1987

Porcine Growth Hormone: Implications for Hog Producers and the Swine Industry

Martin I. Meltzer

Robert J. Kalter

Cornell University

Ithaca, New York 14853-7801

March 2, 1987

Swine -- Cost of production

AAEA paper presented at its annual meetings.

Abstract

Porcine Growth Hormone (pGH) causes a significant feed efficiency improvement in swine with resulting positive short-run economic impacts on medium-sized hog farms. Linear programming results indicate that pGH will not alter competitive positions within this group. Land values, hog and corn supplies will change as will the quality of meat produced.

Biographical Sketch of Presenting Author

Martin I. Meltzer obtained his undergraduate degree in Agricultural Economics at the University of Zimbabwe. After working a year at U.S.A.I.D./Zimbabwe, he entered the Master's program at Cornell University, obtaining his degree in 1987. He is currently studying for his Ph.D. with a dissertation topic of biotechnology transfer to Africa.

It has been estimated that about 4 billion pounds of fat are trimmed from carcasses, wholesale and retail cuts and cooked meat every year (Etherton and Meserole). Thus, any technology that would improve feed efficiency and reduce carcass fat is of interest to producers, meat processors and consumers. Growth hormones and beta-adrenergic agonists have that ability. By acting as "repartitioning agents," they alter the rate at which muscle and fat are synthesized and broken down. Since recombinant-DNA technology can assure commercial supplies of animal growth hormones, this paper will, based on a recent study (Meltzer), examine the economic impact of porcine growth hormone- (pGH) induced feed efficiency on the pig industry. It will be assumed that regulatory approval for the farm use of pGH will be granted.

Repartitioning Agents and Hog Growth Performance

The exact actions of the repartitioning agents are unknown. They seem to increase the rate at which fat in the body is broken down (a lypolytic effect) and slow down the rate at which it is constructed. This allows more nutrients to be available for the construction of other tissues, such as muscle. As it takes approximately 2 1/2 times more carbohydrates to form a given mass of fat than it does muscle (McDonald et al.), using a repartitioning agent will result in a leaner animal that requires less feed to achieve a given weight.

Table 1 details some experimental results from administering pGH to hogs. The variability of results is due mainly to different dosage rates used to fulfill differing primary experimental objectives. For example, titration for the optimal dosage rate of pGH was the main concern of Rebhun et al., and their results are especially interesting because "[i]t is evident that the dose range selected (.01 - .07 mg/ha/d) for this experiment did not encompass a maximally effective dose since ADG, F/G and carcass composition increased in a linear manner with PGH dose (Rebhun et al.).

Based on the values in Table 1, pGH can cause a 10% - 15% gain in feed efficiency, with 20% and 5% as plausible upper and lower limits, respectively. As mentioned earlier, a pGH-induced increase in feed efficiency should be accompanied by decreases in carcass fat. This has been the case, as Machlin (for example) reported about a 20% reduction in backfat. It should be noted that virtually all these results were obtained from pigs being fed what can be considered a "standard" diet, containing approximately 14% crude protein.[1] Experimental work has not been confined to pigs. Lambs given beta-adrenergic agonists have also produced results similar to those in Table 1 (Beermann et al.; Baker et al.), whilst administering bovine growth hormone to lactating dairy cows has resulted in increased milk yields (Bauman et al.).

Farm Level pGH Implications

To examine the effect of pGH at the farm level, three representative hog farms with varying resources and profitabilities were constructed. Feed rations were adjusted to represent four response levels to pGH. A linear program was used to determine the optimal output for each of the three representative farms, given certain constraints and assuming that the objective was to maximize net returns (gross margins). It is important to note that the study only concerns the impact on the fattening stage of the hog (i.e. after the weaning and feeding stages). Little data are currently available to assess the effect of additional hormone on either pre-weaned or feeder pigs.

