Growth Management for Optimum Appeal of Pork

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Introduction

The quality of food products is of increasing importance for consumers in developed countries (Harrington, 1992). Food-producers who ignore this trend risk loss of markets. For producers of animal products, it is also evident that the conditions under which the animals are housed also plays a role in consumer appeal (Harrington, 1992). Moreover, in today's society, eating patterns for many consumers are changing to lighter, more easily-prepared meals. This trend often favors foodstuffs containing less meat and, consequently, reducing the demand for meat products (Moller and Iversen, 1993). For these and other reasons, the per capita consumption of pork has decreased over the last decade in many western countries (Nielsen, 1993).

The challenge before the swine industry is to prevent market erosion by producing products with high consumer appeal. The problem isn't simple. It is very difficult to describe the terms "quality" and "appeal" in ways that will satisfy all consumers. Honikel (1991) expressed appeal as "appreciation" and defined appreciation as the sum of several subjective and objective factors (figure 1).

The Honikel (1991) model suggests that elements of the production environment as well as slaughter and processing factors influencing product quality are important components of appreciation. In this paper we will only discuss those factors that can be influenced by decisions made by the farm manager. The discussion will be concentrated on the following four parameters: (1) price of pork, (2) taste of pork, (3) nutritional value of pork and (4) image of the swine production.

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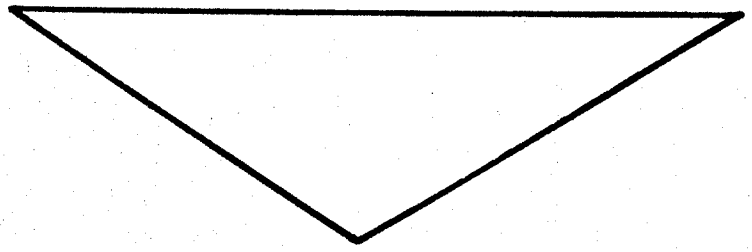
Figure 1. KEY FACTORS AND RELATIONSHIPS THAT INFLUENCE CONSUMER APPRECIATION OF PORK PRODUCTS

Animal welfare	Hygienic characteristics
Ecology	Technological characteristics
Slaughter	Nutritional value
Chilling	Sensorial value
PRODUCTION QUALITY	PRODUCT QUALITY



APPRECIATION (Appeal)

Basic Needs	Price	Assumed Needs	Social Culture Needs
Food		Fresh	Enjoyment
Health		Natural	Convenience
Availability		Uncontaminated	Custom
			Social Status

Honikel (1991)

Price of Pork

In a market economy, purchase decisions are generally driven by the consumer's perception of price and value relationships. In almost all circumstances the biological

variable having the greatest influence on the price that must be charged for pork is the efficiency with which feed is converted to product. Two key ways to reduce price are:

1. Increase the number of pigs produced per sow/year.
2. Increase growth rate and(or) feed efficiency.

Success in improving one or both of these factors would allow producers to market a less expensive product without reducing net return.

Litter Size. The average littersize for 619 farms enrolled in the Illinois Farm Business Records Service during 1992 is shown in table 1.

Table 1. AVERAGE PRODUCTIVITY IN ILLINOIS SWINE HERDS (619 Farms)

Pigs farrowed per litter	9.7
Pigs weaned per litter	8.18
Litters farrowed per female per year	1.90
Pigs weaned per female per year	15.68

Illinois FBFM (1993).

The average number of pigs weaned per sow per year in the 619 herds was 15.68. Post-weaning mortality was 6.3% resulting in an average of 14.7 pigs marketed per sow per year. Contrast this with the data in table 2. European farmers have been able to consistently produce more pigs per sow per year than their American counter-parts.

The sow's potential is greater than the production being realized on the average U.S. farm. The economical effect of increasing productivity in the sow herd is calculated in table 3. In this example it is assumed that 1,500 pigs are produced per year either with 100 sows (15 pigs produced per sow per year) or 75 sows (20 pigs produced per sow per year).

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Table 2. NUMBER OF PIGS PRODUCED PER SOW PER YEAR IN SEVERAL EUROPEAN COUNTRIES

Country	Pig per Sow per Year, 1991
Germany	17.43
France	19.54
Italy	16.41
Netherlands	19.43
Belgium	13.74
UK	18.98
Ireland	22.65
Denmark	19.24

EuroStat (1992).

