WHY DO WE OVERFEED PIGS?

Robert A. Easter and Hans H. Stein

Introduction

No one would challenge the statement, "Pigs must eat in order to grow." However, there can be significant discussion around the question, "How much should the pig eat?" The traditional, North American response has been to let them eat freely. And, feeders, pens and diets have been designed to encourage maximum feed consumption. Pigs usually do grow faster if they can be encouraged to eat more. But, is maximum growth rate always consistent with maximum economic return? That depends on the relationship between feed intake and the composition of growth. This paper will offer some thoughts on that relationship.

Energy Intake and Growth Composition

Feed provides essential nutrients and energy. If one assumes that diets are formulated to be adequate in the necessary nutrients regardless of intake, then the discussion can be focused exclusively on energy. Clearly, not all consumed energy is available for growth. There are losses due to inefficiencies in digestion and metabolism. Additionally, a portion of the energy must be used for maintenance. The remainder is available for growth and is used primarily of lean and fat tissues. The relative rates of lean and fat growth determine the percentage lean in the animal at slaughter and, value.

Whittemore (1987) is often credited with the hypothetical representation of growth shown in figure 1. The Whittemore model seeks to describe the effect of increasing daily energy intake on total growth rate and on the growth of lean and fat tissues. As energy intake increases above that required for maintenance, i.e., zero growth, a portion of the consumed energy is used for lean growth and a lesser amount is used for obligatory fat growth, e.g., kidney fat. This relationship continues without appreciable change until the pig's lean growth potential is realized. Energy consumption in excess of that required to achieve maximum lean growth, is used for fat synthesis.

The Whittemore (1987) model is supported by a large body of empirical evidence. Classical studies of pig growth, c.f. McMeekan (1940) and Fowler (1968), demonstrated the capacity of the pig to vary body fat content in response to dietary energy. Over the past decade, much research effort has been devoted to the development of compounds, such as the beta adrenergic agonists and porcine somatotropin, to alter the partitioning of energy in favor of lean growth.

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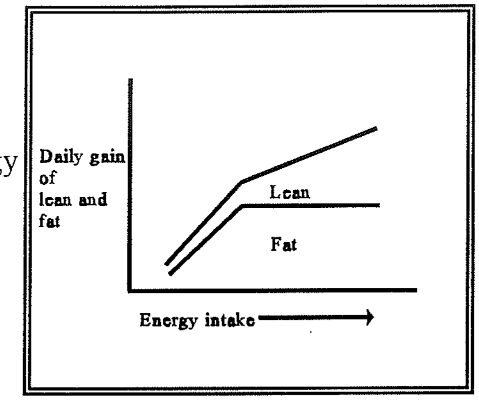
Figure 1 Partitioning of energy to lean and fat growth. After Whittemore (1987)



Recent data has continued to confirm the wisdom of restricting energy intake in the finishing phase in order to increase carcass the proportion of lean in the carcass. The data, table 1, from Campbell et al. (1985) illustrate the point.

Table 1. Effect of energy intake on the growth of Lean and fat tissues in 100 to 198 lb finishing pigs[1]

		Growth rate of tissue, grams/day			
		Entire males		Gilts	
Metabolizable energy, kcal/d	Lbs/day of a corn-soy diet (approximate)	Protein	Fat	Protein	Fat
5497	3.7	69.4	79	63.4	125
6572	4.5	94.8	150	84.5	208
7887	5.4	129.5	184	103.0	279
8962	6.2	130.0	304	102.0	332
9990	6.9	132.0	352	99.0	371

[1] Campbell et al. (1985)

The daily energy level was varied between 5,497 kcal and 9,990 kcal, which is roughly the equivalent of increasing the daily ration of a corn-soybean meal diet from 3.7 to 6.9 lbs. Diets were formulated to insure that amino acid intake did not limit growth at any level of feeding. Protein growth increased in both entire males and gilts as energy intake increased. Maximum protein growth was achieved at 7,887 kcal of daily energy intake in both genders. Fat growth continued as energy intake increased.

Although the work cited above addresses intake up to maximum voluntary consumption, it does not give consideration to intake beyond the normal upper limit. Pekas (1983), working at the USDA Center in Nebraska, developed a technique for overfeeding pigs through a tube surgically installed in the greater curvature of the stomach. He used this technique to provide a level of feeding well beyond that which would be consumed voluntarily. He reported marked increases in gain (Pekas, 1985). More importantly, carcass composition remained constant, i.e., there was an proportional increase in both protein and fat growth. This finding supported a hypothesis that extra muscle could be obtained if pigs could be caused to eat more.

We thought it useful to challenge this hypothesis and a series of experiments were conducted at the University of Illinois. Pigs were fitted with stomach cannulas and allowed to recover from the surgery. Littermates to the cannulated pigs were retained as controls to verify that surgical modification had not altered growth. A group of pigs were killed at the beginning of the experiment and the bodies were ground and analyzed chemically to establish initial composition. The remaining pigs were fed for four weeks, killed and the bodies analyzed. The comparison of initial and final composition data were was used to establish the net gain in fat and protein content. The results of an initial experiment (Newcomb et al., 1993) are described in table 2.

