The Effect of RN Genotype on Pork Quality

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MUSCLE BIOCHEMISTRY

Introduction

The importance of quality attributes of fresh pork has become an important issue during the past decade. The interest in improving the color, water-holding capacity, palatability and consistency of fresh pork has increased dramatically. A variety of approaches have evolved as means of improving the quality of pork. These approaches include: genetics, management, nutrition, animal handling, slaughter procedures and postmortem handling of the carcass. The focus of this discussion will involve a genetic component of meat quality.

Many factors influence the rate and extent of pH decline in postmortem muscle. Traditionally, the combination of a rapid pH decline and elevated temperature have been the major contributors to reduced water-holding capacity, and a light color (PSE). Monin and Sellier (1985) suggested an alternative perspective from studies involving the Hampshire breed. In that study, Hampshire animals had normal rates of postmortem pH decline; however, the resulting meat was of low quality. In addition, ultimate pH values were significantly lower than the large white carcasses. These findings led the researchers to conclude that some Hampshire animals had excessive “glycolytic potential” (GP). The high glycolytic potential corresponded to abnormally high levels of muscle glycogen and results in a lower ultimate pH in post-mortem muscle. Subsequent studies suggest that high GP levels are associated with a single dominant gene known as the Rendement Napole (RN) gene (Naveau, 1986). Several studies have confirmed the presence of the RN gene in pig populations containing Hampshire ancestry in Sweden (Lundström et al., 1996), France (Fernandez and Monin, 1994) and the United States (Sutton, 1997 and Miller, 1998).

Glycolytic Potential Determination

The major source of muscle carbohydrate is glycogen. Glycogen is a polymer of glucose units linked with α1-4 and α1-6 linkages formed around a “foundation” protein, P-glycogenin (Brooks et al., 1996). When energy is required, glycogen is hydrolyzed to glucose by the action of glycogen phosphorylase, which cleaves α1-4 bonds. Debranching enzyme is required to cleave α1-6 bonds. Collectively, the hydrolyzation of glycogen is referred to as glycolgenolysis. The glucose products that are produced by glycolgenolysis are metabolized via glycolysis. As a result of glucose metabolism, a net yield of ATP occurs supplying the body with an energy source. The end-product of this metabolism is lactic acid. In living tissue, lactic acid is shuttled to the liver and reconverted to pyruvic acid and used as an energy source. However, the production of lactic acid in postmortem muscle accounts for the pH decline.

The RN gene is associated with elevated initial glycogen levels. Monin and Sellier (1985) suggested the following equation to approximate the total metabolic compounds transformable to lactic acid present in the muscle at slaughter: glycolytic potential = 2[glycogen] + [glucose] + [glucose-6-phosphate] + [lactate]

Glycolytic potential (GP) is expressed in µmole lactate equivalent per gram of fresh tissue.

The procedure of Dalrymple and Hamm (1973) allows for the extraction of metabolic intermediates simultaneously. Perchloric acid is used to deproteinate the muscle samples and extract the metabolites of interest. Additionally, amylo-α-1, 4-α-1,6-glucosidase from Aspergillus Niger is used to breakdown the glycogen molecule to free glucose. The resulting perchloric acid extracts are used to quantify glycogen (as free glucose), glucose, glucose-6-phosphate (G-6-P) and lactate (salt form of lactic acid).

Determination of the concentration of glycogen, glucose, and glucose-6-phosphate can be achieved using the methods of Keppler and Decker (1972). The first step used hexokinase to catalyze the phosphorylation of glucose (and hydrolyzed glycogen as glucose) to G-6-P. The G-6-P formed (and initially present) is oxidized to 6-phosphogluconate in the presence of nicotinamide adenine dinucleotide (NAD). This reaction is catalyzed by glucose-6-phosphate dehydrogenase. During this oxidation, an
equimolar amount of NAD is reduced to NADH. The consequent increase in absorbance at 340 nm is directly proportional to the concentration of the metabolites and G-6-P can be estimated.

Lactate concentration is estimated by the addition of excess NAD to force the reaction to completion (Bergmeyer, 1974). The increased absorbance at 340 nm due to NADH formation is used to estimate a measure of the lactate present.

