PRODUCTION TOOL

Variations in pork quality: History, definition, extent, resolution

R.G. Kauffman, R.G. Cassens, A. Scherer, D.L. Meeker

Historical perspective

The consumer purchases meat after making a judgement about quantity and quality received for price paid. Quantity and price are easy to assess, whereas quality is a more subjective characteristic and is more difficult to measure, particularly as done by consumers.

Through the years, pork has had an excellent image. It has been considered an attractive, nutritious and wholesome meat available for a reasonable price. In addition, it has lent itself well to conversion to a variety of processed products — such as ham and bacon — which have different palatability and keeping properties. Since the trend is to use more pork for further processing, quality is equally important for ensuring 'ideal' processed pork as well as 'ideal' fresh pork.

But, the image hasn't been totally positive. Pork has been perceived as a fatty meat. This probably resulted not only from the heavy layers of backfat found on most hogs some years ago but also from the fact that pork fat is softer than fat from other meat animal species. Therein arose the concept that pork was "greasy" or "hard to digest."

Pork producers attempted to change this image beginning in the 1950s by instituting breeding programs designed to lower the fat content of pork carcasses. In reality, they were seeking to produce a trim, muscular "meat type" hog. This change was advantageous but, in the process of selection, the quality of the muscle was unexpectedly changed, too.

Pale, soft and exudative (PSE) pork quickly became recognized as undesirable not only because of its unattractive visual appearance but also because of shrinkage due to drip loss and the fact that the meat was less functional for processed products. PSE meat was often associated with trim, muscular hogs. Subsequently, it was also recognized that some of these same hogs were more susceptible to stress and, in fact, suffered the potentially terminal condition known as porcine stress syndrome (PSS).

RGK, RGC: Dept. of Meat & Animal Science, University of Wisconsin—Madison; A.S, Fachhoschschule Lippe Lemgo, Germany; DLM National Pork Producers Council, Des Moines, IA.

This article is reprinted from a 1992 National Pork Producers Council Publication. Contact: National Pork Producers Council, PO Box 10383, Des Moines, Iowa 50306.

Present situation

Other changes were occurring, however, beginning in the early 1970s. Consumers were becoming much more active and involved. There was a growing concern about safety of foods. Much of the interest centered on meat in the diet and possible relationships to human health. A strong desire developed for lean, low-fat meat. Consumption of pork declined. In response, producers renewed efforts to lower fat content of the animals even further. Also, packing companies were making changes to improve efficiency.

The pork industry started using the phrase "Pork, the other white meat"® in 1986 to emphasize the positive nutritional attributes of pork. This successful promotional campaign helped stabilize the consumption of pork.

Now there is an effort by the entire industry — from producers to processors — to improve global competitiveness. Competition from other countries with tightly controlled breeding, marketing and grading schemes is fueling change in the United States industry.

The problem

We believe the quality of pork is once again changing as a result of continued emphasis on efficiently producing leaner and leaner meat. There is a suspicion that color of the retail product is becoming less desirable and that the consumer is experiencing a cooked product that is drier and less juicy when consumed. Texture of pork seems softer and more exudative. Overall, there appears to be a great variation in quality of pork. Part of the problem is a lack of recorded assessments or tracking of pork quality in the past 25 years. So, we cannot make an informed judgement about trends in quality and thereby relate characteristics of the meat to consumer likes and dislikes. If, indeed, quality is deteriorating and becoming more variable, the point may be reached where consumers object seriously or even reject pork, and manufacturers experience difficulties in acquiring suitable pork for further processing.

Objective

With all of this in mind, we decided to conduct a survey of pork quality. The goal was to establish whether there was variation in muscle quality sufficient to warrant concern

for the industry. The aim was to examine fresh pork from a number of commercial hog slaughtering plants in several areas where pork is produced. The survey was conducted during the summer of 1991 and therefore represents only one season of the year.

In the remainder of this report we:

- define muscle quality,
- explain how much variation in muscle quality exists in the industry today, and
- make recommendations which could lead to the situation where all pork is of 'ideal' quality.

Pork quality defined

'Ideal' quality in fresh pork is defined as a combination of traits that includes appearance, taste, nutritional value and wholesomeness. These quality traits must be optimized and consistently presented to the consumer and meat processor in order to ensure continued acceptance.