Table 2. Effect of hyperalimentation on Growth and composition of growth in 70 lb pigs[1]

Item	Noncannulated pigs fed ad libitum	Cannulated pigs fed ad libitum	Cannulated pigs hyperalimented to 120% of ad libitum
No. of pigs	9	9	20
Avg. daily feed, lbs	4.79	4.70	5.67
Avg. daily gain, lbs	1.91	1.95	2.22
Gain/feed	.41	.43	.40
Protein gain, lbs	5.00	5.31	5.30
Fat gain, lbs	9.00	8.88	11.71

[1] Newcomb et al. (1993)

Cannulated pigs voluntarily consumed an amount equal to noncannulated controls and their growth rates were similar. As one would expected, the cannulated pigs provided with 120% of the feed voluntarily consumed by the control animals grew faster. Note, however, that providing 20% more feed did not increase protein gain. However, the extra feed resulted in a dramatic increase in fat gain.

It is reasonable to ask if there are circumstances where pigs might benefit from increased energy intake. It has been suggested (Michael Ellis, personal communication) that some very lean genotypes may have a level of voluntary feed intake that fails to provide the energy needed to support maximum protein growth. That hypothesis has not been tested. However, Newcomb (1990) did examine the effect of hyperalimentation in pigs with increased lean growth due to treatment with recombinant porcine growth hormone.

The protocol for this experiment was similar to that described previously with the exception that some pigs were treated with 3 mg per day of porcine somatotropin (PST). The results are shown in table 3. Observe that there was a reduction in voluntary feed intake when non-cannulated pigs were treated with PST. This is a consistent effect of somatotropin treatment and leads to the question, "Does feed intake limit protein growth in PST-treated pigs?" When PST-treated pigs were hyperalimented to the level of feed consumed by non-cannulated pigs injected with a saline placebo, there was a marked increase in daily gain. Note however, that this increase in gain was accounted for by an increase in fat deposition, not by an increase protein gain. Thus, even in pigs that have enhanced lean growth, the level of voluntary consumption of a corn-soybean meal diet provides sufficient energy to maximize lean gain.

Table 3. Effect of hyperalimentation on growth Composition in pigs treated with porcine somatotropin (pst)[1]

	Treatments			
Item	Non-cannulated ad libitum-fed saline injection	Non-cannulated ad libitum-fed PST injection	Cannulated ad libitum-fed PST injection	Cannulated hyperalimented PST injection
No. pigs	5	5	6	8
Daily feed, lbs	7.50	6.66	6.46	7.52
Daily gain, lbs	2.28	2.50	2.61	3.10
Gain/feed	.31	.38	.42	.42
Protein gain, lbs	14.03	17.46	18.70	19.09
Fat gain, lbs	35.64	26.20	22.50	31.30

[1] Newcomb (1990)

Are there any circumstances where energy intake actually limits lean growth? A coherent argument can be made that this situation does exist early in the pig's life and may continue well into the weanling period. Several experiments, cf. Cook et al., 1991; Nam and Aherne, 1994, have shown that rate of gain is increased by adding fat to the nursery diet. Cook et al. (1991) demonstrated that fat addition resulted in an absolute increase in daily caloric intake by pigs between weaning and 50 pounds live weight. Given that much of the total body weight gain in weanling pigs is protein mass, it is likely that increasing energy intake does augment daily lean gain.

Restricting Energy Intake

Feed restriction programs designed to reduce the rate of fat growth have been employed for decades in countries where the market rewards farmers for producing lean carcasses. Such programs are described in various publications (ARC, 1979; English et al., 1988). Automated feeding systems are often employed to facilitate feed-restriction.

It would seem logical that energy intake could be reduced by feeding low-energy or diluted diets. Unfortunately, the pig has a significant capability to increase the volume of feed consumed in order to maintain a fixed level of energy intake. The ability to over-eat appears to be a function of the dietary diluent that is used. In a classical experiment, Baker et al. (1968) found that pigs could over-eat to maintain energy intake even when the diet contained 40% sand. But, the addition of only 10% fiber (cellulose) resulted in a depression in daily energy consumption. In contrast, Kennelly and Aherne (1980) reported that finishing pigs fed diets containing 22% oat hulls were able to increase feed intake to maintain digestible energy intake.

We recently conducted an experiment to determine whether the percent lean in the carcass at slaughter could be increased by feeding a diet with a selected combination of diluents. The diet formulations are shown in table 4. Three diluents were used: wheat bran, corn gluten feed and

Table 4. Diet composition

	Diet Number				
Ingredients	1	2	3	4	5
Corn	68.65	75.95	62.70	49.45	36.15
Soybean meal	24.40	22.00	17.50	12.90	8.40
Fat	5.5	-	-	-	-
Wheat bran	-	-	10.00	20.00	30.00
Corn gluten feed	-	-	5.00	10.00	15.00
Alfalfa meal	-	-	3.00	6.00	9.00
Dicalcium phosphate	1.10	0.90	0.60	0.25	-
Limestone	-	0.80	0.85	1.05	1.10
Copper sulfate	0.05	0.05	0.05	0.05	0.05
Illini vitamin premix	0.10	0.10	0.10	0.10	0.10
Trace-mineral salt	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Energy, kcal/lb	1593	1501	1410	1321	1231

Pekas, J. C. 1983. A method for direct gastric feeding and the effect on voluntary ingestion in young swine. Appetite: J. Intake Res. 4:23.

Pekas, J. C. 1985. Animal growth during liberation from appetite suppression. Growth 49:19.

Whittemore, C. T. 1987. Elements of Pig Science. Longman. New York.