Identification and Classification of RN- Genotypes

At the present, the RN gene cannot be identified directly, because there is no DNA-based test. The lack of a DNA-based test requires that animal’s genotype be predicted by glycolytic potential. After the glycolytic potential of each animal of a population has been determined, a frequency distribution is created. This bimodal distribution, reported by several authors (Naveau, 1986; LeRoy et al., 1990; Fernandez et al., 1992), is the indication that the dominant allele of RN gene (RN-) is segregating within the population. Animals in the upper distribution having the higher glycolytic potential are classified as homozygous RN-RN- or heterozygous RN- rn+. It is not possible to distinguish between the homozygous dominant and the heterozygote at this time which is one of the weaknesses of this classification procedure. The animals located in the lower distribution are classified as homozygous normal (rn+rn+). The threshold values for glycolytic potential used to distinguish between homozygous normal (rn+rn+) and homozygous negative (RN-RN-) and heterozygotes (RN-rn+) depends on the population studied and sampling method used. A summary of threshold values reported in the literature is presented in Table 1.

Sampling Methods

Spring loaded biopsy

The determination of glycolytic potential phenotype for genotype classification requires a muscle sample. The muscle sample can be taken either from the live animal or post-mortem. Sampling live animals requires biopsy equipment which has been developed to ensure adequate sample retrieval without causing any injury to the animal. Initial techniques for skeletal muscle biopsy were reported by Schmidt et al. (1971) and Sybesma et al. (1972). The idea behind these techniques was to evaluate the meat quality in the live animal. The technique involved the use of “koffler tongs” which allowed for a sample to be removed from the live animal; however, the use of local anesthesia was required. Schoberlein (1976) and Lahucky et al. (1980) further improved the biopsy technique to limit injury and eliminate the need for local anesthesia. Several studies have utilized the live animal biopsy technique to evaluate correlations between muscle metabolites and pig muscle quality (Hennebach et al., 1980; Hennebach et al., 1982; Lahucky et al., 1982; Kovac et al., 1985; Lahucky 1987). Talment et al. (1989) initiated the use of the biopsy to determine glycolytic potential by taking a sample from the longissimus muscle. Spring loaded biopsy equipment has been used to obtain a sample of muscle from the live animal with the assumption being that this approach will provide a sample of resting muscle (Fernandez et al., 1992). However, the time required obtain the sample and freeze it in liquid nitrogen may result in limited degradation of muscle glycogen. Fernandez et al. (1992) reported the lactate content in a biopsy sample was $5\pm3 \mu$mol g$^{-1}$, which indicates low levels of glycogenolysis are occurring during the sampling procedure.

Post-mortem sampling

Several authors have used longissimus samples taken post-mortem for glycolytic potential determination (Estrade et al., 1993; Lundström et al., 1996; Enfalt et al., 1997; Sutton, 1997). This method avoids the live animal sampling and carcass depreciation. However, sampling post-mortem is unlikely to produce actual resting muscle gly-
cogen level. This makes the pre-slaughter handling tech-
nique very crucial to metabolite levels within the muscles
which will affect the accuracy of the assay results. Several
environmental factors could affect the muscle glycogen
level of a given animal, such as loading at the farm, fight-
ing in transport, crowding in transport, unloading handling
procedure, fighting in lairage, and time of rest prior to
slaughter. It is important when sampling a population that
the environmental factors discussed above must be con-
sistent across all pigs. All of these factors should be closely
monitored and controlled if accurate results are to be ob-
tained; otherwise, phenotype mis-classifications are likely
to occur, particularly in the case of animals with high gly-
colytic potential.

Other methods
Lundström and Enfalt (1997) have proposed a new,
quicker method to identify RN- animals. Meat juice from
slightly thawed longissimus samples were collected from
a chop and a small sample of 5 µl of this juice was ana-
lyzed using a device used for checking the blood glucose
in diabetes patients (Glucometer Elite, Bayer Diagnostics).
This blood glucose analyzer determines free glucose con-
centration within the sample very rapidly, with results be-
ing available within 60 seconds. After classifying the
samples by way of the complete enzymatic glycolytic po-
tential determination, it was reported that only 4 of 53
samples had been misclassified by the glucose test from
meat juice (Lundström and Enfalt, 1997). These results sug-
gest that this method could be a very rapid, inexpensive
method for phenotyping of animals within a population in
which the RN gene is segregating.