At retail, the meat must have a normal bright color, be free of surface exudate and firm in appearance. After cooking, the meat must smell good, be tender and give a desirable sensation of flavor, texture and juiciness in the mouth. If the consumer or processor is disappointed, repeat purchases will not be made.

Nutrition is also basic to pork quality. Pork contains:

- proteins having a desirable quantity and combination of the essential amino acids in a biologically available form,
- water-soluble vitamins, especially thiamin,
- some minerals, notable iron and zinc, and
- high-energy lipids, including the essential fatty acids.

Wholesomeness refers in large part to safety of the product for consumption. Safety is influenced by the health of the live hog, by approved slaughter practices and by proper handling and storage of the meat. Quality assurance programs in production and processing are designed to maintain wholesomeness.

The following fresh pork traits are useful predictors of ultimate quality:

1. Muscle color

Fresh pork should be reddish-pink (Fig 1). Muscles are usually uniform in color, but individual muscles or muscle groups are inherently different in their biological makeup and can vary considerably in color. A dark purplish-red color (Fig 2) may be the result of:

- increased quantities of color pigments due to advanced age or greater physiological activity;
- less surface oxygen penetration;
- surface dehydration;
- bacterial contamination; and, most likely of all,
- little accumulation of lactic acid during postmortem conversion of muscle to meat.

Conversely, a pale pinkish-gray color (Fig 3) is usually the result of a rapid conversion of muscle glycogen to lactic acid at high body temperatures, causing a rapid increase in acidity immediately after slaughter.

Consumers object to pork that is either too pale or too dark in color. Abnormally pale muscles quickly turn gray at retail and lose fluids, resulting in economic losses during processing and dry-tasting products after cooking. Some dark muscles having a high ultimate pH will have a shorter shelf life because the less acidic condition allows bacterial growth. Consumers perceive that dark meat comes from older animals or that the product has been abused.

2. Muscle firmness / wetness

Soft, floppy and exudative muscles usually accompany the pale pinkish-gray color (Fig 3), but also can be associated with the reddish-pink color (Fig 4) and even darker colors. Ideally, the muscle surface should be free of fluids and be firm to the touch (Fig 1). If it is soft, floppy and exudative, it will have predictably poor water-holding properties and will thus shrink excessively during handling, processing and storage, sometimes in excess of 7%.

3. Marbling

Marbling is the visible fat in muscles. Slight amounts of marbling are desirable for a juicy, flavorful cooked product. However, abundant quantities of marbling do not make pork proportionately more palatable but do supply extra calories from fat. Excessive marbling should be avoided.

Extent of variation in muscle quality: results of the 1991 industry survey

Procedures

Fourteen hog-slaughtering plants were surveyed during July and August, representing eight companies located in eight states. We estimated that the number of hogs slaughtered by these plants was about 40% of the nation's total. Varying time periods were spent in each plant. All names and locations of plants were kept confidential because the primary aim was to assess quality variation, not company differences. A total of 10,753 hams representing as many carcasses was included in the survey.

Table 1. — Description of quality scores

Score	Color	Firmness / Wetness	Marbling
1	pale pinkish gray	very soft, floppy & exudative	devoid to practically devoid
2	grayish pink	soft, floppy & exudative	traces to slight
3	reddish pink	slightly firm & moist	small to moderate
4	purplish red	firm & moderately dry	moderate to slightly abundant
5	dark purplish red	very firm & dry	moderately abundant or greater

Before starting data collection, two evaluators carefully compared color, firmness/wetness and marbling scores (described in the 1991 *Procedures to Evaluate Market Hogs* bulletin) with actual variations on the gluteus medius muscle surface as it appeared on a commercial pork-cut line. This muscle was chosen because it is one of the major muscles that is subject to quality variation and one that is accessible for visual observation when the chilled carcass is being cut. These three visible quality variables were used because they were considered to be the ones most closely related to pork quality and which could be subjectively appraised under practical commercial conditions. Each set of scores was based on a five-point scale (Table 1).

During preparation for the survey, the evaluators independently scored hams possessing gluteus medius muscles varying widely in quality. They compared their results to ensure that each was consistent with the other and that their scores agreed with the National Pork Producers Council (NPPC) standards. This was important because during the survey the evaluators alternated in scoring and recording data.