In selecting suitable data sources, it is noted that Iowa, Illinois, Minnesota and Indiana produced 51.2% of all U.S. liveweight hogs in 1980 (Van Arsdall and Nelson). These four states belong to the North Central region, where approximately 42% of the

---

[1]Recent experiments (Boyd et al.) have achieved gains in feed efficiency of 30% or more, with decreases in fat of up to 70%. However, the crude protein content of the diets was increased to about 20% and the trials ran for only 60 days before slaughter.

hog farms had annual sales of 500 to 1,999 head. The vast majority of these farms are "farrow-to-finish" operations. Consequently, the three representative farms were modeled using average farrow-to-finish hog farm management data collected from approximately 160 farms in Southwestern Minnesota (Welsch et al.). These data divided the total sample into three group averages (accounting for 20%, 60% and 20%), labelled Least Efficient, Average Efficiency and Most Efficient. Efficiency was defined by the total profit and loss for the farms. There was a strong correlation between profit and physical efficiency.

For example, large differences between the three farm types were seen in coefficients of production. The Least Efficient farm obtained a gross margin of $103 per acre of corn compared to $157 and $205 for the Average and Most Efficient farms. Returns from the other crops showed a similar pattern. The Least Efficient farm required 14.29 bushels of corn and 280 lbs of bought protein to raise a pig to a market weight of 235 lb. This is 2.79 bushels and nearly 100 lb. more than the Most Efficient farm. Such differences in efficiency can be assumed attributable to influences such as management and soil quality.

The linear programming models include activities for producing hogs and beef, growing corn, soybeans, alfalfa hay and corn silage, and activities for selling livestock and crops. Resources varied slightly between farms. Resources for the Average Efficiency farm were 300 arable acres, a limit of 150 acres for soybeans, a corn-alfalfa ratio of 1:0.2, $80,000 working capital, 80 head of beef and 1,200 pigs.

A corn-to-soybean price ratio of 1:2.3 was used (corn at $2.50/bu), which is approximately equal to the 1977-1983 average of 1:2.58 (USDA/ERS, 1984). For the Least, Average and Most Efficient farms, live hog prices used were $47.97, $48.82 and $51.63 (per hundred weight).[2] Based on work by Kalter et al., who used Monte Carlo techniques to find a "[wholesale] price required for economic feasibility" to produce

[2]Average live weights at market were 235 lbs, 229 lbs and 223 lbs.

bovine growth hormone, pGH was costed at two dollars per gram. It was calculated that a total of one gram pGH per pig would be required during the fattening stage. This dosage allowed a rather generous "safety margin," because the range of probable total dosages is 0.4 grams to 0.7 grams (based on Machlin's and Rebhun et al.'s work presented in Table 1.) Therefore, using pGH will cause the non-feed variable costs of $20.00, $15.20 and $10.40 per head (for Least, Average and Most Efficient farms) to rise by $2.00.

Results from the Linear Programs

Figure 1 presents the results of the three representative farms' total gross margins (net returns) at four different response rates to pGH. One can see that the Least Efficient farm has the largest percentage increase in gross margins (of up to 40%), whilst the other two farms show more modest rates of increase. All three farms have very similar percentage gains in return per $100 feed fed (Figure 2). Figure 2 also demonstrates that, at the 20% response level, the Least Efficient farm's return per $100 feed fed is almost the same as the Average farm's at the zero hormone level. This correlates very closely to the previously mentioned differences in efficiency between the farms. Use of pGH does not alter relative rankings in efficiency. Only improved management can have this result.

The Average and Most Efficient farms both show constant increases in returns per $100 feed fed but experience a slight drop in total gross margins at the 5% response level. The decrease in gross margins occurs because the constraints imposed (especially those on working capital) mean that pig numbers must be reduced (by about 2%) in order to make money available to pay for the hormone. Given the constraints, commercial adoption of pGH by the top 80% of the farms (the Average and Most Efficient cases) will require response levels of at least 10%.

