THE STRESS SYNDROME AND MEAT QUALITY

METHODS FOR PREDICTION OF PALE, SOFT, EXUDATIVE PORK.

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The condition of pale, soft and exudative (PSE) pork has long been considered to be simply a post mortem phenomenon. Now there is substantial evidence that these pigs are suffering from a myopathy which predisposes them to an abnormal postmortem metabolism.

Conditions such as the Porcine Malignant Hyperthermia Syndrome and Acute Back Muscle Degeneration and Necrosis which occur in the live animal, seem to be closely related to this myopathy.

Genetic studies on PSE indicate a moderate heritability for various post mortem muscle quality traits. With the aid of reliable methods to determine the abnormal condition in the live animal, it would theoretically be possible to select more effectively and economically against stress- and PSE-susceptibility.

So far three methods have been developed:

- Analysis of blood serum for CPK, Aldolase, GOT or other enzyme activities.
- Muscle biopsy analysis for glucose-6-phosphate, lactate or energy-rich phosphates.
- Non-destructive testing of young pigs for sensitivity to the Malignant Hyperthermia Syndrome by allowing them to inhale the anesthetic halothane (Fluothane) for a 5 minute period. The development of muscular rigidity and stiffness indicates a susceptibility to stress and a potential for PSE meat.

The relationship of the various methods with ultimate muscle and carcass quality as well as the problems inherent with each method are discussed.

It is concluded that the third test seems to be the most promising one for application in breeding of pigs for optimal stress resistance and muscle quality.
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Introduction

The condition of pale, soft, exudative (PSE) muscle has long been considered to be a post mortem phenomenon, which occurred predominantly in the lean meaty type of pig as a consequence of the stress applied by transportation and slaughter. Recent studies, reviewed by Cassens et al. (1974), indicate that there is in these pigs an abnormal condition in the musculature in vivo.

It is likely that in addition to PSE and the Porcine Stress Syndrome (Topel et al., 1968) also Acute Back Muscle Degeneration and Necrosis (Bickhardt, 1972) and hypersensitivity to halothane (Malignant Hyperthermia; Sybjesma and Eikeelenboom, 1969) are expressions of the same abnormal condition.

Genetic studies on the inheritance of abnormal muscle quality indicate a moderate coefficient of heritability of 0.3 for various post mortem muscle quality characteristics (Wensing et al., 1970; Jonsen, 1971; Walstra et al., 1971). This paper reviews recent research on methods for diagnosing the abnormal condition in the live animal, which can possibly be used as selection criteria in a breeding program directed towards optimal muscle quality.

I Serum enzyme analysis

In 1967 Sybjesma and Hessel-de Heer first reported the observation of elevated serum lactate dehydrogenase (LDH) activity, due to increase of the muscle specific isoenzyme, in stress-susceptible Pietrain pigs as compared with stress-resistant Yorkshire pigs. This observation has been confirmed by several others (Addis and Kallweit, 1969; Merkel, 1971; Reddy et al., 1971) while in addition other serum enzyme levels such as glutamic-oxalacetic-transaminase (GOT), creatine phosphokinase (CPK), malate dehydrogenase (MDH), glutamic-pyruvic transaminase (GPT) and

2.6, diphospho-fructoaldolase have been reported to be increased in stress-susceptible pigs (Eikeelenboom et al., 1970; Bickhardt, 1971; Schmidt et al., 1971).

The decreased selective permeability of the muscle fiber membranes as evidenced by the leakage of large protein molecules suggests that these pigs are suffering from a myopathic condition. Since, unlike the other enzymes CPK only occurs in muscle tissue, it is the most specific indicator of this condition.

Most of the studies mentioned above have shown differences in mean serum enzyme activities between breeds with different degrees of stress-susceptibility. In a relatively few number of studies the direct relationship between serum enzyme levels and post mortem muscle quality within a breed has been investigated. Schmidt et al. (1971) found CPK, determined in samples taken 6 or 12 days ante mortem from Dutch Landrace pigs, significantly related to muscle protein solubility and subjective evaluation at 24 hrs post mortem. CPK was also significantly related to G6P and lactate levels in muscle biopsies taken immediately prior to blood sampling.

The results of Allen and Patterson (1971) indicate that enzyme activities are related to the method of sampling. Puncture of the vena cava gave elevated readings as compared with samples obtained from the ear vein, which is probably due to contamination of the serum with muscular tissue. Bickhardt (1971) found differences in mean serum enzyme activity to increase between groups of stress resistant and stress-susceptible pigs after short term exercise.