When the evaluators arrived at a plant, they first became familiar with the pork-cut line and then chose a well-lighted, logistically appropriate location in which to work. Within one minute after a ham had been cut from the carcass, it was evaluated. At random, a ham was removed from the line and the evaluator would subjectively score for color, marbling and firmness/wetness (by physically touching the cut surface of the gluteus medius after removing any fat smears and/or excess water resulting from the cutting procedures). The other evaluator would record the information. This procedure progressed at the rate of one ham every 30 seconds for a period of 10 minutes. The evaluators took a 5-minute break and then began in reversed roles. This routine continued until the pork-cut line stopped. Approximately 300 hams were evaluated on any given day. Occasionally, internal ham temperature was measured.

For ease of interpreting the final results, the color and firmness/wetness scores were grouped in various combinations (Table 2.).

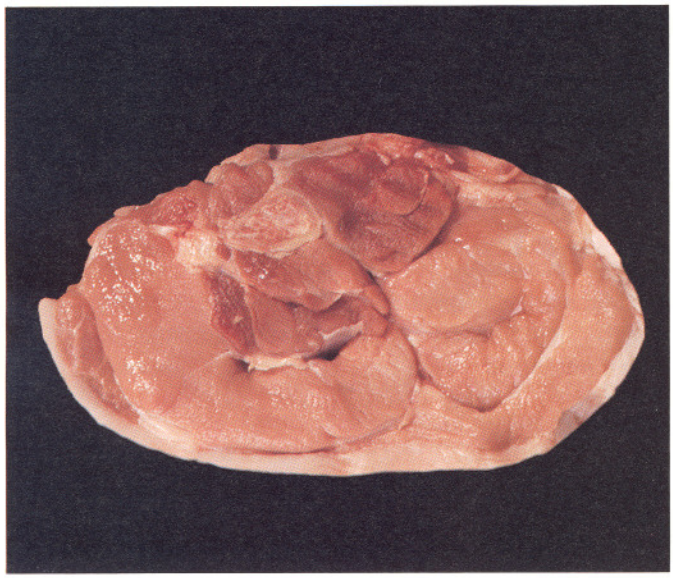
All data were analyzed according to quality characteristics, plant of origin, day and week and evaluator. In addition to calculating percentages of observations related to each quality group, Chi-square analyses were performed to assess significant interactions.

Results

The average line speed for the 14 plants was about 850 carcasses per hour and the time from stunning until the carcasses were moved into the chiller ranged from 25 to 45 minutes. Some plants chilled the carcasses rapidly using subzero temperatures (°F) to surface freeze the carcasses, whereas other plants used more conventional chilling systems and in some instances, packed the carcasses so tightly that chilling efficiency may have been reduced.

Table 2. — Description of quality groups

Color Scores	Firmness/ wetness scores	Description	Groups
1	1 & 2	very pale, soft & exudative	PSEx
2	1 & 2	pale, soft & exudative	PSE
1 & 2	3, 4 & 5	pale, firm & nonexudative	PFN
3	1 & 2	reddish pink, soft & exudative	RSE
3	3, 4 & 5	reddish pink, firm & nonexudative	RFN
4 & 5	1 & 2	dark purplish red, soft & exudative	DSE
4	3, 4 & 5	dark purplish red, firm & dry	DFD
5	4 & 5	very dark purplish red, firm & dry	DFDx