As pGH-induced feed efficiency improves, all three farms increase the output of hogs (except for the small drop at the 5% response level). Relatively, the increases are similar for all farms but are always proportionally smaller than the increase in feed efficiency (largest increase is 10% at 20% response level). Therefore, the amount of corn sold rises steadily on the Average and Most Efficient farms to a maximum of 215% and 145% of zero hormone totals. The Least Efficient farm always grows just enough corn to feed pigs and plants the rest of its land to soybeans. Despite this being a more profitable use of resources and corn, constraints on working capital and soybean acreage prevent larger increases in pig numbers on the Average and Most Efficient farms. Increasing the amount of working capital available and/or expanding the limit on soybean acreage[3] would allow greater increases in pig production and a smaller rise in the amount of corn sold. However, constraints on pig numbers (representing facilities) would prevent corn sales from completely dropping to their zero hormone levels.

The existing constraints and increased pig profitability have implications for marginal land values for each farm. Table 2 illustrates how the objective function of each farm would increase if the land constraint is relaxed by one acre. At any given response level, the Most Efficient farm has the lowest marginal value for extra acreage. This is due to the farm being more efficient in maximizing gross margins with existing resources. The lower marginal value does not mean that the farmer would not be interested in securing more land, were it available, but rather would be prepared to spend less money to obtain it than the other two farm types. As already mentioned, an increase in maximum soybean acreage would increase total gross

[3]Both farms plant soybeans at the maximum 150 acre limit. Increasing this would release working capital from corn, which costs $131 per acre versus $67 per acre for soybeans.

margins by allowing expanded hog production. Hence the marginal value of the constraint on soybean acreage increases with increases in feed efficiency.

The implication of these marginal values on farm land prices is potentially substantial. Land prices would need to fall if hog farmers who adopt pGH are to consider additional land purchase worthwhile. Basically, what is suggested is that the reduction in corn required to feed pigs will tend to reduce the value of corn land in the major hog producing regions.[4]

Sensitivity Analysis

A sensitivity analysis looks at the upper and lower limits (ranges) over which a resource (e.g. total arable land) or an activity (e.g. selling a hog) can be changed without altering either the "basis"[5] (in the case of resources) or the level of an activity in an optimal solution. If a resource amount is altered within the range described by its limits, the actual level of activity (but not the basis) will often change as the linear program reallocates the new set of resources. When either an activity or a resource parameter is altered it is likely that the total gross margin will change (even when the optimal solution and/or basis remains the same).

Total arable land is a constrained resource, yet the upper and lower limits for all three farms showed a wide and stable range (i.e., relative insensitivity), as feed efficiency increased. The 339-acre upper limit for the Least Efficient farm at the zero hormone level drops by a maximum of 10 acres (at the 20% response level). The linear program value was set at 275 acres. The Average and Most Efficient farms had upper boundaries of 730 acres and 856 acres, which stayed static regardless of level of feed efficiency. Therefore, these two farms could more than double the land they use

---

[4]Of course, this assumes static demand for corn from other uses (e.g. corn sweetener).

[5]The basis is the list of activities that make up the optimal (or indeed any other) solution.

without altering their farm's optimal basis. They would, of course, probably alter the amount of one or more activities.

Perhaps not surprisingly, maximum working capital becomes more crucial as feed efficiency/hog profitability increases. Although increased gross margins generated from initial pGH use (Figure 1) would be used as a source of extra working funds, knowledge of a farm's debt structure and other claims on cash flow would be necessary for this to be accurately modeled. In general, given the present farm debt situation, constraints on working capital cannot be disregarded. Nevertheless, it is possible to generate a hierarchy of events that would occur if this constraint were eased. Assuming that the objective function is to maximize net returns, any available extra funds would be used to expand the activity with the highest marginal return. For both the Average and Most Efficient farms this is actually alfalfa-hay. However, in both cases extra working capital would first go into producing more pigs, which would bring the second highest marginal returns. This is because expanding the alfalfa acreage would mean a further increase in corn acreage (due to the fixed corn-alfalfa ratio). Even without the ratio constraint there is a practical limit, dictated by storage and transport costs, on the amount of alfalfa hay that one farm can expect to sell.

