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Pork Quality: pH Decline and Pork Quality

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Pork Quality: pH Decline and Pork Quality

Abstract
The properties of fresh and processed pork are dependent on factors related to composition of the product such as moisture, lipid and protein content. It is important to recognize, however, that it is not just the amount of these components, but rather the characteristics of protein, lipid and water that are responsible for differences in pork color, texture, water holding capacity and tenderness. In many cases, it is the proteins in pork that are primarily important in the variations that are observed in these traits. The state and nature of proteins are primarily responsible for pork color, pork texture, pork tenderness and water holding capacity.

Disciplines
Agriculture | Animal Sciences | Meat Science

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factsheet

Pork Information Gateway

Pork Quality: pH Decline and Pork Quality

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Introduction

The properties of fresh and processed pork are dependent on factors related to composition of the product such as moisture, lipid and protein content. It is important to recognize, however, that it is not just the amount of these components, but rather the characteristics of protein, lipid and water that are responsible for differences in pork color, texture, water holding capacity and tenderness. In many cases, it is the proteins in pork that are primarily important in the variations that are observed in these traits. The state and nature of proteins are primarily responsible for pork color, pork texture, pork tenderness and water holding capacity.

One of the major factors that influences protein behavior in fresh and processed pork is the pH of the product. pH is defined as the negative log of the hydrogen ion concentration. As the hydrogen ion concentration increases due to the dissociation of lactic acid in pork, the pH declines. Simply put, the pH is essentially the relative acidity. Pure water has a pH of 7.0 (or is neutral), the pH of lemon juice is approximately 2-3 and the pH of milk is approximately 6.8. pH can directly affect the solubility of protein, the function of a protein, and the ability of a protein to bind water. As a general rule, low pH has a detrimental effect on these characteristics.

Figure 1. Variations in pH decline in early postmortem muscle.

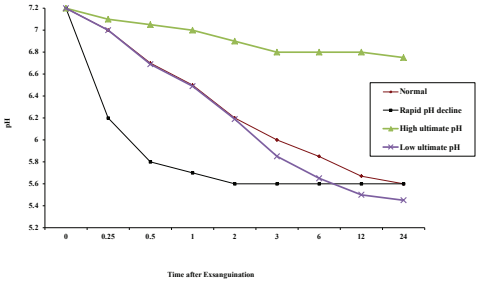
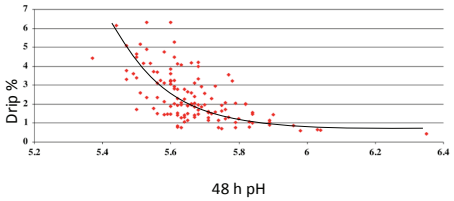


Figure 2. pH influences drip loss in pork loin chops



Wagner, C. E. Influence of selection for improved growth rate on fresh pork quality. M. S. Thesis, Iowa State University

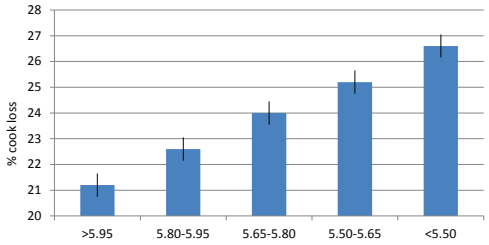
What is the reason for differences in pH?

Metabolism of muscle glycogen (a complex carbohydrate) plays the primary role in the conversion of muscle to meat and the expression of different quality attributes of fresh pork. After exsanguination, muscle no longer receives two very important components for normal metabolism: energy and oxygen. This means that the carbohydrate energy stored as glycogen is the only available source of energy for the early postmortem muscle to utilize. Because oxygen is no longer available to the muscle, the by-product of glycogen breakdown is lactic acid. A normal pH decline curve is noted in figure 1. The extent of pH decline is primarily affected by the amount of glycogen in muscle at the time of slaughter. The amount of glycogen present in the muscle at slaughter is directly proportional to the potential amount of lactic acid. Therefore, the more glycogen present in the muscle, the greater the potential for lower ultimate pH.

In addition to the extent of pH decline, the rate of pH decline in early postmortem muscle is a very important determining factor of fresh pork quality. If metabolism of glycogen is rapid, then the production of lactic acid, and the subsequent pH decline, is rapid.

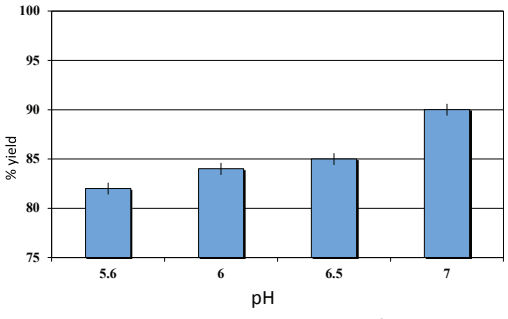
Factors that affect postmortem glycolysis (postmortem metabolism of glycogen) are varied: 1) genetic predisposition (porcine stress syndrome; mutation in the Ryanodine receptor gene (recently reviewed by Barbut et al., 2007); 2) elevated metabolism prior to slaughter (Rosenvold & Andersen, 2003); 3) postmortem carcass chilling (Tomovic´ et al., 2008) and (or) 4) combinations of all of these.