Table 3. EFFECT OF INCREASING PRODUCTIVITY IN SOW HERDS (1,500 Pigs Produced per Year)

Production Costs per Year	100 Sows	75 Sows	Diff.
Housing and animals, mortgage, $/year[1]	25,000	18,750	6,250
Feed, $/year[2]	14,300	11,700	2,600
Labor, medicine, vaccine, etc., $/year[3]	10,000	7,500	2,500
Total costs per year, $	49,300	37,950	11,350
Total costs per weaned pig, $	32.9	25.3	7.6
Sow herd costs per lb of pork, cents[4]	13.7	10.5	3.2

[1]Housing and animals: $2,500 per sow, interest rate = 10%.
[2]$130 per 1,000 kg.
[3]$100 per sow/year
[4]At 240 lb slaughter weight.

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These calculations show that increasing productivity in the sow herds to a level similar to that achieved by major pork producing countries in Europe would allow the American swine producer to decrease the retail price on products without reducing net profit.

Growth Rate and Efficiency. The efficiency with which feed is converted to a marketable product is due in significant part to growth rate and growth composition. Factors such as nutrition, genetics, environment, health and management have important impacts on growth. Introduction of growth modifiers, such as beta adrenergic agonists and porcine somatotropin, could have significant impact (table 4) as well.

Table 4. EFFECT OF FEEDING β-ADRENERGIC AGONISTS TO FINISHING PIGS

Measurement	Percent Improvement
Live weight gain	+ 5
Feed intake	- 3
Feed efficiency	+ 6
Dressing percent	+ 1.5

Peters (1990).

Significant improvements in both growth rate and feed efficiency can be achieved in the swine industry. It should be possible to market a less expensive product in the future, without lowering the overall profit to the swine industry.

Taste

Very little research has been directed at manipulation of pork taste (sensory) characteristics. It is known that feeding certain ingredients to finishing pig will have an influence on the flavor. A classic example is the fact that feeding fish-products to pigs during the finishing period will result in "fishy" pork.

A recent Danish study found that feeding high levels of corn to finishing pigs had a negative influence on both taste and smell characteristics of pork compared to barley-based

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diets (Petersen and Madsen, 1992). The study may have been confounded. Both gilts and entire males were used and the pork from entire males tended to have elevated levels of skatole when they were fed a corn-soybean meal diet. Skatole is known to have a negative influence on the smell of pork.

Taste panels were extensively used in these studies and that presents certain difficulties (Hovenier et al., 1993). In particular, prior experience may have biased taste panel members to favor meat from pigs fed barley-based diets. However, this mimics reality. Consumers have experience-based concepts of "good" taste in pork products. Given the diversity in American society, clever producers may find opportunity in a segmented market.

Differences in management practices can also have an impact on the taste of pork. In a recent Danish experiment the effect of housing pigs in dirty, eg., manure contaminated, or a clean environment on tissue skatole levels was investigated. The results from the study are shown in table 5.

Table 5. SKATOLE LEVELS IN PIGS HOUSED IN A CLEAN OR DIRTY ENVIRONMENT DURING GROWTH

	Dirty	Clean
Skatole in subcutaneous fat, ppm	0.17	0.07

Hansen et al. (1992).

Little is known about the role of diet and management in the establishment of sensory characteristics in pork. We have provided some evidence that it may be possible to change the taste of pork, but more research in the area is needed.

Nutritional Value and Health

Nutritional value has significant influence on the appeal of various foods for an increasing number of consumers and will likely be of even greater importance in the future (Harrington, 1992). This growing interest in health-promoting products has exerted a

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negative influence on the consumption of pork in several Western countries. To reverse this trend, it is important that pork be recognized as the nutritious food that it is.

Leanness

In the modern market leanness is of paramount importance. Several packers have indicated that it is difficult to buy pigs with an average lean content higher than 50%. In contrast, the average percent of leanness in all slaughtered pigs in Denmark in 1992 was 59.3% (Jensen, 1993). Several factors within the purview of farm management can directly influence leanness.

Genotype

One of the more rapid ways to improve leanness is by changing genotype. Because the heritability for leanness is high progress can be made rapidly. A recent study by the Meat and Livestock Commission (MLC, 1992) serves to illustrate some of the genotype differences extant today (table 6) in Great Britain.