Turning to the sensitivity of the parameters of certain activities, it was found that soybeans showed increasingly greater tolerance to reductions in selling prices or increases in variable costs. This is because soybeans profitably use relatively small amounts of working capital (see earlier). Therefore, as feed efficiency and rate of return improve in hog production, soybeans become a more important element in the mix of activities. The sensitivity of the resource constraint limiting soybean acreage shows the same pattern--and increasing the limit raises questions regarding rotational requirements. Corn variable costs and prices become more sensitive as feed efficiency improves. This is due to the farms having to sell excess corn produced as opposed to changing production to relatively more profitable soybeans and/or hogs. As feed efficiency and per head profitability increase, all three farms exhibit decreasing sensitivity to decreases in hog prices/increases in non-feed variable costs. For example, the Least Efficient farm has its selling price lower boundary, at which the number of hogs sold will be changed, reduced from $107 to $95.2 (-11%) per head. The Average and Most Efficient farms both see their sensitivities decrease in a like manner by about 10%. However, this decreasing sensitivity does not alter the Least Efficient farm's relative competitive ability to handle decreasing prices (as supplies increase) and/or increased non-feed variable costs (if hormone is more than $2/head).

Macroeconomic Effects: The Pork Industry

Growth hormone improves carcass quality, as evidenced by the reduction in backfat (see earlier). A leaner animal generally results, if a carcass yield and grade system is used, in higher returns per animal for the farmer. It also represents a potential reduction in labor costs used to trim fat, which could be passed on to the consumer in the form of cheaper and leaner meat. This may help change the current per capita consumption trend for pork, which has fluctuated around 60 pounds per year. In comparison, poultry has steadily increased from 30 lbs to over 50 lbs per person in a space of twenty years (Haidacher et al.).

Besides a desire for lean meat, undoubtedly the relative price of pork and consumer income affect per capita pork consumption. Compared to beef and chicken, pork consumption has been estimated to be the most sensitive to changes in price (highest negative own price elasticity). However, when the effect of changes in income are considered, pork has just about the same quality elasticity as beef and chicken, though expenditure and quantity elasticities are small (Haidacher et al.). This means that consumers will switch to higher quality pork as their incomes increase, without either spending much more or buying physically larger amounts.

The above comments give rise to the suggestion that if the U.S. pork industry wishes to alter consumption patterns, it should concentrate on producing quality products at relatively low prices. The pork industry has attempted to meet such demands, but it appears that noticeable progress in producing a leaner hog stopped around 1980 (Hayenga et al.). Instead there is a current drive, seen on many supermarket shelves, of packers trimming off all excess fat, adding to consumer cost.

Before recommending growth hormone as a method of producing leaner meat to satisfy consumer demand, it must be recognized that the current U.S. pork industry is in poor position to take full advantage. Currently less than 25% of all hogs slaughtered are priced on a yield and grade system (Hayenga et al.). This compares to about 68% for steers and 87% for lambs and mutton (USDA, 1985). The rest of the animals are sold live.

Most meat packers offer a yield and grade system, but in 1981 the National Pork Producers Council found that "...71% of the pork producers [surveyed] consider the monetary incentives to produce lean, heavy muscled pork to be fair to poor" (Meeker, National Pork Council). The question is, can the situation be changed by the commercial use of pGH? PGH can be considered a tool by which farmers can produce leaner (and therefore higher graded) meat, provided that there is enough financial incentive to use it. Farm revenue could increase through reduced feed costs and higher graded carcasses. An example, constructed using a major meat packer's (Wilson Foods) current carcass grading system, showed that a farmer could gain an average per head increase in premiums of $2.90[6]. Added to savings in feed, this represents a significant portion of potential total per head gains in gross margins. It is evident that, in order to take full advantage of pGH, the pork industry must make major changes in both incentives to produce lean meat and in overall grading systems.