The Occurrence and Frequency of the Rendement
Napole Gene

To date the RN gene has only been reported in pure-
bred and crossbred Hampshires or composite lines with
Hampshire inclusion. Several authors have used glycolytic
potential as a predictor of the presence of the RN- allele
within Hampshire lines or Hampshire crossbred popula-
tions (Monin & Sellier, 1985; Naveau, 1986; Fernandez et
al., 1992; Estrade et al., 1993; Sutton, 1997 and Miller,
1998). However, only a few have attempted to locate pigs
with high glycolytic potential within other breeds. Enfalt et
al. (1994) sampled Hampshire (n = 126) and Yorkshire (n =
100) entire males and females and reported a bimodal dis-
tribution of glycolytic potential and Napole Yield within
the Hampshires which is similar to other findings
(Fernandez et al., 1992). The glycolytic potential of York-
shires was normally distributed which was in agreement
with Talment et al. (1989). In comparison with Yorkshires,
Hampshires had lower ultimate pH, water-holding capac-
ity, Napole Yield, and greater cooking loss, glycolytic po-
tential, and reflectance scores (Monin and Sellier, 1985;
Enfalt et al., 1994). Comparisons between Hampshires and
Yorkshires (Enfalt et al., 1994), Hampshires, Large Whites
and Pietrains (Monin and Sellier, 1985), and Hampshires,
Yorkshires and Swedish Landraces (Essen-Gustavsson and
Fjelkner-Modig, 1985) all yielded higher glycolytic poten-
tial in the Hampshire populations with values being ap-
proximately 70-80 µmol/g greater in the Hampshires. Miller
(1998) reported a difference of 92.5 µmol/g when compar-
ing a population of American RN- Hampshires (homozy-
gous RN- RN- and heterozygous RN- rn+) to American York-
shires. Yorkshires also had a lower drip loss (4.58% vs
5.87%) and lower cooking loss (22.7% vs 25.5%) than the
homozygous and heterozygous Hampshires. The homozy-
gous and heterozygous Hampshires had a lower ultimate
pH (.13) and 1.5% lower protein content than Yorkshires
which is consistent with the literature.

Limited gene frequency estimates are available. Lundström, cited by Fernandez and Monin (1994), reported
a frequency of .5 within a Hampshire population in Swed-
en, while Enfalt et al. (1994) estimated the frequency at
.72 from a population of Swedish Hampshires and Miller

Table 2. Effects of the RN gene or breed on meat quality traits.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Comparisons</th>
<th>pH*</th>
<th>Drip Loss, %</th>
<th>EELb</th>
<th>WHCc</th>
<th>FOPd</th>
<th>Napole Yield, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller, 1998</td>
<td>RNrn- RNrn-</td>
<td>-.15</td>
<td>2.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Miller, 1998</td>
<td>RNrn- RNrn-</td>
<td>-.13***</td>
<td>1.29**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enfalt et al., 1997</td>
<td>RNrn- RNrn-</td>
<td></td>
<td>1.6*</td>
<td></td>
<td></td>
<td></td>
<td>-4.7***</td>
</tr>
<tr>
<td>Sutton, 1997</td>
<td>RNrn- RNrn-</td>
<td>-.12***</td>
<td>2.22***</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Lundström et al., 1996</td>
<td>RNrn- RNrn-</td>
<td></td>
<td>1.4***</td>
<td></td>
<td></td>
<td></td>
<td>-6.5***</td>
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<td>LeRoy et al., 1996</td>
<td>RNrn- RNrn-</td>
<td></td>
<td>3.4***</td>
<td></td>
<td></td>
<td></td>
<td>-7.9***</td>
</tr>
<tr>
<td>Enfalt et al., 1994</td>
<td>RNrn- RNrn-</td>
<td></td>
<td>-2.8*</td>
<td></td>
<td></td>
<td></td>
<td>-5.9***</td>
</tr>
<tr>
<td>Monin and Sellier, 1985</td>
<td>RNrn- RNrn-</td>
<td></td>
<td>1.9***</td>
<td></td>
<td></td>
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</table>

* ultimate pH of the longissimus
b reflectance
c water-holding capacity, %
d fiber optic probe
Meat quality and eating quality

