factsheet
Pork Information Gateway

Utilization of Pale, Soft, and Exudative Pork

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Introduction

The production of leaner pork has often been accompanied by lower quality muscle. Leaner pork has a higher percentage of moisture and less fat deposited within the muscle as marbling. Excessive leanness can be associated with pale, soft, and exudative (PSE) pork, which has lower consumer acceptability. The percentage of PSE pork in the United States can range from 10-40%. PSE and red, soft, and Exudative (RSE) pork result in approximately $100 million in annual losses for the pork industry according to Cannon and coworkers (et al.) (1996) and Carr et al. (1997). Thus, it is essential that this product be utilized as effectively as possible to minimize losses that occur due to reduced quality.

What is PSE Pork?

Low quality pork can possess unacceptable characteristics known as PSE. This condition is evidenced by a very light gray color. Furthermore, the muscle is very soft in texture and lacks the ability to hold water. Thus, the appearance of PSE pork reveals a very light color with soft appearance and separation between muscles with exudate (drip, purge, or moisture loss from the muscle) that ranges from light red to clear in color. Although PSE pork has acceptable nutritive value and taste, some protein and vitamin loss occurs with the exudate. Recent advances in genetics have reduced PSE incidence, but it still can occur in heavily muscled, exceptionally lean pork.

Description of Pale, Soft, and Exudative Pork

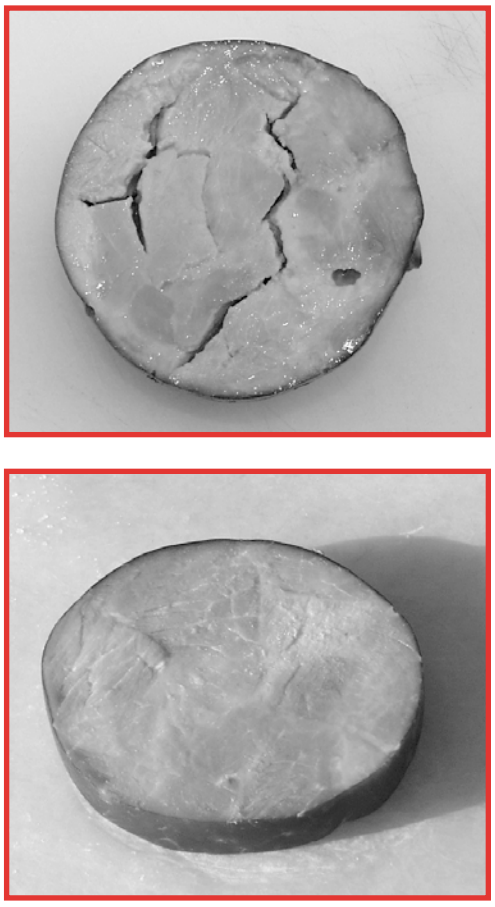
PSE is detrimental when it occurs in the loin and ham due to their value and utilization in processing. The loin is a high dollar wholesale cut that is usually fabricated into chops and often undesirable to consumers when it has a grayish color that is evident in PSE meat. Ham is processed 75-90% of the time into either whole hams (boneless and bone-in), sectioned and formed, chunked and formed, or country-cured hams. Formulation of these products is difficult when PSE meat is utilized. Lack of functional protein causes cracking and low water-holding capacity as well as poor cured color formation (Solomon et al., 1998). Similarly, loins can be processed into Canadian Bacon or sausage products. However, when PSE meat is utilized, Canadian Bacon also demonstrates poor texture, water holding capacity, and color, and sausage products are a low dollar item. A high dollar sausage product that has been sometimes suggested as a means for utilizing low pH PSE meat is fermented dried sausage. However, even though the low pH facilitates fermentation and drying, PSE meat results in a crumbly texture when used for dry sausage.

What Can Be Done About PSE Pork?

Since the effort to produce lean pork contributes to the PSE condition, it appears that the pork industry may need to manage this quality challenge in the future. Consumers will continue to demand lean pork and the industry must produce less fat and upgrade the acceptability of any PSE pork that occurs. Therefore, the optimal utilization of PSE pork should be identified.