Richter et al. (1973) demonstrated the logarithm of CPK activity, determined in blood samples taken after certain "standardized" stress conditions, to be related to meat percentage (r = 0.31), G6P (r = 0.32) and pH value (r = 0.41). Considerable variation in mean CPK value with large standard deviations were found between the various days of sampling, representing possibly environmental influences. Correlations of enzyme activity determined twice in one sample and in two samples in succession with an interval of one week, were 0.81 and 0.68, respectively.

Before the CPK test can be used in a pig performance testing scheme as

Measurements of pH at 45 minutes post mortem were a better predictor than G6P or lactate. No substantial difference in predictive quality could be shown between G6P and lactate. Sampling at 14 and 6 weeks ante mortem did not show a significant relationship between both metabolites and ultimate muscle quality. Calculations on heritability coefficients suggested a rather high heritability for the criteria measured. In further research (Petersse et al., 1973) no effect of site of sampling or exercise on the results and post mortem muscle characteristic was observed, although the biopsy technique allowed direct observation on the tissue which had been vaporized. Lactate, but particularly glucose-6-phosphate (G6P) determined in samples taken 6 or 12 days ante mortem, predicted muscle quality at 24 hrs post mortem. Other enzyme activities between breeds with different degrees of stress susceptibility were compared with stress-resistant Yorkshire pigs. This observation has been confirmed by several others (Addis and Kallweit, 1969; Merkel, 1971; Reddy et al., 1971) while in addition other serum enzyme levels such as glutamic-oxalacetic-transaminase (GOT), creatine phosphokinase (CPK), malate dehydrogenase (MDH), glutamic-pyruvic transaminase (GPT) and

has been recommended by Richter et al. (1973) further research needs to be done in order to increase the accuracy of the test and to improve the relationship with ultimate quality.

II Muscle biopsy analysis

Sair et al. (1970) and Lister et al. (1970) found considerable differences in energy rich phosphate and lactate levels between muscle samples taken at the time of death from anaesthetized stress-susceptible and stress-resistant pigs. Bickhardt et al. (1972), using an in vivo freezing technique, found higher levels of lactate and lower levels of pyruvate and several glycolytic intermediates in the longissimus muscle of a strain of German Landrace with a high incidence of PSE as compared with a strain from the same breed with a low incidence of PSE.

Schmidt et al. (1971, 1972) designed a muscle biopsy technique whereby 200 mg samples of the longissimus muscle were obtained without the use of a general anaesthetic. Lactate, but particularly glucose-6-phosphate (G6P) determined in samples taken 6 or 12 days ante mortem, predicted as well ultimate muscle quality characteristics as did post mortem pH and rigor measurements.

Sybjesma et al. (1972) repeated the experiment on a larger number of pigs and found lower, although significant, relationships between G6P or lactate and ultimate quality (Table I).

<table>
<thead>
<tr>
<th>Traits</th>
<th>Norwegian</th>
<th>Dutch</th>
<th>Dutch</th>
<th>Pietrain</th>
<th>Belgian</th>
<th>L.S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BpT</td>
<td>5.65</td>
<td>3.09</td>
<td>2.24</td>
<td>5.80</td>
<td>5.13</td>
<td>0.62</td>
</tr>
<tr>
<td>Lactate</td>
<td>0.95</td>
<td>11.31</td>
<td>7.40</td>
<td>12.28</td>
<td>14.04</td>
<td>1.06</td>
</tr>
<tr>
<td>45 min. post mortem</td>
<td>80</td>
<td>102</td>
<td>96</td>
<td>82</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>pH(m, semim.)</td>
<td>6.46</td>
<td>6.51</td>
<td>6.69</td>
<td>6.22</td>
<td>6.17</td>
<td>0.13</td>
</tr>
<tr>
<td>(M.long.dorsa)</td>
<td>6.55</td>
<td>6.41</td>
<td>6.71</td>
<td>6.21</td>
<td>6.22</td>
<td>0.15</td>
</tr>
<tr>
<td>rigor</td>
<td>4.6</td>
<td>5.7</td>
<td>5.1</td>
<td>8.8</td>
<td>8.9</td>
<td>1.0</td>
</tr>
<tr>
<td>24 h post mortem</td>
<td>30.6</td>
<td>31.1</td>
<td>16.4</td>
<td>50.3</td>
<td>49.8</td>
<td>9.6</td>
</tr>
</tbody>
</table>

Table 1. TWO WEEKS ANTE MORTEM BIPSY AND POST MORTEM MUSCLE QUALITY RESULTS IN FIVE BREEDS OF PIGS (WALSTRA, DATA TO BE PUBLISHED)

Although the biopsy technique allows direct observation on the tissue which is primarily affected in PSE-susceptible pigs, the parameters which have been developed so far are not yet suitable as a selection criterion.