A summary of published results on the effects of the RN gene on meat quality traits is presented in Table 2. Meat quality effects of the RN gene were first characterized by Sayre et al. (1963) and later by Monin and Sellier (1985). These earlier findings were more recently validated by the National Pork Producers Council Terminal Line Program Results (1994), which showed that the Hampshire had the lowest ultimate pH when compared to a range of other sire lines and breeds commonly used in the United States pork industry. Several authors have subsequently characterized the meat quality effects of the Hampshire and attributed them to a single gene, which is commonly called the Rendement Napole gene. Longissimus ultimate pH was found to be lower for RN heterozygotes and RN homozygotes by Enfalt et al. (1994), LeRoy et al. (1996), Lundström et al. (1996), Sutton (1997), and Miller (1998). The pH in RN animals declines at a normal rate, but continues to decline to low ultimate values generally below 5.4. The literature estimate of ultimate pH differences between RN- and rn+ ranges from -1.2 (Lundström et al., 1996) to -2.2 (LeRoy et al., 1996). Only one comparison has been made comparing the RN homozygotes and rn+ homozygotes, where the difference in ultimate pH was -0.2 (LeRoy et al., 1996). Lundström et al. (1996) analyzed the relationship between glycolytic potential and longissimus pH and reported a correlation coefficient of .86. When ultimate pH was included in their statistical model as a covariate they observed no differences in drip loss and cooking loss between RN- and rn+. Results from these studies suggest that the RN gene effects on drip loss and cooking loss are a secondary response mediated by ultimate pH. Miller (1998) reported a correlation of .5 in a population of only 72 animals indicating a moderate to strong relationship between GP and longissimus pH.

Drip loss has been characterized in numerous studies (Enfalt et al., 1993; Lundström et al., 1996; Sutton, 1997; Enfalt et al., 1997; Miller, 1998). High drip loss or low water-holding capacity is hypothesized to be the result of the low ultimate pH of RN animals. The pH is approaching the isoelectric point of muscle. Once the ultimate pH reaches the isoelectric point, the water-holding capacity is reduced dramatically. Increases in drip losses for RN animals ranging from .6 (Enfalt et al., 1997) to 2.53 (Sutton, 1997) percentage units higher when compared to rn+ animals have been reported. Other studies have also reported higher drip losses when comparing carriers with normal animals (Lundström et al., 1996) and Hampshires in comparison to Yorkshires (Enfalt et al., 1994). Another factor that may contribute to the decreased water-holding capacity of the meat is the reduction of total protein in RN muscle, which has been shown by several researchers (Estrade et al., 1993; Lundström et al., 1996; Miller, 1998). Estrade et al. (1993) showed a decrease of 5-7% protein within the white fibers of the muscle when comparing RN animals to rn+ animals; however, Lundström et al. (1996) evaluated the water-holding capacity on an equal protein basis and still observed differences in water-holding capacity, suggesting other factors are contributing to the lowered water binding characteristics in the longissimus. Reduced water-holding capacity may be attributed to two effects 1) the low ultimate pH and 2) increased glycogen content and the associated reduction in protein content. Water in muscle is bound to both glycogen and protein (2-4 g of water/1 g of glycogen or protein) and more water is likely to be bound to glycogen in RN animals due to their elevated levels. Glycogen, in turn is more likely to be hydrolyzed post-mortem thus decreasing the water-holding capacity of the meat from RN animals.

The color of muscle from Hampshires and RN animals has been characterized. Sayre (1963) and Monin and Sellier (1985) observed higher reflectance and fiber optic probe values for Hampshires compared to Yorkshires indicating paler meat. Other studies have observed similar results with higher reflectance values for RN carriers compared to rn+ homozygotes (Enfalt et al., 1994; LeRoy et al., 1996; Lundström et al., 1996). LeRoy et al. (1996) compared the two homozygotes and reported higher reflectance values for RN homozygotes. However, in contrast Enfalt et al. (1997) showed no differences between the RN heterozygotes and rn+ homozygote genotypes. Enfalt et al. (1994) and Lundström et al. (1996) both reported higher fiber optic probe values when comparing RN animals to rn+ animals. Miller (1998) reported higher Hunter L* value for pigs with GP>220 umol/g compared to pigs with a GP<180 umol/g (54.1 vs 51.6; respectively).