Table 6. LEANNESS IN DIFFERENT GENOTYPES[1]

Item	Company			
	J	K	L	M
Carcass lean, %	58.2	51.2	53.4	57.7
Lean gain, lb/day	0.88	0.69	0.78	0.76

MLC (1993).

[1] Genotypes are identified only by code in the report.

Feeding Strategy

In many genotypes, carcass leanness can be manipulated by controlling energy intake. However, feed intake restriction is not often practical. It may be possible to reduce daily

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energy intake by reducing energy density in the diet. A recent Danish study (table 7) demonstrated that appropriate ingredient selection, coupled with reduced dietary energy concentration, could be used to improve carcass quality.

Table 7. EFFECT OF DIFFERENT ENERGY LEVELS ON THE CARCASS

Item	Diet 1	Diet 2	Diet 3
Kcal/kg feed	3,000	3,150	3,300
Daily weight gain[a]	764[a]	778[b]	805[c]
FCR, Mcal/kg weight gain	8.4	8.4	9.1
Lean meat, %	59.4	59.0	57.6

Stein (1992).

It was possible to increase the lean content in the carcass by 1.8 percentage units by decreasing the energy density in the diet by 10% with appropriate feed ingredients. A similar effect was reported in a recent American study were almonds hulls were fed to finishing pigs. By adding 15% almond hulls to the diet, the net energy content in the diet dropped 16.6%, and this drop caused the pigs to consume less energy per day. Fat gain was decreased by 9.4% (table 8) and the lean gain was increased by 5.2% (Muirhead, 1993). Pigs have significant capacity to overeat and it appears that energy dilution must involve ingredients that counter this drive.

Table 8. The Effect of Feeding 15% Almond Hulls to Finishing Pigs

Diet	Fat gain, kg	Protein gain, kg	Fat gain/ protein gain
Corn-soybean meal	4.06	4.44	0.93
Corn-soybean meal-almond hulls	3.68	4.67	0.82

Muirhead (1993).

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Repartitioning Agents

Repartitioning agents (table 4) have been shown to increase growth rate and gain to feed ratio. However, another benefit from using these growth promotants is that fat deposition is decreased significantly (Uttero et al., 1993, Jones et al., 1985, Peters, 1990). The results from one study are shown in table 9.

Table 9. EFFECT ON CARCASS COMPOSITION DUE TO FEEDING RACTOPAMINE TO FINISHING PIGS

	Ractopamine	
	0 ppm	20 ppm
Live weight, kg	97.55	98.90
Carcass weight, kg	78.78	78.41
10th rib fat depth, mm	22.48	20.68
10th rib lean depth, mm	51.92	55.32

Uttero et al. (1993).

Production of Entire Males

Leanness can also be increased by producing entire males instead of barrows (Agergard and Jensen, 1993, Fortin et al., 1983). Kempster and Lowe (1993) summarized studies with entire males (table 10).

It is apparent that overall performance is generally increased by feeding entire males. This is especially true for lean content of the carcass and the lean weight gain to feed ratio. The possibility of a negative influence of entire males on taste and smell cannot be ignored. Recent technical developments suggest that sensitive instruments can be used to segregate "problem" carcasses during processing.

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Table 10. TYPICAL PERFORMANCE AND CARCASS DIFFERENCES BETWEEN ENTIRE MALES AND BARROWS

Trait	Relative value of Boars (Barrows = 100)
Live-weight gain	103
Feed efficiency	113
Dressing percentage	99
Carcass weight daily gain	102
Carcass lean percentage	106
Daily lean gain	116
Lean weight/feed	125

Kempster and Lowe (1993).

Intramuscular Fat

Another important factor determining the nutritional value of pork is the amount of intramuscular fat (Nurnberg and Enser, 1993, Petersen, 1993, de Vries et al., 1993). The optimal concentration for acceptable eating quality has been suggested to be between 2% and 2.5% (Bejerholm & Barton-Gade, 1986). A negative correlation between lean percentage in the carcass and the level of intramuscular fat has been observed (Petersen, 1993). The negative relationship is explained by the composition of intramuscular fat. Intramuscular fat consists of three components: 1) fat in fat cells between muscle cells, 2) fat in the muscle cells, and 3) fat in the cell membranes (Osterballe et al. 1990). Fat in the muscle cells and in the cell membranes depends on the type of muscle fiber - red muscle fibers contains more fat than do white muscle fibers. Fat in the fat cells consists mainly of triglycerides (Osterballe et al., 1990) and the actual level depends on the amount of energy available for the pigs during the finishing period. The observed negative correlation between lean percentage and the amount of intramuscular fat is mainly due to a decreased level of fat in fat cells.

