Porcine Stress Syndrome

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The porcine stress syndrome (PSS) is a disorder that was a major concern to the pork industry in the 1960s and the 1970s, and has again become a significant problem. The disorder, when present, is usually associated with heavily muscled animals and results in sudden and unexplained death losses. Animals having PSS often show signs of nervousness and may have muscle tremors indicated by a rapid tremor of the tail. When exposed to stressful situations such as a change in surroundings, a sudden change in the weather, vaccination, castration, estrus or mating, the pigs often respond by becoming overly excited and developing reddish blotches on their skin and by experiencing muscle rigidity followed by rapid, labored breathing. Their body temperature also begins to rise and they begin to show signs of heat stress even in cold weather. At this point, many producers have attempted to save them by spraying with water, but the condition progresses so rapidly that it is virtually impossible to cool the pigs fast enough.

Death losses from PSS usually occur during the process of sorting and delivering animals for slaughter. In addition, death losses are higher in the summer months when temperatures are higher and pigs are unable to rid themselves of body heat. Research has revealed many characteristics of PSS animals. Some of these findings are summarized in this fact sheet.

What Makes Some Pigs Stress-Susceptible?

Although the metabolic basis of PSS is not completely understood, researchers have learned many facts about the problem. PSS pigs cannot cope well with stressful situations. When exposed to a stress, they undergo several reactions, including a very rapid depletion of their muscle energy stores. As their muscle energy stores are being depleted, there is also a corresponding increase in lactic acid in both the muscle and blood. Normal pigs can remove the lactic acid from the muscle and blood fast enough to prevent excessive build-up. However, PSS pigs have such great quantities of lactic acid produced that they cannot remove it from the muscle. Therefore, following a stressful situation, the levels of lactic acid increase in PSS pigs which increases blood acidity creating a condition known as metabolic acidosis. Accompanying the acidosis is a build-up of heat due to a wasteful process of utilizing the muscle glycogen for energy.

The primary defect of PSS pigs is likely to be in the muscle structure itself. Certain muscle organelles lack the ability to bind calcium. Higher levels of unbound calcium trigger muscle contraction and the breakdown of energy-rich phosphates. This initiates the series of reactions outlined above that produces excessive amounts of lactic acid.

Genetic Factors

No breed is entirely free of the PSS problem and, likewise, no breed can be termed categorically stress-susceptible. In some European breeds the incidence is extremely high and in others extremely low. The trait is inherited in a simple recessive manner meaning that both the sire and the dam must be at least carriers of the gene responsible for stress-susceptible offspring. On average, one of four offspring of carrier parents will be PSS, two of four will be carriers, and one of four will be free of the condition. Therefore, if there is a problem in the herd, the quickest and most economical step is to replace the sire with one that can be confidently predicted not to be stress-susceptible or a carrier of the disorder.

Although the PSS condition is sometimes found in animals with superior muscling, it is not necessary to sacrifice carcass leanness for freedom from the PSS problem. Instead, one should incorporate meat-type animals into the breeding herd that have

been tested free of the problem or that do not appear to be of the PSS type. PSS pigs normally have a high muscle-to-bone ratio but they have several disadvantages including smaller frame size, lower feed intake, lower daily gain, and smaller litters born and reared.

Tests for PSS

It is now possible to objectively evaluate candidates for the breeding herd by using one of two tests. The most accurate test requires the pig to be anesthetized with halothane. PSS animals respond to halothane anesthesia by showing signs of extreme muscle rigidity within 3 minutes from the start of the treatment. Occasionally, an animal that does not respond within this brief period will respond to a longer treatment, but this is rare. This test provides immediate results, but the equipment involved is expensive and the operator requires training. Halothane levels of 3% to 6% and oxygen flow rates of 1 to 2 liters per minute administered by a semi-closed system, rebreathing anesthetic machine have produced successful results. The gas is delivered to the pig via a large-animal face mask. The rear limbs are monitored carefully, and the mask is removed immediately upon observing muscle rigidity. The test is generally regarded safe for young pigs; however, results are not repeatable in pigs under 7 weeks of age. Although the test is accurate in older pigs, the risk of death due to overexposure increases with the age of the animal. Various European countries have used the halothane test successfully as a selection criterion but the test alone cannot distinguish between carriers and non-carriers, so the gene will never be eradicated using this method.

Blood typing used in conjunction with the halothane test offers great promise in identifying both PSS animals and the carriers of the gene. Researchers have discovered that two blood group locations or loci, called H and S, and three other loci, called Phi, Pgd, and Po-2, are contained on the same chromosome that carries the halothane response gene. Two or more different genes (alleles) are known for each location. Since these genes are all closely linked to the halothane gene, all of the genetic factors on a single chromosome are likely to be inherited together as a single block. Knowing which of these genes are linked to the stress gene in positive-testing animals permits one to discern which littermates carry only one undesirable gene (carrier) and which contain none. This testing procedure is now in widespread use in Sweden. Researchers in the United States are currently modifying the procedure for field use.

The second test involves analyzing blood for creatine phosphokinase (CPK), a serum enzyme that is abnormally high in PSS pigs. The serum test requires submitting the blood sample to a hospital or laboratory with CPK testing capability. It is important that the blood obtained for these tests be drawn at least 2 hours and preferably 8 to 12 hours following a physical stress such as a 100-yard run or a 5-mile truck ride. The blood must be taken from an ear vein or some other superficial vein so the blood sample is not contaminated with muscle tissue. It is important to exercise care in handling the pigs since the test results will be inflated if the pig has sustained muscle bruising from fighting or harsh treatment prior to sampling.