The Napole Yield technique was first described by Naveau (1986) as a laboratory procedure to estimate the yield of Paris style of processing hams. The technique has been used as a means of moisture retention. In several studies, Napole yields were lowered from RN carrier animals compared to normal genotypes (LeRoy et al., 1996; Lundström et al., 1996; Sutton, 1997; Enfalt et al., 1997) and also between purebred Hampshires and Yorkshires (Enfalt et al., 1994). These difference appears to be rather consistent across populations (Table 2) and Napole Yield has been used to classify animals for RN genotypes.

A summary of the literature relating to the effects of the RN gene on eating quality traits is presented in Table 3. Although meat quality attributes from RN animals are below average in terms of low ultimate pH values, water-holding capacity, and reflectance values, some studies have observed advantages in eating quality for this genotype. Reduction in Warner-Brazier for RN heterozygotes shear force indicating more tender meat for this genotype have been observed (Lundström et al., 1996; Sutton, 1997; Miller, 1998). However, LeRoy et al. (1996) did not observe a difference in tenderness between RN- and rn+ muscle when evaluated with a sensory panel. Enfalt et al. (1994) showed shear force advantages for purebred Hampshires compared
Similar results were reported by the National Pork Producers Council in their Terminal Sire Evaluation, (1994), where Hampshire's were shown to have lower shear force values and have more tender and juicy meat after cooking than a variety of genotypes. Lundström et al. (1996) compared 159 progeny of Hampshire sires with known RN gene status and evaluated differences in shear force and sensory parameters and showed a stronger taste and smell and a more acid flavor for animals which carry the RN- allele. The difference in shear force values between the RN- and rn+ pigs were relatively small (5%). However, no statistical difference in tenderness was observed in the sensory results, but a numerical trend similar to other data existed with improved tenderness values for animals with the RN- allele. Lundström et al. (1996) went on to hypothesize that any tenderness advantage may be related to the larger amount of sarcoplasm around the myofibril in RN- animals due to the higher glycogen content, which may dilute the effect of toughness caused by myofibrillar protein. Sutton (1997) evaluated 106 pigs from two commercial lines of pigs. The pigs were classified as the RN- or homozygous normal (rn+) using glycolytic potential determination. RN- longissimus chops had 12% lower shear force values than homozygous normal animals. Miller (1998) reported RN- animals had 13.4% higher tenderness scores. A negative trait associated with the RN animals is increased acidity of the meat which was detected by the sensory panel (Lundström et al., 1996; and Sutton, 1997).

A summary of the literature relating the effects of the RN gene on growth and carcass characteristics is presented in Table 4. There have been a limited number of studies conducted in this area. LeRoy et al. (1996) were the first to characterize the effects by comparing the three possible genotypes, namely heterozygotes, RN- homozygotes and rn+ homozygotes. The heterozygotes grew faster than rn+ animals and RN- homozygotes also grew faster than rn+ homozygote animals. Enfalt et al. (1997) also compared RN- heterozygotes to rn+ animals and reported average daily gain advantages of +26 g/day. These results from these studies suggest a small advantages in average daily gain (ranging from 10 to 50 g per day). Miller (1998) reported numerical advantages in growth (36 g/day) and carcass (1.9 mm less back fat) for animals with high glycolytic potential; however, they were not statistically significant.

Along with possible growth advantages, there is evidence of decreased backfat depths, and increased carcass lean percentage for RN homozygotes and heterozygotes compared to rn+ homozygotes; however, the differences are relatively small (Table 4). LeRoy et al. (1996) compared both RN- homozygote and heterozygotes to rn+ animals and reported decreased backfat depths of 1.3 mm, when comparing the heterozygote to normal animals with an increase in carcass lean of 1%. The difference between RN- homozygotes and rn+ homozygotes was -2.1 mm for back fat and +.9% carcass lean percent. Enfalt et al. (1997) also reported a trend for decreased backfat (1.2 mm) and increased carcass lean percentage (1.0%) for RN homozygotes and heterozygotes compared to rn+ homozygotes. These numbers appear to be consistent to those reported by LeRoy et al. (1996). Gain:feed ratio, which is very important to the economics of production, was evaluated by Miller (1998). He reported a small numerical advantage in gain: feed ratios for pigs with high GP compared to low glycolytic potential pigs.