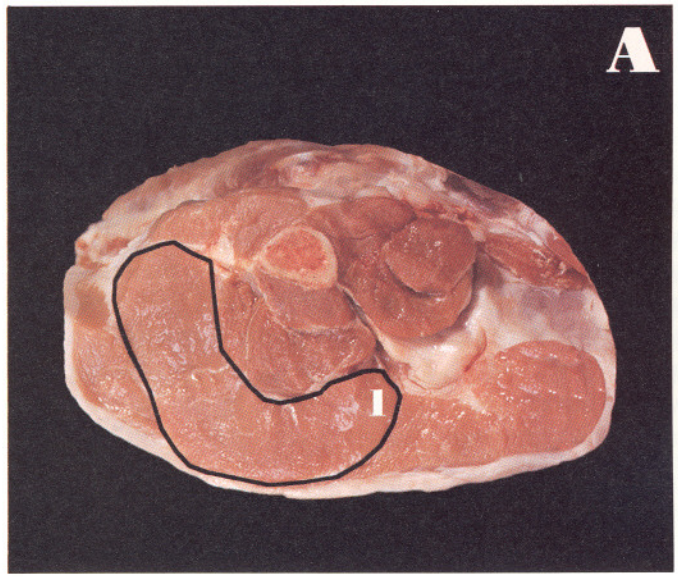
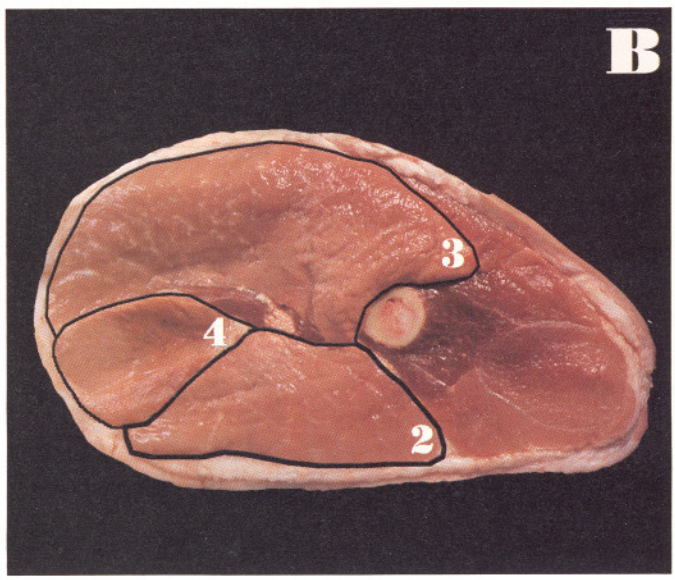


Fig 1. — (top left) RFN (Ideal) quality: reddish pink, firm, nonexudative and containing slight quantities of marbling.

Fig 2. — (top right) DFD quality: dark purplish red, very firm, dry (free of surface fluids) and containing slight quantities of marbling.

Fig 3. — (left middle) PSE quality: pale pinkish gray, very soft and floppy, very exudative and devoid of marbling.

Fig 4 (A and B). — (right, middle and bottom) RSE quality: reddish pink, soft and floppy, exudative and practically devoid of marbling. A: Hamloin interface, (1) gluteus medius. B: Center of ham, (2) biceps femoris, (3) semimembranosus, (4) semitendinosus.



Each evaluator examined similar numbers of hams, and when each of their sets of data were examined separately, the results were similar to the combined results.

There were significant interactions between day of week and plant location. However, these interactions were anticipated and there was little that could be done statistically to adjust the final results. Table 3 and Figs 5–7 are included to indicate the prevalence of what we identified as RFN (reddish-pink, firm and non-exudative) or 'ideal' quality pork, RSE (reddish-pink, soft and exudative) or questionable quality pork, PSE pork and DFD (dark, firm and dry) pork. Table 3 and Fig 5 represent the results when all plants were combined, day of week was not considered, and when all hams were sorted into the four major quality groups as described in Table 2 and illustrated in Figs 1–4. The PFN (pale, firm and non-exudative) group is not represented in Fig 5 because of its infrequency (<0.5%).

Figs 6 and 7 reflect the variations of pork quality for the RFN, PSE and DFD groups when sorted either by day of week (Fig 6) or by plant (Fig 7). Overall, the survey indicated that at least one-quarter of all the pork was clearly undesirable (16% PSE and 10% DFD), and only 16% was identified as RFN or 'ideal'. It is of particular interest that the prevalence of PSE pork was more than fivefold greater in some plants than others (6% to 33%) (Fig 7), and that DFD pork existed to a much greater extent (10%, with a range in plants from 4% to 18%) (Fig 7) than had been previously reported or that was suspected by the industry. As anticipated, most hams possessed very little marbling (93% contained devoid to slight amounts) (Table 3).