PSE Reduction: Pre-Harvest Handling

Handling of pigs prior to the conversion process from live animal to carcass (pre-harvest) can affect muscle quality. Minimizing stress can reduce the conversion of energy stored in the muscle as glycogen to lactic acid which lowers pH and promotes PSE muscle production (Aberle et al., 2001). Pre-harvest stress may be decreased by less crowding of pigs during transit to market and in the holding area in the meat plant. Gentle handling without trauma as well as sufficient lighting in the holding area or from the holding area to restraining further reduces stress. Less stress is encountered if pigs can move in a clockwise direction on level ground or on a slight incline as opposed to a decline. Maintenance of a cool environmental temperature further reduces stress and use of a cool water shower prior to harvest is commonly recommended.



Post-Harvest Handling

Rigid temperature control can reduce the development of PSE pork after the pigs have been converted to carcasses. It is important to expedite the movement of pork carcasses to a storage cooler after harvest. Delayed chilling of pork carcasses will cause a more rapid decline in pH and enhance PSE development (Aberle et al., 2001). Furthermore, a rapid chill process can reduce the incidence of PSE muscle.

Storage Techniques Prior to Processing

A colder, more uniform storage temperature prior to processing reduces the development of PSE pork. Lower temperature will maintain superior color, increase firmness, and reduce moisture loss. Further protection against PSE pork can be achieved through the reduction of hydraulic pressure applied to pork cuts from the practice of stacking cuts, by reduced and gentle handling, and with the maintenance of a constant temperature near freezing. Minimal temperature fluctuation will reduce purge loss.

Figure 1: Example of the cracked texture that occurs in processed meats when too high of a level of PSE meat is utilized. The top sample demonstrates cracking, while the bottom sample demonstrates desirable texture.

After Processing

Processed pork products will be better protected against color deterioration, firmness, and water-holding capacity if they are vacuum packaged, stored at a constant temperature between 32-35°F, and protected from rough handling, and stacking of packaged cuts on top of each other or from damaged boxes. Poor handling and inadequate temperature control have the same adverse effects on pro-cessed pork as poor quality raw materials.

Utilization Techniques: Dilution Techniques

Fresh PSE meat is undesirable to consumers, and 100% PSE meat cannot be utilized in high quality processed products (Schilling et al., 2001; Schilling, 2002; Motzer et al., 1998). Li and Wick (2001) demonstrated increased cook yield and firmness in sausage products formulated with PSE pork if mechanically deboned

turkey meat was utilized in the formulation. Their discovery reveals the potential of utilizing PSE pork in sausage-type products when utilizing other functional ingredients. This is a valid alternative, but it would be more valuable to utilize higher value cuts in deli meats since sausage is a lower dollar item. Motzer et al. (1998) revealed that utilizing 50% PSE pork in a restructured product with either modified food starch or carrageenan yielded better quality pork than 100% PSE treatments. Schilling et al. (2002) later demonstrated that combining 25% PSE and 75% RFN (red, firm, and non-exudative) pork in a chunked and formed ham was similar in quality to a 100% RFN pork sample when soy protein concentrate and modified food starch were incorporated together at 2 and 1.5%, respectively. Similarly, Torley et al., (2000) reported that increasing the ionic strength and utilization of polyphosphates resulted in increased cooking yield similar to that of a product manufactured from RFN pork.

This research makes it clear that PSE pork can be incorporated into processed products, but it can be unsatisfactory to use formulations with more than 25% PSE. Samples formulated with 25% PSE pork exhibit acceptable texture, but those formulated with 75 or 100% PSE often sustain cracking (Figure 1). Severity of the PSE condition also decreases quality. Depending on the severity of the condition, greater percentages of PSE might be able to be utilized, but further investigations are necessary to determine these possibilities.

Incorporation of PSE pork in Fresh Restructured Products

Three factors are important in the incorporation of PSE meat into restructured products. The first factor is the dilution effect, which was mentioned in the previous section. The second factor is the particle size of the raw material, and the third is the utilization of binders and curing adjuncts to improve quality. Research by Schilling (2002) has revealed that up to 25% PSE pork can be incorporated in boneless cured products with resultant color and bind properties that yield an acceptable product. Smaller particle size enhances the masking effect of the PSE dilution factor through improved ingredient incorporation. However, smaller particle size may be impractical since it is often associated with low value sausage products. Chunking and forming either the ham muscles or the loin is a more successful method than sectioning and forming. Sectioning and forming into sections greater than 3 inches by 3 inches prevents the dilution effect throughout the product that is evident in chunked and formed products in which the raw material is chunked into 1-inch cubes before tumbling.