**Table 3. Effects of the RN gene and breed on eating quality traits.**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Comparisons</th>
<th>Cooking Loss, %</th>
<th>Shear Force, kg</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavor</th>
<th>Acidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller, 1998</td>
<td>(RN —) m’- m’</td>
<td>1.57</td>
<td>-17*</td>
<td>1.4*</td>
<td>.66*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miller, 1998</td>
<td>RN m’- m’- m’</td>
<td>4.30***</td>
<td>-14</td>
<td>-1.4**</td>
<td>-1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miller, 1998</td>
<td>(RN —) Hamp- York</td>
<td>2.8***</td>
<td>-17</td>
<td>-1.7**</td>
<td>-1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sutton, 1997</td>
<td>RN m’- m’- m’</td>
<td>3.53***</td>
<td>-2.7**</td>
<td>-2.7**</td>
<td>-2.7**</td>
<td></td>
<td></td>
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<tr>
<td>Lundström et al., 1996</td>
<td>RN m’- m’- m’</td>
<td>3.0*</td>
<td>-2*</td>
<td>-2*</td>
<td>-2*</td>
<td></td>
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<tr>
<td>LeRoy et al., 1996</td>
<td>RN m’- m’- m’</td>
<td>.10***</td>
<td>—</td>
<td>-1.27***</td>
<td>-1.27***</td>
<td>-1.27</td>
<td>—</td>
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<tr>
<td></td>
<td>RN RN- m’- m’</td>
<td>.09***</td>
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<td>Enfalt et al., 1994</td>
<td>Hamp - York</td>
<td>2.8***</td>
<td>-3**</td>
<td>—</td>
<td>—</td>
<td>-3**</td>
<td>—</td>
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<tr>
<td>Monin and Sellier, 1985</td>
<td>Hamp - York</td>
<td>2.1*</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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</tbody>
</table>

* P < .05, ** P < .01, *** P < .001, respectively

0 or tender, juicy, no off-flavor, non acidic — 10 or tough, dry, off flavor, acidic

To Yorkshires. Similar results were reported by the National Pork Producers Council in their Terminal Sire Evaluation, (1994), where Hampshire’s were shown to have lower shear force values and have more tender and juicy meat after cooking than a variety of genotypes.
Table 4. Effects of the RN gene or breed on growth and carcass traits.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Comparisons</th>
<th>ADG, g</th>
<th>Slaughter Yield, %</th>
<th>Carcass Length, cm</th>
<th>Backfat Depth, mm</th>
<th>Loin Eye Area, cm²</th>
<th>Carcass Lean, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller, 1998</td>
<td>RNrn⁻⁻rn⁻⁻</td>
<td>36.0</td>
<td>.2</td>
<td>-1.0</td>
<td>-1.9</td>
<td>1.6</td>
<td>—</td>
</tr>
<tr>
<td>Enfalt et al., 1997</td>
<td>RNrn⁻⁻rn⁻⁻</td>
<td>26.0 **</td>
<td>-.2</td>
<td>1</td>
<td>-1.2</td>
<td>—</td>
<td>1.0</td>
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<tr>
<td>LeRoy et al., 1996</td>
<td>RNrn⁻⁻rn⁺</td>
<td>50.0 *</td>
<td>—</td>
<td>.16</td>
<td>-1.3 *</td>
<td>3.3</td>
<td>1.0</td>
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<td></td>
<td>RNrn⁻⁻rn⁻⁻</td>
<td>10.0 *</td>
<td>—</td>
<td>.20</td>
<td>-2.1 *</td>
<td>2.9</td>
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*, **, *** P < .05, P < .01, P < .001, respectively

Summary

The RN gene can be detected within a population by determining the glycolytic potential of the pigs. The pigs can be sampled by either live animal biopsy or post-mortem muscle samples. Glycolytic potential is plotted into a frequency distribution to determine if the RN gene is segregating. If the RN gene is segregating within the population sampled a bimodal distribution is observed. The breakpoint between the two distributions is used as the threshold value to determine the predicted genotype of the individual pigs. A number of studies have investigated meat and eating quality effects of the gene. Decreased ultimate pH, water-holding capacity of the meat and color scores have been reported by several authors, while some data has indicated tenderness advantages. On-farm performance of the animals is limited; however, a small advantage for RN⁻ ani-

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