Table 3. — Overall distribution of color, firmness and marbling (n = 10,753)

	%	
Color		
Pinkish gray	16.2	100.0
Reddish pink	65.8	
Dark purplish red	18.0	
Firmness		
Soft (scores 1–2)	74.0	100.0
Firm (scores 3–5)	26.0	
Marbling		
Devoid to practically devoid	56.5	100.0
Traces to slight	36.8	
Small to modest	5.7	
Moderate to slightly abundant	0.9	
Moderately abundant or greater	0.1	

Discussion

The United States has a pork supply that contains about 16% PSE and 10% DFD, both representing proportions that should be alarming and of concern to the industry. This variation is shared by all companies, yet some have less than others. It is important to remember that this was a single survey at one specific time of the year, and that there was no attempt to determine the reason for the variations observed. It is known that a number of factors are related to pork quality including:

- genetics;
- nutrition;
- time of year (temperature and humidity levels and fluctuations);
- handling procedures on the farm and during transit to the packing plant;
- care of the hogs after arrival at the packing plant,
- method of stunning; and
- method and time of chilling after slaughter.

If the survey were repeated, somewhat different results would be expected. However, the present results give some perspective of what may exist in general for this industry. This is the first major survey that has been conducted in the past 30 years, and, at the moment, it is the best indicator available.

There were a surprisingly large number of DFD hams in the population (10%). This suggests significant stress just prior to slaughter. The current genetic makeup of hogs may make them more susceptible to stress. Handling procedures during loading at the farm, in transit and during the holding period just prior to slaughter may contribute. Nevertheless, pork processors should be aware of how DFD pork differs

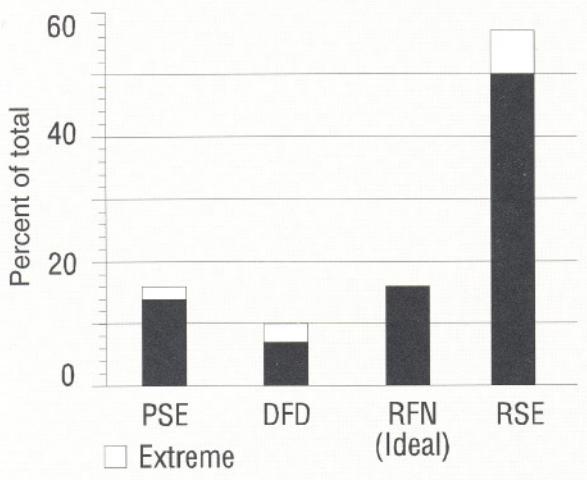


Fig 5. — Overall quality distribution (n = 10,753)

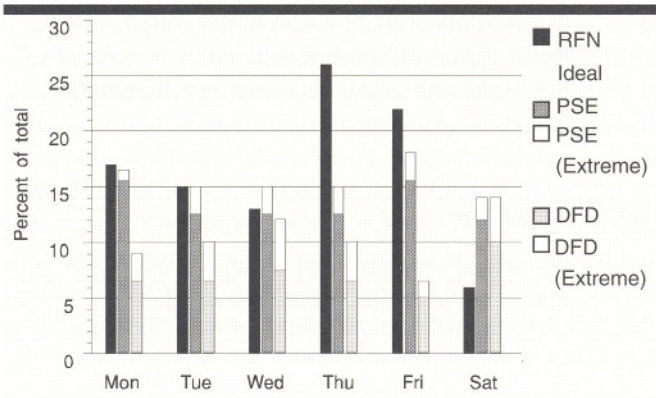


Fig. 6 — Quality by day of week as percent of total

from RFN pork so they can take advantage of its desirable attributes (high water-holding capacity, tenderness) and be especially cautious about the disadvantages (susceptibility to spoilage during conventional refrigeration, unattractive dark appearance).

Since over one-half of the hams possessed normal color but were soft and floppy, and presumable exudative (see Figs 2 and 5), there is concern about using color as the only indicator of water-holding capacity. This normal color, accompanied by a soft, floppy and exudative condition, is likely to be an intermediate condition of the PSE problem.

In general, there is a positive association between lighter colors and lower water-holding capacities. However, the correlation is not perfect, suggesting that the industry needs to be aware of this and seek other methods independent of color to assess water-holding capacity. Also, the relation between firmness and wetness is not perfect. Softness or floppiness may be the result of transversal shrinkage due to myosin denaturation during a rapid postmortem pH decline and a lower ultimate pH, muscle temperature and time lapsed after the muscle has gone into rigor. Even though we did not detect any major variations in ham temperature when they were monitored, and although most of the hams originated from hogs slaughtered the previous day, it is conceivable that at least a portion of the 74% of hams that were soft and floppy (RSE) resulted from one of these factors. There appeared to be a higher prevalence of the RSE condition and a lower prevalence of PSE in those plants that used subzero temperatures to surface freeze carcasses.

