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Processing PSE and DFD Pork

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The quantity and quality of pork derived from swine is of economic importance to producers, processors and consumers. Quantity is the amount of lean (muscle) in relation to trimmable fat and bone. Quality is a combination of traits—including color, muscle firmness and apparent moisture loss—that result in an appetizing, palatable and nutritious product.

What is PSE and DFD?

Normal pork is a bright, grayish-pink color, has a firm lean and does not lose moisture. Pale, soft and exudative (PSE) pork is paler, has a soft lean and appears watery (exudative). In contrast, dark, firm and dry (DFD) pork is darker, has a very firm lean and a dry, sticky surface. Normal and PSE pork are illustrated in Figure 1.

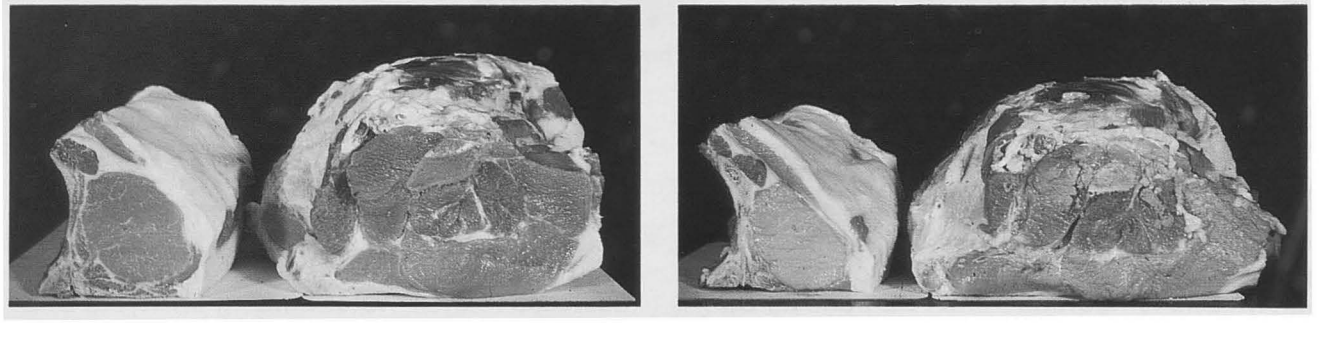

Figure 1. Left, the cut surfaces of a normal loin and ham; right, a pale, soft and watery (exudative) loin and ham.

Causes of PSE and DFD

Immediately after slaughter, glycogen (animal starch) in the muscle of a normal carcass begins to be converted to lactic acid. As this conversion progresses, the pH (acidity) decreases. (Note: the lower the pH, the more acid the meat is.) In a carcass that yields PSE pork, the pH decline is rapid and there is a corresponding increase in muscle temperature, which is also detrimental to the meat quality. In contrast, a carcass that will yield DFD pork has musculature with little or no glycogen and thus the pH remains high. These pH patterns are illustrated in Figure 2.

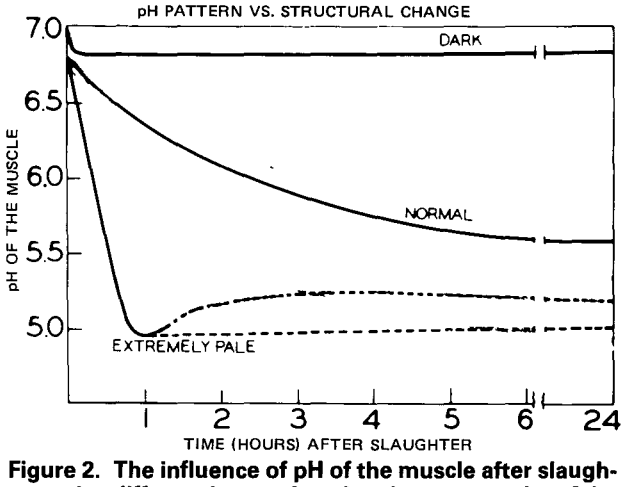

Figure 2. The influence of pH of the muscle after slaughter and at different hours after slaughter upon color of the lean (from Briskey, E. J. 1964 Adv. Food Res. 13:89).

Thus, in addition to obvious visual differences between PSE, normal and DFD pork, there are vast differences in pH of the lean.

The amount of glycogen in the muscle at the time of slaughter and the rate at which it is converted to lactic acid is closely related to the amount of stress the pig experiences prior to slaughter. The stress may come from normal moving and mixing of pigs during marketing, adverse (hot or cold) weather conditions, strange environments, etc.

Some pigs are more susceptible to stress than others. Pigs susceptible to stress are said to have the porcine stress syndrome (PSS). If PSS pigs are stressed, glycogen reserves from the liver are transported to the musculature for energy. If these pigs are slaughtered before most of the glycogen is used, the remaining glycogen will be rapidly converted to lactic acid upon slaughter, resulting in rapid pH decline, high muscle temperature and PSE pork. If PSS pigs use up a moderate amount of glycogen, the pH decline in the musculature will be normal and the pork will be normal in appearance. If PSS pigs use up nearly all of the muscle glycogen before slaughter, little or none will be available for post-mortem conversion to lactic acid, the pH will drop very little and the musculature will be DFD.

Stress-resistant pigs, however, do not substantially succumb to stress conditions. They have a normal amount of glycogen present in their musculature at slaughter regardless of the amount of stress and convert this glycogen to lactic acid and heat at a slower rate. Therefore, carcasses from these pigs almost always yield pork of a normal color and firmness.

PSS is inherited and tends to occur more in pigs with superior muscling. Producers can select against PSS by proper swine breeding programs; however, attention must also be given to trimness and muscling as well, or fatter pigs will result.