III Testing for hypersensitivity to halothane

Previous studies from our laboratory have shown that stress-susceptible Pietrain pigs are hypersensitive to halothane (Fluothane, ICI) anaesthesia (Sybjesma and Eikeelenboom, 1969). The symptoms these pigs develop when they are subjected to this type of anaesthesia closely resemble those which may occur in these pigs during conditions of physiological stress or exercise. The condition, characterized by severe muscle rigidity, progressive hyperthermia and a metabolic acidosis, has been defined as

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Malignant Hyperthermia Syndrome (MHS) (Sybesma and Eikelenboom, 1969; Allen et al., 1970),
Recent pathological studies suggest that the syndrome provoked by halothane is non-lethal in young pigs, provided that appropriate measures are taken immediately (Rapacz, 1972; Hall et al., 1972).
Eikelenboom and Minkema (1974) evaluated the relationship between the reaction of young Dutch Landrace pigs to halothane anaesthesia and the occurrence of PSE muscle upon normal slaughter at 100 kg. At an average age of 15 weeks, 231 Dutch Landrace pigs were subjected to anaesthesia in a resuscitation chamber and an increased 1-4% halothane supplied through a facemask for 5 minutes. Thirteen percent of the pigs showed signs of the MHS: muscular spasm with extreme extension of fore and hind legs. As soon as the first positive signs developed treatment was immediately stopped and the pig's reaction to halothane challenge was qualified as either positive (MHS-susceptible) or negative (non-susceptible). Considerable differences in growth and carcass composition traits between susceptible and non-susceptible pigs were found (Eikelenboom and Minkema, 1974). These results indicate that the susceptible pigs were of a leaner meat type than the others, an observation which has also been made by Christian (1973) in American Yorkshire pigs.

Skin and loin muscle quality of susceptible pigs 45 min. post mortem had significantly lower pH and significantly higher temperature and rigor scores, while protein solubility and subjective evaluation at 24 hrs post mortem were significantly inferior only in the susceptible gilts (Table 2). No significant differences in 24 hrs post mortem characteristics were found between susceptible and non-susceptible barrows. However, since 45 min. post mortem measurements did not differ significantly between susceptible gilts and barrows, it was suggested that the sarcoplasmic proteins in barrows are less sensitive early post mortem to denaturation causing factors than in gilts (Eikelenboom and Minkema, 1974).

This non-destructive test for the Malignant Hyperthermia Syndrome is less expensive but easier to perform and interpret than the two methods discussed before and hence seems to be more promising. Further research will determine whether this test is suitable application in commercial pig testing and breeding schemes for optimal stress resistance and muscle quality.

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Table 2: RESULTS OF MUSCLE QUALITY MEASUREMENTS IN DUTCH LANDRACE GILTS AND BARROWS WITH DIFFERENT REACTIONS UPON CHALLENGE WITH HALOTHANE

<table>
<thead>
<tr>
<th>Traits</th>
<th>Gilts</th>
<th>Barrows</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (M. semimembranosus)</td>
<td>5.92 ± 0.20, 6.52 ± 0.29***</td>
<td>5.87 ± 0.26, 6.41 ± 0.28***</td>
</tr>
<tr>
<td>(M. long. dorsi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature (°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(M. semimembranosus)</td>
<td>40.82 ± 0.59, 40.06 ± 0.65***</td>
<td>40.79 ± 0.51, 39.70 ± 0.74***</td>
</tr>
<tr>
<td>(M. long. dorsi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rigor</td>
<td>7.07 ± 0.59, 4.13 ± 0.32***</td>
<td>6.50 ± 1.10, 2.79 ± 2.11***</td>
</tr>
<tr>
<td>transmission (%)</td>
<td>73.1 ± 1.2, 44.7 ± 2.35, 1.5***</td>
<td>46.7 ± 2.6, 37.8 ± 2.22, 0</td>
</tr>
</tbody>
</table>

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References