---

[6]This was constructed using an example of a hog delivery provided in a Wilson Foods pamphlet that also contained the company's yield and carcass matrix.

Conclusions

PGH has been demonstrated to significantly improve feed efficiency in swine, which can be expected to have an appreciable positive short-run impact on the economic returns for hog farms. The use of this technology should not change the recent opinion that medium-sized hog farms (500 - 1,000 head sold) will remain dominant in the pig industry (Wilson and Eidman). However, pGH will not alter the relative competitive position of farms within the medium-size group. Therefore, if a hog farm is currently having financial trouble due to inefficiency, the farmer should not expect pGH to transform its situation without changing management practices. Land values can also be expected to change as hog and corn supplies change (as will their prices).

PGH offers the hog industry an opportunity to reorganize and produce a leaner, cheaper product. Repartitioning agents will be available for other species. Therefore, even if the incentives offered by meat packers are inadequate, hog producers still may be compelled to use pGH simply to remain competitive with other meat types.

Table 1. Effects of Repartitioning Agents on Porcine Feed Efficiency

Experiment	Average daily gain (kgs/day)			Feed/Gain ratio[a] (kgs fed per kg gain)		
Dosage[b]	w/out	with	(+/-)	w/out	with	(+/-)
CHUNG et al.						
.022 mg pGH	.91	1.00	(+9.9%)	2.7	2.6	(-4.0%)
MACHLIN						
.033 mg pGH	.77	.86	(+11.7%)	3.73	3.46	(-7.2%)
.066 mg pGH	.77	.76	(-1.3%)	3.73	3.26	(-14.6%)
.132 mg pGH	.77	.83	(+7.8%)	3.73	3.14	(-15.8%)
REBHUN et al.						
.010 mg pGH	.90	.98	(+8.9%)	2.86	2.72	(-4.9%)
.030 mg pGH	.90	.95	(+5.6%)	2.86	2.58	(-9.8%)
.070 mg pGH	.90	1.03	(+14.4%)	2.86	2.36	(-17.5%)
ETHERTON						
.030 mg pGH	.90	1.00	(+11.1%)	3.0	2.4	(-20.0%)

[a] A decrease in the feed/gain ratio means an increase in feed efficiency

[b] All dosages of Porcine Growth Hormone (pGH) reported in units administered per kg body weight/day

