - market	0.28	0.29	0.32	0.32	0.30	0.31	0.24	0.25	0.25	0.27	0.25	0.30
d 0 – end[d]	0.33	0.33	0.36	0.36	0.36	0.36	0.32	0.35	0.34	0.34	0.34	0.38

[a]Trt by gender by block, P = 0.05
[b]Dietary energy by block, P = 0.05 (when no covariate used)
[c]Gender by block, P = 0.04
[d]Trt by gender by block, P = 0.01

Appendix III. The effect of initial body weight, gender and energy concentration on energy and lysine intake of growing/finishing pigs in a commercial barn.

Initial weight group	Heavy						Light					
Gender	Male			Female			Male			Female		
Formulated DE, Mcal/kg	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**
DE intake, Mcal/d[a]												
d 0 – 21	7.20	7.42	8.08	6.69	7.39	7.64	6.16	6.32	6.65	5.89	6.45	6.37
d 22 – 42	8.48	8.78	9.09	7.89	8.35	8.83	9.09	9.05	9.85	8.57	9.48	9.29
d 0 – 42	7.80	8.07	8.55	7.24	7.83	8.20	7.65	7.72	8.30	7.28	8.01	7.88
d 43 - 1st pull (d 57)	12.19	13.09	12.83	11.20	11.68	11.86	10.48	9.89	10.21	8.18	9.14	9.00
d 0 - 1st pull (d 57)	8.89	9.24	9.54	8.17	8.67	9.03	8.60	8.53	9.07	7.75	8.52	8.44
d 57 – market	11.84	11.78	10.30	9.73	9.74	10.71	12.70	12.11	12.39	10.71	11.01	10.47
d 0 – market	9.89	10.15	10.09	8.97	9.26	9.88	9.39	9.16	9.68	8.33	8.77	8.67

[a]LSMeans. Based on measured DE values, determined on a pen basis.

Appendix IV. Comparison of actual DE intake relative to intake estimated by NRC[a] (expressed as a percentage).

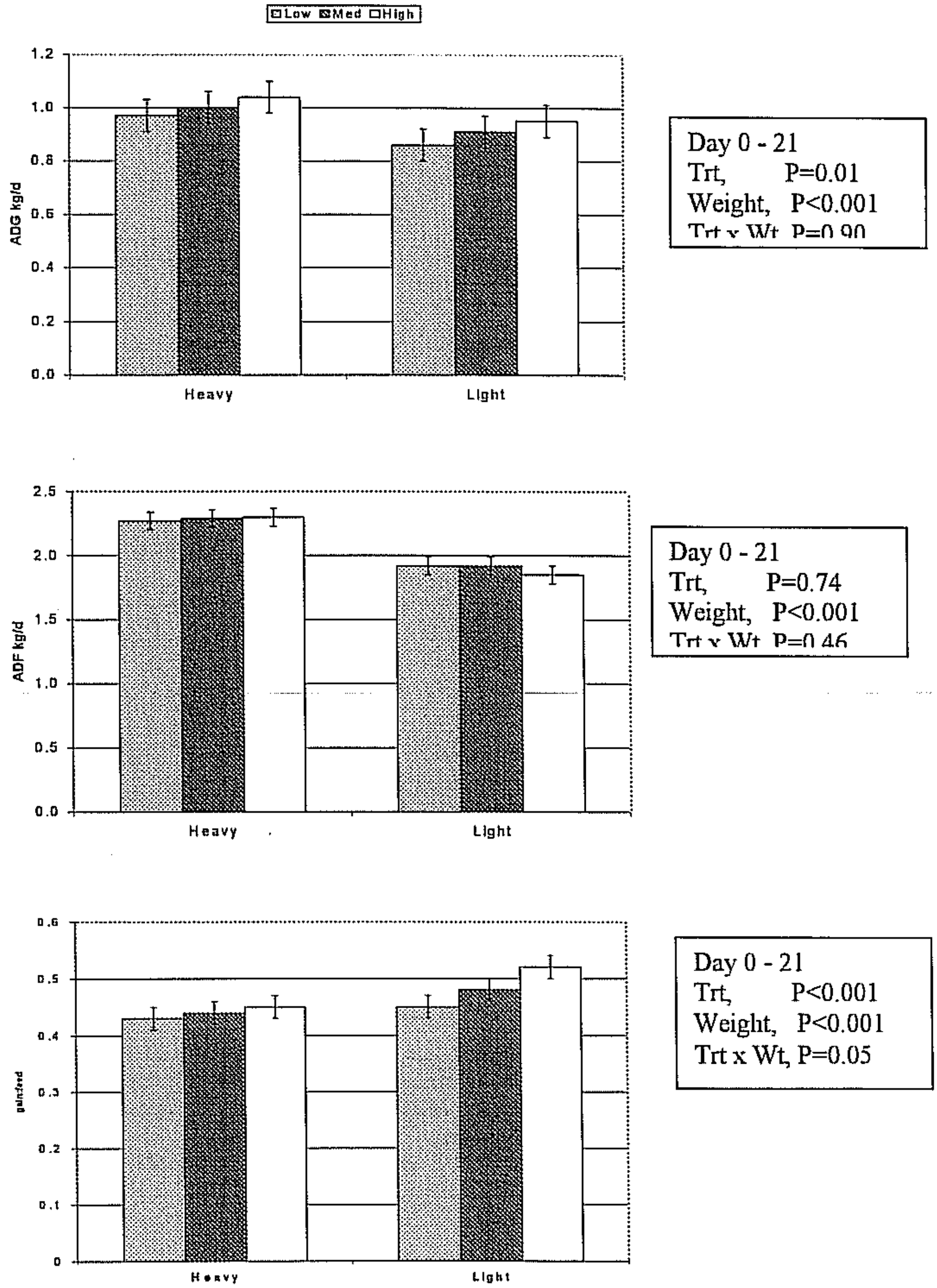
Initial weight group	Heavy						Light					
Gender	Male			Female			Male			Female		
Formulated DE, Mcal/kg	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**	**3.12**	**3.30**	**3.43**
d 0 – 21	94	98	104	87	96	100	89	91	97	86	94	93
d 22 – 42	98	100	103	95	96	101	97	96	103	93	101	97
d 0 – 42	98	101	106	94	98	103	95	95	102	91	99	97
d 43 - 1st pull (d 57)	107	118	112	99	103	105	112	107	112	92	102	102
d 0 - 1st pull (d 57)	100	104	107	93	98	103	96	96	102	87	95	94
d 57 – market	111	110	97	93	92	101	111	105	106	93	94	89
	3.12	**3.30**	**3.43**		**Male**	**Female**		**Heavy**	**Light**			
d 0 – 21	89	95	98		95	93		97	91			
d 22 – 42	96	98	101		100	97		99	98			
d 0 – 42	94	98	102		112	97		100	97			
d 43 - 1st pull (d 57)	102	107	107		111	100		107	104			
d 0 - 1st pull (d 57)	94	98	101		101	95		101	95			
d 57 – market	102	100	98		107	94		101	100			