Figure 3. Cook loss (%) in pH categories



Lonergan et al. 2007. Influence of lipid content on pork sensory quality within pH classification J. Anim. Sci. 85:1074

Figure 4. Effect of pH on yield of 2.8 % myofibrillar protein gels after 1000 x g centrifugation



Westphalen et al., 2005, Meat Science., 70:293-299

When pH decline is normal (Figure 1), we expect a good quality pork product. When the pH decline is rapid (Figure 1), there is a great chance that a combination of high temperatures and low pH can result in conditions that denature proteins. These proteins are responsible for binding, water, influencing texture, and imparting color. The result is a pale color, soft texture, and poor water holding capacity. This product is often referred to as Pale, Soft, and Exudative (PSE). If the rate of pH decline is normal, but extends to a lower than normal ultimate pH (Figure 1), the result is poor water holding capacity. This occurs most often when muscle stores of glycogen are high. Finally a slow pH decline with a high ultimate pH (above 6.5; Figure 1) can be a problem for consistency in color and texture. This product is often has a very dark color.

How does pH affect pork quality?

1. How does pH affect meat color?

When pH declines rapidly (Figure 1) before the muscle has been significantly cooled, a partial denaturation of sarcoplasmic (water soluble proteins in muscle and meat) occurs. Of primary importance is denaturation of the pigment protein myoglobin. Denaturation of myoglobin will lessen the color intensity of the meat. Under extreme conditions, denaturation of the myofibrillar proteins alters the color by allowing those structures to reflect more light. It is also clear that low ultimate pH causes lighter color (Huff-Lonergan et al., 2002, Smith et al., 2011).

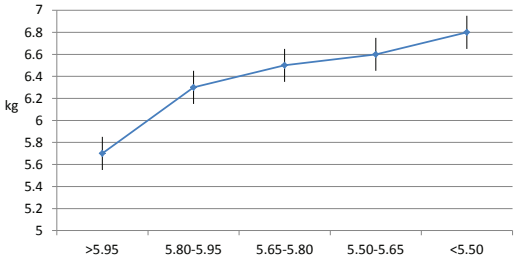
2. How does pH affect meat firmness?

Conditions that affect the structural integrity of postmortem muscle will ultimately affect overall meat quality and functionality. Actin and myosin are the major contractile proteins associated with formation of meat's protein lattice. Myosin binds to actin during muscle contraction and ultimately forms a permanent rigor bond in meat in post mortem conditions. Conditions that can denature proteins (low pH, high temperature) can denature myosin and result in soft textured fresh pork. Low ultimate pH also results in soft texture (Huff-Lonergan et al., 2002). This is because the myofibrillar proteins are less functional at lower pH.

3. How does pH affect water holding capacity?

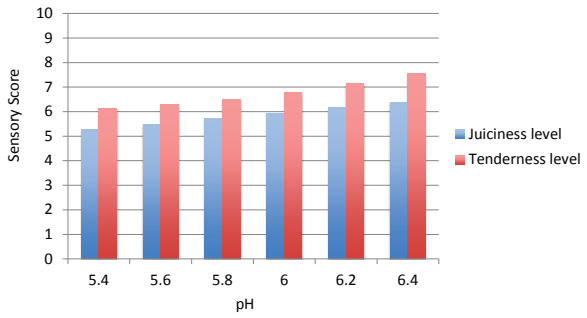
Proteins are responsible for water binding in pork. Specifically it is the myofibrilar proteins - actin and myosin - that bind water and are influenced by pH. A rapid pH decline generally creates the aforementioned combination of low pH and high temperature. This condition denatures myosin and because denatured myosin is less functional, there is less protein available to bind water.

Figure 5. Star probe values are affected by pH



Lonergan et al. 2007. Influence of lipid content on pork sensory quality within pH classification J. Anim. Sci. 85:1074

Figure 6. Sensory juiciness and tenderness levels are affected by pH classification



Moeller et al. 2010. Meat Science. 85:96

The extent of pH decline also affects water holding capacity. Water is a dipolar molecule that is most likely to bind to proteins that have a net charge. Meat proteins have no net charge at pH 5.1. This point is referred to as the isoelectric point. As the pH of meat approaches that low pH of 5.1, the water holding capacity drops drastically. Low pH predicts greater drip loss in fresh pork chops (Figure 2), greater cooking losses in fresh pork chops (Figure 3), and less water holding capacity.

It is well known that the water holding capacity of myofibrillar proteins can be increased with the addition of salt. Salts solubilize myofibrillar proteins by changing their conformation which exposes more hydrophilic binding sites. This increases the ability of these proteins to bind water. However, ability of these proteins to bind water is still affected by pH (Figure 4).

4. How does pH affect sensory quality?

Since the extent of pH decline has an impact on fresh (uncooked) pork firmness and on water holding capacity, it stands to reason that it will impact sensory tenderness. It is clear that higher pH values predict more tender pork and more juicy pork (Figure 5). This is confirmed in other studies that have used mechanical methods like star probe values (higher star probe values = less tender) to evaluate tenderness of fresh pork (Figure 6).

Summary

Proteins are responsible for many of the functional and quality characteristics of fresh and processed pork. Because proteins are influenced by the rate and extent of pH decline in pork, it stands to reason that pH can have a profound affect on fresh and processed meat quality.

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