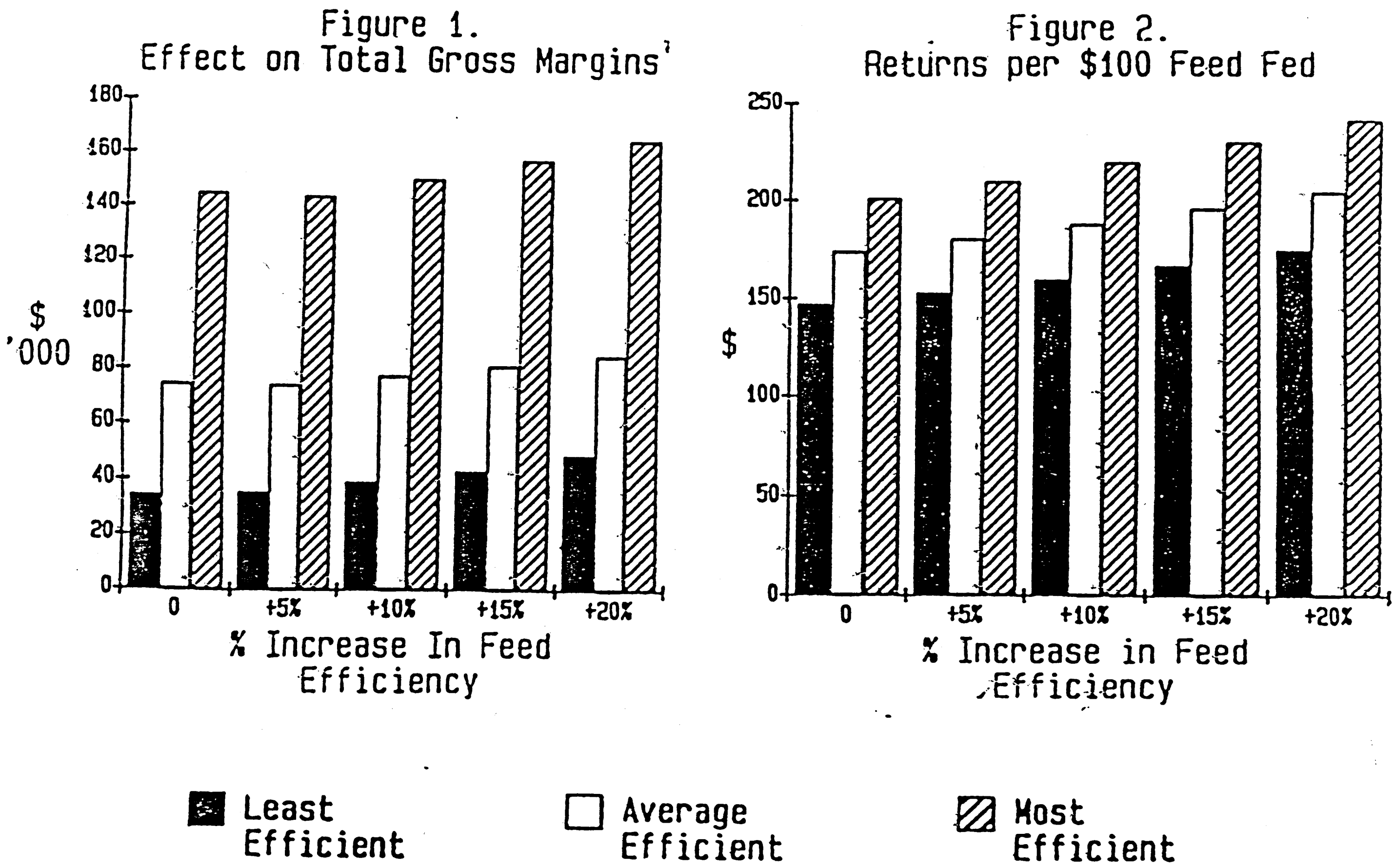
SOURCES: Chung et al., p.123; Machlin, pp. 797-799; Rebhun et al., p. 251; Etherton; Jones et al., p. 908.

Table 2. Marginal Values of an Extra Acre of Total Land ($ per acre)

Farm Type	MARGINAL LAND VALUES				
	No pGH	pGH induced increased feed efficiency			
		5%	10%	15%	20%
Least Efficient	82.64	81.69	78.17	74.58	69.13
Average Efficiency	86.56	86.89	78.86	70.34	61.58
Most Efficient	75.77	77.60	64.74	51.02	36.35

SOURCE: Results from the linear programming models.

IMPACT OF PGH ON REPRESENTATIVE FARMS



References

Baker, P. K., R. H. Dalrymple, D. L. Ingle and C. A. Ricks. "Use of B-Adrenergic Agonist to Alter Muscle and Fat Deposition in Lambs." *J. An. Sci.* 59(5). 1984.

Bauman, D. E., P. J. Eppard, M. J. DeGeeter and G. M. Lanza. "Responses of High Producing Dairy Cows to Long Term Treatment with Pituitary- and Recombinant-Somatotropin." *J. Dairy Sci.* 68(1985):1352.