If marbling becomes a factor of importance in improving pork quality, then pork producers will have to select breeding stock that have the ability to deposit marbling in a way that does not increase other less desirable fat deposits. From this survey, it is obvious that the production of excessive quantities of marbling is not a problem.

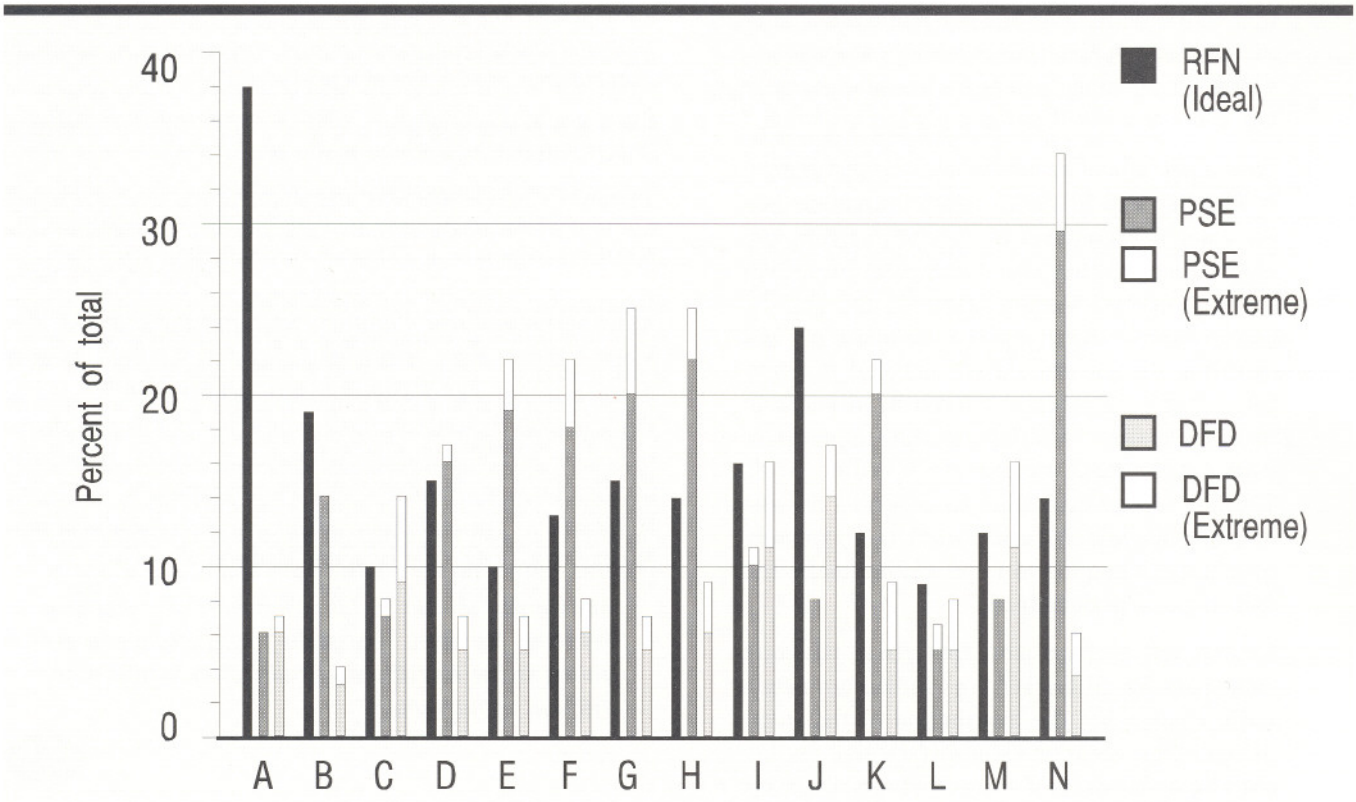


Fig 7. — Quality by plant as percent of total

Resolution: recommendations to minimize quality variations

Pork quality is affected by both genetics and environment, and can be controlled if the industry so chooses. Some European countries, such as the Netherlands, have significantly reduced PSS through the elimination of halothane-positive boars in breeding programs. Denmark's pork packers have developed model procedures to minimize stress prior to slaughter, using care in moving hogs to the stunning restrainer. They also were pioneers in developing rapid chilling procedures after slaughter. These are examples of how to minimize or eliminate variations in quality. We also know that marbling deposition is heritable, thus it can be included in breeding programs without jeopardizing carcass composition.