The incorporation of PSE pork into fresh restructured products has been studied less, but this practice has been utilized by the meat industry. The use of sodium tripolyphosphate and other phosphates with ascorbic acid plus the dilution effect of 75% normal pork will maintain acceptable color and bind. Furthermore, precooked, marinated, and injected adjuncts will protect color and bind. Restructured products manufactured with up to 25% PSE muscle and complemented with 75% normal quality pork and adjuncts that enhance appearance, flavor, and bind should be acceptable to consumers.

Marination

Severini et al. (1989) demonstrated that immersion curing of loins in 10% salt solution before chilling for 72h (40°F) revealed similar brine absorption and salt uptake for PSE and normal samples. They concluded that it was possible to obtain acceptable aged cured products with PSE muscles if the salt uptake can be controlled. In order to accomplish this, one must detect PSE meat as early as possible to begin salting the raw material and determine appropriate salting and aging conditions for the raw material utilized.

Enhanced Meats: Injected Adjuncts

Loins and hams can be enhanced through the injection of tripolyphosphate and salt dissolved in water. Brewer et al. (1999) reported that enhancement improved the texture of loins by increasing the tenderness of PSE meat. Brewer et al. (2002) also revealed the potential of improving pork quality at various pH levels by enhancement with 6 to 12% solution.

Formulated Adjuncts

Both binders and curing adjuncts are effective in improving the functionality of PSE meat. However, one limitation of binders is that none of them can be utilized at levels greater than 3.5% in the finished product. Phosphates and salt improve bind by increasing ionic strength, and ascorbic acid and sodium nitrite promote improved color. Modified food starch (corn) demonstrates potential to improve cooking

yields, decrease purge loss, and stabilize color, and soy protein improves cooking yields (Schilling, 2002). Milkowski and Sosnicki (1999) reported that transglutimase could be utilized to improve the quality of packaged and canned hams formulated from PSE meat. Motzer et al. (1998) reported that k-carrageenan is capable of increasing cook yields and decreasing purge loss, but that it leaves a slimy precipitate on the product. Utilizing a combination of these adjuncts may be the most favorable method in improving the quality of processed meats formulated with any percentage of PSE. Schilling (2002) revealed that incorporating 2 and 1.5% soy protein concentrate and modified food starch in the finished product improved color and yields in chunked and formed cured pork at all levels of PSE pork (0, 25, 50, 75, and 100% PSE). It is important to note that while improvement is possible with use of adjuncts, PSE pork is still likely to result in less yield and lower bind strength than normal pork utilized with the same levels of the same adjuncts.

Synergistic Techniques

The most successful way to utilize PSE pork is through combining dilution with other techniques in sausage or deli products. The incorporation of binders and a percentage of PSE pork appear to be the most logical alternative for utilizing PSE pork if one is able to reduce the particle size of the raw material. Utilizing 25% PSE meat and appropriate binders can produce a product similar in quality to that with no PSE incorporated. If processing a whole muscle product, marination and injection will improve quality, but these methods have limitations due to the inability to dilute the raw material with normal pork.

Potential Techniques

Camou and Sebranek (1991) reported that slow heating of protein gels increased the functionality of PSE meat when compared to fast heating, but that normal pork had much higher gel strength than PSE meat. By slow heating of gels formulated with a combination of PSE and normal pork, it may be possible to increase functionality in emulsion-type products. Perhaps, the most interesting alternative in utilizing PSE pork is to prevent it altogether by rapidly chilling carcasses after slaughter to reduce the incidence of PSE and enhancing it with solution to improve the quality of the meat that is altered through rapid chilling. Rapid chilling can lead to less tender pork through cold shortening, but this method appears to have merit since palatability can be improved by injecting a water, salt, and phosphate solution into the loin or ham, thus enhancing the product. The water, salt, and phosphate will increase the juiciness and tenderness of the product, and incidence of PSE will be reduced through the rapid chilling.

Summary and Conclusions

The production of lean pork can lead to the quality deficiency known as pale, soft, and exudative pork. This quality challenge can be minimized through careful handling and reduced temperature before harvesting and prior to processing.

Optimal utilization of PSE pork may be accomplished through processing alternatives such as the dilution of PSE pork in the formulation for ready-to-eat meats and restructured products. Marination and the incorporation of adjuncts which improve the color, texture, flavor, and bind of processed products such as phosphates, ascorbic acid, nitrite, carrageenan, modified food starch, and soy protein can be successfully incorporated into product formulations to improve the acceptability of PSE pork.

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