A recent finding by Canadian researchers promises to revolutionize stress testing. A single-point mutation has been detected in the gene for the skeletal muscle receptor that binds a drug called ryanodine. This receptor, called the sarcoplasmic reticulum calcium channel protein, controls movement of the calcium from the sarcoplasmic reticulum into the muscle cytoplasm. The defect in the PSS pig appears to be a hypersensitive gating of this channel resulting in it being more easily opened than normal and preventing or making difficult its closure. The result is muscle contraction, hypermetabolism, and hyperthermia characteristic of this syndrome. This mutation at nucleotide position 1843 is a single-base pair change of C to T and creates an amino acid change of arginine to cysteine. This change can be detected by electrophoresis of the amplified product of this DNA segment, after it has been cleaved with a restriction enzyme (Hin PI). This mutation is consistent across five breeds and hence is likely to have had a common origin. A noninvasive diagnostic test should soon be released that will identify the individual genotypes and provide the basis for elimination of the gene from the breeding population or for its planned use in breeding programs.

Relation of the PSS to Meat Quality

Much has been said about the use of pork quality estimates when selecting breeding stock. It is true that most PSS animals will yield pale, soft, and exudative (PSE) muscle. However, not all pigs that produce normal quality carcasses are free of PSS. The quality of fresh pork is the result of the genetic make-up of the animal and the conditions under which the animal is slaughtered.

It has been demonstrated that much of the low-quality PSE pork is the end result of PSS, but research shows the genetic and environmental influences to be closely related. Those animals that are stress-susceptible may die enroute to market or, if they survive until slaughter, produce a high incidence of PSE muscle. In populations with a low incidence of PSS, preslaughter and slaughter conditions are relatively more influential in producing PSE pork.

High-quality, uncured pork is reddish pink in color, firm in texture, relatively free of surface juices, and (for some consumers) contains modest amounts of marbling. These characteristics result in a juicy, tender, flavorful, nutritious product when properly cooked. In addition, high-quality pork will retain most of its juices during cutting, packaging, freezing, and cooking and also during curing, smoking, and emulsifying in the making of manufactured products.

On the other hand, PSE pork is low in quality for the following reasons:

- It is soft, mushy, loose-textured, floppy, pale, and unappealing.
- The muscles become acidic, especially during early stages after slaughter, and consequently the proteins lose their ability to retain juices.
- The condition appears more frequently in the loin and outer ham muscles, giving a two-toned appearance in many pork cuts.
- Affected muscles appear to have little or no marbling.
- In the unprocessed fresh condition, it releases juices during cutting and handling (shrinkage is sometimes greater than 7%) as well as in the retail package, turns gray in color and is unattractive to consumers, and has a shorter shelf-life than normal pork.
- When used for manufactured products (smoked cuts, sausage products), it shrinks excessively (3 to 10% above normal for fully cooked hams), lacks uniform cured color, shows separation of individual muscles, and may be difficult to slice.
- Frozen cuts lose excessive amounts of juice upon thawing.

In some instances PSS pigs do not produce PSE muscle. Several factors may interfere with the usually close relationship. For example, the particular stage of stress response developed by the pig at the moment of slaughter will dictate the conditions

within the muscles. If an animal is stress-susceptible but survives a stress that occurs well in advance of slaughter, the muscles may be depleted of their energy reserves. In this instance the meat may appear dark, firm, and dry (DFD) because very little acid is produced after death. The DFD condition is undesirable in appearance and is more subject to spoilage due to higher ultimate pH (less acidity), but it does not have the other disadvantages of PSE muscle. If preslaughter conditions are right, PSS pigs can yield normal appearing muscle. These complicating factors suggest that it is more reliable to base animal selection on direct measurements on the animals in question rather than on meat quality characteristics of their littermates' carcasses.

Preslaughter Handling Practices and Prevention of PSE Pork

Some environmental conditions may be comfortable to a stress-resistant animal but stressful to the pig with PSS. Consequently, it may be impossible to handle pigs under practical conditions without imposing some stress.

Some of the undesirable meat characteristics can be minimized by observing simple management practices at marketing time. The following are suggestions for reducing losses associated with handling market hogs:

- Avoid crowding in holding pens and trucks. Make sure loading and unloading facilities are well-designed to minimize excitement. Train handling personnel in animal behavior, and be patient.

- Eliminate the opportunity for fighting. Do not mix pigs that have not been reared together. When handling pigs, treat them quietly at all times and refrain from use of an electric prod.

- Avoid extremes in temperature and other environmental conditions. Do not move pigs during the hottest part of the day.

- Use general precautions in all phases of the marketing process. Do not require pigs to walk long distances; avoid driving pigs over slippery surfaces; do not feed pigs 12 to 24 hours prior to marketing; and spread the stress over long periods and allow time for adjustment.

- Include a 2- to 4-hour resting period in preslaughter handling. Avoid slaughter immediately after arrival at the plant. Use showering for cooling if temperatures are high. Move pigs from holding pens to the stunning location as carefully as possible to minimize crowding and exciting the pigs.

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