Incidence of PSE and DFD

There have been no official recent reports on the incidence of PSE and DFD pork. However, surveys in the 1960's indicated that the incidence of PSE pork was as high as 33%, with the rate lowest during the winter months. Our personal observations lead us to believe that the current incidence of PSE pork in the pork industry ranges from 5-20% and that the incidence of DFD pork is approximately 5%. It is important to recognize that variations of PSE and DFD pork exist. Pork appearance is usually classified on the following scale: 1 = pale; 2 = slightly pink; 3 = grayish-pink or normal; 4 = slightly dark, and 5 = dark. Some investigators consider pork with a score of 2 PSE while others do not.

pH and Processing

PSE pork is subject to severe weight loss during processing due to the release of juices, primarily as a result of the rapid production of lactic acid discussed above and elevated temperature after death. The consequent drop in pH to near the isoelectric point (the pH at which muscle has the lowest ability to bind water) of the major muscle proteins (5.3) results in a decrease in their water-binding ability. In DFD pork, by contrast, water-binding capacity is high and shrinkage is minimized.

Ham Yields

A study on the effects of PSE and DFD pork on ham shrinkage was conducted by Kauffman and others. As shown in Table 1, ham shrinkage differed consistently among the three muscle conditions during transit (refrigerated truck transport from one plant to another) and throughout all stages of processing. The greatest relative difference in shrinkage occurred during transit when the product was fresh. PSE hams shrank about three times more than normal hams (1.5 vs .45%) and six times more than DFD hams (.23%). Even though the transit shrinkage of normal hams was small, they lost twice the percentage of weight as DFD hams. During the curing process, PSE hams lost more than twice the weight lost by DFD hams (2.46 vs .99%). PSE hams also lost more weight (9.13%) than normal hams (8.49%) and DFD (6.51%) hams during smoking. In both gross and net shrinkage, there was an absolute three percentage unit added shrink when comparing normal and DFD or normal and PSE hams.

Sausage Manufacture

Fresh pork quality can also affect sausage manufacture. Townsend and others (J. Food Sci., 45:622) prepared dry, fermented sausages from PSE pork, normal pork, or a 50/50 mixture of PSE and normal pork. Sausage made from PSE pork took only 50-60% as long for drying compared to sausage made from normal pork. Sausage prepared with PSE pork only had the highest moisture diffusion rate (dried the most rapidly), highest degree of fat rancidity and highest lactic acid content. The cured color of sausage from the PSE group was a paler red and more yellowish than sausage prepared with normal pork only. Water holding capacity and tenderness were lowest and highest for sausages made, respectively, from PSE pork only and from normal pork.

Phosphates

It should be mentioned that polyphosphates are permitted in various processed pork products to help improve water binding capacity. In 1982, the regulations were extended by the USDA to permit the addition of phosphates in several products to decrease the amount of juices lost through cooking. Legal limits for added residual phosphates are set at 0.5% in the finished product.

Sorting Product

Many processors now use pork trimmings to produce specialty products such as stuffed and cured rolls. When these trimmings are comprised of a combination of PSE normal and DFD pork, it is advisable to pre-sort the pork according to quality. Pre-sorting also not only gives more control of processing yields, but insures greater uniformity in the final appearance and eating characteristics of the finished product. This sorting need not be complicated; it is recommended that the trimmings be sorted into three quality groups: PSE (scores 1 and 2), Normal (score of 3) and DFD (scores 4 and 5).

Retail Display and Cooking

Fox and others (J. Food Sci., 45:786) cut PSE and normal pork loins into chops and stored them up to eight days in a 30°F retail display under fluorescent light. As compared to normal chops, PSE chops had greater weight loss during display and scored lower on general appearance, flavor, cooked aroma, juiciness and overall satisfaction. However, normal chops were slightly less tender, but had higher thiamine (vitamin B_1) values.

Normal chops developed less rancidity. The color and general appearance scores decreased and the rancidity increased more rap-

Table 1. Proportional Shrinkage of PSE, Normal and DFD Hams During Processing[a]

	Muscle type		
	PSE	Normal	DFD
Item	$\bar{X}$	$\bar{X}$	$\bar{X}$
In-transit shrink, %	1.51	.45	.23
Shrinkage during cure, %	2.46	1.78	.99
Shrinkage during smoking, %	9.13	8.49	6.51
Total gross shrink	13.10	10.72	7.73
Minus % cure added	−5.88	−6.32	−5.86
Net processing shrink, %	7.22	4.40	1.87

[a]R. G. Kauffman, D. Wachholz, D. Henderson and J. V. Lochner. 1978. J. Anim. Sci., 46:1236.

idly in PSE chops than in normal chops as the display time increased. It was observed that the deleterious changes that take place in PSE pork are primarily chemical rather than microbiological.

Recent studies by Cloke (Home Ec. Res. J., 9:240) demonstrated that PSE muscle released more moisture earlier and at a lower temperature during cooking than normal samples. Cumulative water loss at 77°C (170°F) internal temperature was 50 percent greater in extremely PSE pork than in normal pork.

Since PSE pork becomes more rancid and less attractive as display time increases, it would seem advisable to repackage it as soon as appearance changes are noted. It might also seem advisable to sell PSE pork at a discount to move it out of the retail case before it deteriorates.

Summary

PSE pork, in general, is inferior to normal pork. Swine breeders can eliminate PSE pork by proper selection procedures. Until then, however, processors should sort fresh pork into groups according to quality prior to processing and display. Sorting would result in more predictable and controllable yields, and more uniform consumer products.

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