Beermann, D. H., D. E. Hogue, V. K. Fishell, R. H. Dalrymple and C. A. Ricks. "Effects of the Repartitioning Agent Cimaterol and Fishmeal on Growth Performance, Carcass Characteristics and Skeletal Muscle Growth in Lambs." *J. An. Sci.* 62(6):370-81. 1986.

Boyd, R. D., D. Wray-Cahen, D. E. Bauman, D. H. Beermann, A. F. De Neergard and L. M. Souza. "A Review of Somatotropin's Effect on Productive Efficiency and Carcass Composition in Growing Swine." *Animal Health and Nutrition* 42(2):23-26. February 1987.

Chung, C. S., T. D. Etherton and J. P. Wiggins. "Stimulation of Swine Growth by Porcine Growth Hormone." *J. An. Sci.* 60(1):126-129. 1985.

Etherton, T. D. Personal letter, October 1985.

Etherton, T. D. and V. K. Meserole. "New Technology Studied to Improve Growth." *Sci. in Agriculture*, Pennsylvania State University, 1982.

Haidacher, R. C., J. A. Craven, K. S. Huang, D. M. Smallwood and J. R. Blaylock. *Consumer Demand for Red Meats, Poultry, and Fish*, USDA, ERS, GES 820818, 1982.

Hayenga, M. L., B. Grisdale, R. G. Kauffmann, H. R. Cross and L. L. Christian. "A Carcass Merit Pricing System for the Pork Industry." *Amer. J. Agr. Econ.* 67(2). 1985.

Jones, R. W., R. A. Easter, P. K. McKeith, R. H. Dalrymple, H. M. Maddock and P. J. Bechtel. "Effect of the B-Adrenergic Agonist Cimaterol (CL 263,780) on the Growth and Carcass Characteristics of Finishing Swine," *J. An. Sci.* 61(4):908. 1985.

Kalter, R. J., R. Milligan, W. Lesser, L. Tauer, W. Magrath and D. Bauman. *Biotechnology and the Dairy Industry: Production Costs and Commercial Potential of the Bovine Growth Hormone.* Cornell University Dept. of Agr. Econ. Res. 85-22, December 1985.

Machlin, L. J. "Effect of Porcine Growth Hormone on Growth and Carcass Composition of the Pig." *J. An. Sci.* 35(4). 1972.

McDonald, P., R. A. Edwards and J. F. Greenhalgh. *Animal Nutrition*, 2nd ed., Hafner, New York, 1973.

Meeker, D. National Pork Producers Council. Telephone Interview, Jan., 1986.

Meltzer, M. I. *Repartitioning Agents in Livestock: Economic Impact of Porcine Growth Hormone.* MS Thesis, Cornell University, 1987.

Rebhun, J. P., T. D. Etherton, J. P. Wiggins, C. S. Chung, P. E. Walton and N. Steele. "Stimulation of Swine Growth Performance by Porcine Growth Hormone (pGH); Determination of the Maximally Effective pGH Dose." Abstracts: *J. An. Sci.* 61(Sup. 1):251. 1985.

USDA. *Economic Indicators of the Farm Sector: Farm Sector Review, 1983*, Economic Research Services, ECIFS 3-2, 1984.

USDA. *Market News: Livestock, Meat, Wool: Weekly Summary and Statistics.* Livestock Division, Agric. Marketing Services, 53(52). Dec. 28, 1985.

Van Arsdall, R. N. and K. E. Nelson. *U.S. Hog Production*, USDA/ERS, Washington, D.C., Agricultural Economic Report No. 511, 1984.

Welsch, D. E., B. Keffe, E. J. Weiness, P. A. Fales and D.E. Talley. *Southwestern Minnesota Farm Management Association: 1984 Annual Report*. University of Minnesota Dept. of Agric. and Applied Econ., Econ. Report ER85-2, May 1985.

Wilson, P. A. and V. R. Eidman. "Dominant Enterprise Size in the Swine Industry," *Amer. J. Agr. Econ.* 67(2):279-289. May 1985.