What should the United States pork industry do to guarantee that pork is not only lean, but that this lean is consistently firm, free of exudation, free of abnormalities, has a fresh-appearing, reddish-pink color and contains slight amounts of marbling? Here are four suggestions:

- Guidelines should be established and practiced to ensure acceptable production, management and welfare procedures at all times that include farrowing, weaning, feeding, handling, shipping and transporting.
- Pork packers should evaluate procedures for preslaughter handling and post-slaughter processing that will eliminate or at least minimize quality variations. Such factors as stunning and exsanguination, hot boning, time from stunning to chilling, and rate of chilling need further attention.
- Procedures should be put in place to electronically identify and evaluate every individual hog slaughtered. Procedures are needed to record and report abnormalities (via USDA Meat Inspection Service), carcass weight, leanness, and quality. Color, water-holding capacity, ultimate pH and marbling content should be included in every packer report to producers to continually inform them of quality variations so that appropriate steps can be made to improve breeding stock. Working toward marketing all hogs on a carcass-merit, value-added basis would be extremely beneficial in helping to improve the image and usefulness of pork as food.
- Finally, and perhaps most important, the total value paid for all market hogs should not necessarily change, but the distribution of that total should reflect accurate value differentials (as dictated by supply-demand forces) between desirable and undesirable meat quality. Similar to having price differentials for lean and fat carcasses, such differentials also should exist for variations in quality. Price differentials offered by packers can be one of the greatest incentives to generate change.

References

Briskey EJ. Etiological status and associated studies of pale, soft, exudative porcine musculature. In: Chichester CO, Mrak EM, and Stewart GF, eds. *Advances in Food Research* 13:89. New York: Academic Press; 1964.

Cassens RG, Giesler FJ, and Kolb QE, eds. The Proceedings of the Pork Quality Symposium. Madison, Wisconsin: Univ. Wisconsin Ext. Pub. 72-0. 1972.

Cassens RG, Giesler FJ, and Eikelenboom G. Animal physiology and meat quality. In: Chichester CO, Mrak EM, and Stewart GF, eds. *Advances in Food Research* 21:71. New York: Academic Press; 1975.

Epley RJ, Addis PB, and Allen CE. Processing PSE and DFD pork. Univ. Minnesota Agr. Ext. Sv. Pub. AG-FO-1948; 1983.

Forrest JC, Gundlach RF, and Briskey EJ. A preliminary survey of the variations in certain pork ham muscle characteristics. Proc. XV Research Conf. Am. Meat Inst. Found., Chicago, IL; 1963.

Hessel-de Heer JCM, Schmidt GR, Sybesma W, and van der Wal PG, eds. Proceedings of the 2nd International Symposium on Condition and Meat Quality of Pigs. Centre for Agr. Publishing & Documentation. Wageningen, Netherlands: A. Verweil (printer); 1971.

National Pork Producers Council. *Procedures to evaluate market hogs.* 3rd Ed. Des Moines Iowa; 1991.

Sebranek JG. Pork Quality: A Research Review. Des Moines, Iowa: National Pork Producers Council; 1981.

Tarrant PV, Eikelenboom G, and Monin G, eds. Evaluation and Control of Meat Quality in Pigs. Boston, Massachussetts: Martinus Nijhoff Pub. (Kluwer Academic Pub. Gp.); 1987.

Acknowledgments: Funding: National Pork Board, Des Moines, IA; WI Pork Producers, Lancaster, WI; Dept. Meat & Anim. Sci., Coll. Agr & Life Sci., Univ. WI-Madison. Statistical Consultation & Analyses: Erik Nordheim and Tom Tabone, Coll. Agr. & Life Sci., Univ. WI-Madison. Survey Assistance: Charles Linssen, Denmark, WI. Photography: B. Wolfgang Hoffmann, Dept. Agr. Journalism, Univ. WI-Madison and Michael I. Kienitz, DLM Imaging, Madison, WI.

Additional thanks to Lisa Summers at American Printing, Madison, Wisconsin for assistance in enabling ***Swine Health and Production*** *to reprint the original photographs.*