[a] Estimated DE intake for growing/finishing pigs (kcal/day) = $13{,}162 \times (1 - e^{-0.0176\,BW})$ (NRC 1998).

Appendix V. The effect of initial block weight, gender and dietary DE concentration on carcass qualities of pigs grown in a commercial barn[a]

Initial weight group	Heavy						Light					
Gender	Male			Female			Male			Female		
Dietary DE, Mcal/kg	3.12	3.30	3.43	3.12	3.30	3.43	3.12	3.30	3.43	3.12	3.30	3.43
Number of pigs	40	40	40	40	40	40	40	40	40	40	40	40
Number of pens	2	2	2	2	2	2	2	2	2	2	2	2
Market weight, kg	119.9	118.8	119.3	119.8	118.4	120.2	118.5	117.1	118.1	117.5	116.9	117.8
Dressing percent, %	78.5	78.0	78.8	78.8	79.7	79.6	77.7	79.5	78.9	79.2	79.8	78.9
Carcass weight, kg	93.2	92.9	93.7	93.7	94.0	94.5	92.2	94.3	93.7	93.7	94.2	93.8
Index[b]	112.4	113.2	113.3	112.4	112.9	112.8	112.0	113.0	111.3	112.6	112.0	112.7
Lean yield, %	61.4	60.9	61.2	62.7	62.5	62.4	61.2	61.1	61.5	63.0	62.5	62.8
Fat, mm	17.1	17.7	17.3	14.6	14.9	15.2	17.2	17.4	17.0	14.0	14.9	14.5
Lean, mm	61.7	59.7	62.0	63.9	64.9	64.5	58.8	60.6	63.1	63.4	63.8	64.7
Incentive,[c] $/carcass	1.87	1.90	1.69	1.92	2.60	1.78	0.78	0.86	1.44	1.89	1.15	1.30
Value, $/pig	148.42	149.00	150.25	149.55	151.17	150.96	145.28	150.07	147.42	149.49	149.06	149.27
St. dev. index[c]	4.36	3.59	3.36	2.91	3.12	2.64	4.58	2.75	5.99	2.69	3.58	3.13
St. dev. lean yield	1.84	1.50	1.49	1.59	1.41	1.61	1.86	1.48	2.04	1.47	1.64	1.47
St. dev. fat	3.71	3.13	2.94	2.64	2.61	2.78	3.58	2.81	4.19	3.12	3.18	3.08
St. dev. lean	4.91	3.97	5.90	6.85	4.92	6.31	5.79	6.53	6.65	5.68	7.19	6.47

[a]The model contained the effects of dietary treatment, initial block weight, gender and all possible 2- and 3-way interactions. No interactions were significant ($P > 0.05$). Except for market weight, the model included market weight as a covariate.
[b]Taken from the Olymel grid.
[c]Deductions for less than 57.9 mm lean and incentives (up to $6.00/carcass) for 58 to 69.9 mm lean. Only deductions applied for hogs over 99.9 kgs dressed weight or under 12 mm fat.
[d]Standard deviations on a pen basis. These were determined primarily because the numbers of pigs per pen for which we had carcass data varied. The standard deviation showed that this did not skew the data (no apparent outliers which would affect the mean).



