Effects of Enhancement of Pork and Beef on Post-Mortem Events

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Introduction

In the meat industry, there is a continual effort to improve the quality of product to meet consumer expectations. There are numerous factors that can contribute to the ultimate outcome of the final meat product. Ante-mortem factors such as genetics, nutrition, and management practices can all have an effect on meat quality. Examples of post-mortem processes that can influence final meat quality include the use of electrical stimulation and accelerated chilling. One such method of post-mortem processing is enhancement. Since the early 1980's (Smith *et al.*, 1984) the enhancement of meat has become a more common practice to create a meat product that is more tender and juicy to the consumer.

Ante- and Post-Mortem Events

Living tissue can gain energy through aerobic or anaerobic metabolism. Under aerobic conditions, glycolysis facilitates the break down of glycogen into pyruvate. In the presence of oxygen, pyruvate ultimately enters the citric acid cycle with the net release of 32-36 ATP molecules for energy. Under anaerobic conditions, glycogen is again broken down to form pyruvate. However, without the presence of oxygen, pyruvate is ultimately converted into lactic acid, lowering the pH of the tissue. In living organisms, the circulatory system removes the lactic acid from the tissue and transports it to the liver. Through gluconeogenesis, lactic acid is metabolized back into glucose via the Cori Cycle.

In the conditions found early post-mortem, the exsanguation process does not allow for the continued function of the circulatory system. This not only necessitates anaerobic metabolism in the muscle, but also impedes the removal of the end products of glycolysis. Therefore, subsequent accumulation of lactic acid will cause a decrease in the pH of the muscle from an ante-mortem pH of 7.0 to an ultimate pH of approximately 5.5. The rate of pH decline in conjunction with temperature at which this occurs, will significantly influence the quality of the meat product.

Enhancement

Enhancement of meat involves the addition of a non-meat product to improve the overall sensory aspects of the final meat product. Improved quality is typically indicated by increased juiciness, tenderness, flavor, improved color, or increased shelf stability. Through enhancement, the processor is able to capture more value in the product while simultaneously ensuring an acceptable dining experience for the consumer. This characteristic is preserved even in meat cooked to a higher degree of doneness. While there are many ingredients that can be added to an enhancement solution, solutions commonly contain salt and phosphate.

Salt or Sodium Chloride

The addition of salt has been used for many years for the preservation of meat and to enhance flavor. When added to an enhancement solution (typically at levels less then .5% in the final product), salt has the ability to improve the water holding capacity (WHC). This will result in decreased purge, less cook loss, and a juicer product. Sodium chloride functions to open the protein matrix, allowing for an increase in the number of side chains available to bind to water, thus increasing the WHC.

Phosphates

Phosphates can be added to an enhancement solution (at a maximum of 0.5% in the final product) to increase the sensory attributes of a meat product. A mixture of alkaline phosphates is most commonly used in an enhancement solution, with the major component in these mixtures being sodium tripolyphosphate.

Sodium tripolyphosphate improves sensory attributes of the meat product by increasing the pH. As the pH of the meat increases, it moves further away from the isoelectric point of the proteins. As proteins move further away from the isoelectric point, they become more negatively charged causing increased water binding and opening of the protein matrix, resulting in increased WHC and juiciness.

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Late Ante-Mortem and/or Early Post-Mortem Manipulation

While the enhancement of a meat product offers many benefits, especially for improved sensory characteristics, the ability to make a safer product, and extended shelf life, it does have its limitations. Enhancement, as it is commonly practiced today, must start with a high quality product with minimal protein damage and denaturation. Low quality raw materials can only be minimally improved through the enhancement process.

However, there are some unique opportunities that can be utilized during the late ante-mortem and/or early post-mortem period to regulate the temperature and rate of pH decline. By manipulating these factors, it may be possible to improve protein functionality, which would lead to increased WHC and improved meat quality.

The time immediately preceding harvest plays a direct role in the development of meat quality. For this reason, late ante-mortem events are important in determining the final attributes of the product. The administration of chemical inhibitors of glycolysis or the physical reduction in body temperature, present unique opportunities to improve quality.

In early post-mortem beef muscle, the use of a glycolytic inhibitors has been explored (Jerez *et al.*, 2003). At 1 h post-mortem, different muscles from 10 beef carcasses were injected and tumbled with a 10% by wt. solution of Sodium Citrate (NaC), Sodium Fluoride (NaF), Sodium Acetate (NaA) or Calcium Chloride ($CaCl_2$). The use of NaC and NaF yielded the highest pH and glycogen content in the muscles by inhibiting glycolysis. Therefore, the use of NaC and NaF in early post-mortem muscle could be used to create a meat product with improved quality by slowing and/or limiting the rate of pH decline.

The use of normal brine components (salt and phosphate) have also been reported to create an improved product by early post-mortem administration (Murphy and Zerby, 2004). The use of solutions containing: salt and dextrose; salt and phosphate; salt, phosphate and dextrose, was shown to improve meat quality in lamb. These solutions, when injected early post-mortem, resulted in a higher ultimate pH when compared to the control sides. These treatments also lead to decreased cook loss and increased tenderness.

While the rate and extent of the pH decline influences the functionality of the muscle proteins, the internal temperature of the muscle also plays a role in determining the final quality of the meat. When early post-mortem pH is at low levels (<5.8) and the internal temperature of the carcass is still elevated (>38ºC), denaturation of myofibrillar and sarcoplasmic proteins will occur (Honikel and Kim, 1986). Therefore, in addition to controlling pH, if the internal temperature of the muscles can be reduced quickly, protein damage and denaturation could be minimized.

Through the use of accelerated chilling, internal temperatures in muscles can be decreased well below the critical limit (>38ºC) early post-mortem (within 2h). Work conducted at the University of Illinois demonstrated how the use of accelerated chilling techniques decreased the internal temperature in pork *longissimus* muscles more rapidly compared to the control sides. This accelerated chilling technique did not result in a change in the ultimate pH of the product, but slowed the rate of pH decline. The reduced rate of pH decline, in combination with the lower internal temperature, led to diminished protein damage and denaturation, as evident through improved quality.

Further research conducted at the University of Illinois combined the techniques of early post-mortem enhancement in combination with accelerated chilling. The results indicated that the use of an enhancement solution in combination with accelerated chilling improved the quality of pork *longissimus* muscle as revealed through improved color scores, decreased cook loss, and increased sensory characteristics. Using the early application of the enhancement solution and the accelerated chilling process, the internal temperature of the product was rapidly decreased, while slowing the rate of pH decline. Furthermore, the early post-mortem application of the enhancement solution inhibited glycolysis, as demonstrated by the higher ultimate pH when compared to the enhanced control section. A patent application has been filed covering procedures coupling rapid chilling, enhancement and inhibition of glycolysis as a means to improve product quality.

Conclusion

In conclusion, the enhancement of meat is a common practice in the meat industry today, used in order to provide a product that is more acceptable for the consumer. Yet, there are limitations to the current enhancement procedures in that raw materials must be of acceptable quality, because enhancement alone cannot improve a low quality product. However, with the application of normal brine (salt, phosphate, etc.) solutions, accelerated chilling techniques and inhibition of glycolysis during the late ante-mortem or early post-mortem period, there are some unique opportunities to improve protein functionality and improve meat quality. Further research into these areas and ways to incorporate these approaches into processing facilities should be explored.

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