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The amounts of red versus white muscle fibers differ between breeds causing differences in the level of intramuscular fat (Mortensen et al., 1983). It has been found that Duroc pigs have a higher level of intramuscular fat than Yorkshire and Landrace pigs.

Fatty Acid Ratios in the Carcass

A high dietary intake of saturated fat has been reported to cause hypertension and to increase the risk of atherosclerosis and coronary heart disease (Keys, 1984). An increased level of polyunsaturated fat (P) compared to saturated fat (S) has been reported to have a positive effect on circulating lipids and to lower the cholesterol level in plasma. It is suggested by some that human dietary fat should have a P:S ratio of 1. The P:S ratio of carcass lipids from retail pork has been shown to be less than 1:0.3 (Breidenstein, 1987). Consequently, there has been an interest in altering the P:S ratio in pork lipids during recent years. Leszcynski et al. (1992) investigated the alteration in composition of pork when pigs were fed diets containing different types and levels of fat during the final 3 or 6 weeks before slaughter. In this study, a control diet was compared to a diet containing 4% tallow or 10% or 20% full-fat soybeans. A summary of the results is shown in table 11.

Table 11. EFFECT ON TISSUE P:S RATIO OF FEEDING DIFFERENT TYPES AND LEVELS OF DIETARY FAT FOR 3 WEEKS OR 6 WEEKS PRIOR TO SLAUGHTER

Item	Control	10% FFS		20% FFS		4% tallow	
		3 wk	6 wk	3 wk	6 wk	3 wk	6 wk
P:S ratio in loin	0.28	0.35	0.33	0.33	0.43	0.32	0.33
P:S ratio in bacon	0.25	0.32	0.40	0.36	0.50	0.28	0.29

Leszcynski et al. (1992).

Leszcynski et al. (1992) were able to demonstrate a response from feeding different types of fat prior to slaughter. The greatest response was obtained by feeding a diet with 20% full-fat soybeans for 6 weeks prior to slaughter. Full-fat soybeans have a high content of polyunsaturated fats. The P:S ratio was increased by 54% in the loin and 100% in bacon

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compared to the control diet. Others, (Petersen and Madsen, 1993; Mortensen et al., 1983; and Osterballe et al., 1990) have found an increased P:S ratio in pork to result from feeding more unsaturated fatty acids to finishing pigs.

Nurnberg and Enser (1993) demonstrated that there are genetic differences in the amount of polyunsaturated fatty acids deposited in the carcass and, they found a difference between barrows and gilts. A summary of their findings are shown in table 12.

Table 12. EFFECT OF GENOTYPE AND SEX ON THE P:S RATIO IN PORK

	Genotype		Sex	
	Pietrain	Belgium Landrace	Barrows	Gilts
P:S ratio in loin	0.46	0.52	0.43	0.53

Nurnberg and Enser (1993).

The Level of Omega-3 Fatty Acids

The level of Omega-3 fatty acids in human food is generally considered to be too low (Skjervold, 1993). A ratio of omega-6 : omega-3 fatty acids of 2:1 is considered as optimal but in most human foods the ratio is 10:1 (Weber 1993, Skjervold, 1993).
Omega-3 fatty acids have been shown to have an impact on the intercellular signal process involved in the synthesis of compounds responsible for plaque formation (Weber, 1993). Omega-3 fatty acids may be able to change the physiologic properties of the LDL-fraction, causing the LDL-particles to become less arterogenic. By including higher levels of omega-3 fatty acids in swine feeds, it is possible to increase the level of omega-3 fatty acids in pork. However, inclusion of effective antioxidants may be necessary to insure that the omega-3 fatty acids are not destroyed in the body (Christensen, 1993). Currently, dietary vitamin E and(or) synthetic antioxidants are being evaluated for this purpose.

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Image

Another factor that influences the appeal of pork is general image of swine production practices. For a growing group of people in this country, animal welfare and drug usage are issues of great importance. One of the future challenges will be to create housing and management systems which are acceptable to all consumers.

Conclusion

Several different possibilities are available for increasing appeal of pork. The four factors evaluated in this paper -- price, taste, nutritional value and image can all to some extent be controlled or manipulated by management decisions at the farm level.

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