Appendix VI. The effect of dietary energy and initial weight on ADG, ADFI and feed efficiency during the first 3 weeks of the experiment. The model contained the effects of dietary trt, weight block, gender and all interactions. No covariate adjustment was included.

Appendix VII. Economic analysis: Scenario 1[a]

	Low	Medium	High
Gross Revenues[1]			
- Total	$144,381	$145,020	$143,324
- Per pig	149.93	150.59	151.51
Feed cost, $/tonne[2]			
- Phase 1 (37 to 60 kg)	188.34	203.58	217.67
- Phase 2 (60 to 80 kf)	177.39	192.10	205.26
- Phase 3 (80 to 95 kg)	168.89	183.04	196.57
- Phase 4 (95 kg to mkt)	162.77	177.09	190.05
Ave. no. pigs by phase			
- Phase 1	963	963	946
- Phase 2	963	963	944
- Phase 3	957	957	944
- Phase 4	863	870	869
Feed usage, tonne[3]			
- Phase 1	50.28	48.06	45.26
- Phase 2	53.54	52.00	47.20
- Phase 3	44.93	43.50	42.90
- Phase 4	70.86	74.04	68.96
Feed cost, $			
- Phase 1	9,469.40	9,784.73	9,851.01
- Phase 2	9,497.96	9,989.58	9,688.27
- Phase 3	7,588.42	7,961.44	8,433.80
- Phase 4	11,534.03	13,111.21	13,104.93
- Total	$38,089.81	$40,846.96	$41,078.01
- Per pig sold	39.55	42.42	43.42
Return over growout feed cost			
- Total	$106,291	$104,173	$102,246
- Per pig sold	$110.37	$108.18	$108.08

[1] Revenue adjusted for reduced value of animals sold at weights below the core, and for mortalities and "pulls" due to health or other problems. No value was assigned to the latter; it was assumed that any revenues earned by the pulls would be offset by feed and other costs.

[2] Includes processing charge of $20/t; Phase 1: 37 to 60 kg; Phase 2: 60 to 80 kg; Phase 3: 80 to 95 kg; Phase 4: 95 to 118 kg

[3] Total quantity of each phase of diet used

Appendix VIII. Economic analysis: Scenario 2[a]

	Low	Medium	High
Gross Revenues[1]			
- Total	$147,378	$148,957	$145,996
- Per pig	153.04	154.68	154.33
Feed cost, $/tonne[2]			
- Phase 1 (37 to 60 kg)	188.34	203.58	217.67
- Phase 2 (60 to 80 kf)	177.39	192.10	205.26
- Phase 3 (80 to 95 kg)	168.89	183.04	196.57
- Phase 4 (95 kg to mkt)	162.77	177.09	190.05
Ave. no. pigs by phase			
- Phase 1	963	963	946
- Phase 2	963	963	944
- Phase 3	957	957	944
- Phase 4	863	870	869
- Holdback pigs[3]	200	188	154
Feed usage, tonne			
- Phase 1	50.28	48.06	45.26
- Phase 2	53.54	52.00	47.20
- Phase 3	44.93	43.50	42.90
- Phase 4	70.86	74.04	68.96
- Holdback feed[4]	10.82	10.37	7.40
Feed cost, $			
- Phase 1	9,469.40	9,784.73	9,851.01
- Phase 2	9,497.96	9,989.58	9,688.27
- Phase 3	7,588.42	7,961.44	8,433.80
- Phase 4	11,534.03	13,111.21	13,104.93
- Holdback feed	1,761.17	1,836.42	1,406.37
- Total	$39,850.98	$42,683.38	$42,484.38
- Per pig sold	41.38	44.32	44.91
Return over growout feed cost			
- Total	$107,527	$106,274	$103,512
- Per pig sold	$111.66	$110.36	$109.42

[1] Revenue adjusted upward, as compared to scenario #1, to reflect that all pigs would be sold with the core; revenue also adjusted for mortalities and "pulls" due to health or other problems. No value was assigned to the latter; it was assumed that any revenues earned by the pulls would be offset by feed and other costs.

[2] Includes processing charge of $20/t; Phase 1: 37 to 60 kg; Phase 2: 60 to 80 kg; Phase 3: 80 to 95 kg; Phase 4: 95 to 118 kg

[3] Number of holdback pigs per 1,000, based on the portion of holdbacks observed in the experiment.

[4] Quantity of feed required to bring hold-back pigs up to market weight; the holdback feed was assumed to be Phase 4 diet, although a very few of the lightest holdbacks may be fed small quantities of Phase 3 diet.