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Variation of water holding capacity in meat due to change in pH with time

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Abstract

Water-holding capacity of fresh meat is an significant asset of fresh meat since it affects the superiority of the final produce. This distinguishing feature can be explained in many different ways, but in fresh foodstuffs that have not been comprehensively processed, it is often described as drip loss or purge. The method through which drip or purge vanishes from meat is predisposed by the pH of the tissue and specifically the myofibril that exists for water to reside. Eventually, specific features of the muscle in the live animal can have a major impact on the amount of moisture that is lost from the final meat products. In short, the complete arrangement of live animal production and handling via initial chilling

Introduction

Majority of water content in muscle is held within the structure of the muscle itself. Muscle holds approximately 75% water, the components include protein (approximately 20%), lipids or fat (approximately 5%), carbohydrates (approximately 1%) and vitamins and minerals (often analyzed as ash, approximately 1%).

One of the most common pork superiority issues is inappropriately high moisture loss commonly described as purge or drip loss in fresh and minimally processed products. Inappropriately high moisture loss from fresh product as purge or drip has been estimated to occur in as much as 50% of the pork produced (Kauffman *et al.*, 1992). Excess in purge consequences in economic losses in many ways including drop in salable product weight and the loss of customers who demand high value product with a least amount of purge. Water-holding capability of meat can also manipulate processing features. Meat with less water-holding capacity frequently tends to produce low-grade processed products.

In the early hours post-mortem biochemical and biophysical processes add to the development of water-holding capacity. This review will highlight the physical location of water in skeletal muscle with an importance on ways of moisture escape within the structure of muscle. In addition, the factors that influence water holding capacity of fresh meat will be reviewed.

Factors influencing drip

The genetics and the handling of the live animal can have a large role in manipulating the future water-holding capacity of that foodstuff. On the other hand, the way the product is handled (predominantly with reverence to cooling) as it enters rigor also has a critical role in changing the quantity of moisture that will be held in the product. All of these factors (genetics, live animal handling and early post-mortem temperature management) have the prospective to greatly influence the rate and degree of pH decline, and thus the water-holding capability of the meat.

Physical/biochemical factors affecting water-holding capacity

- **Net charge effect**

When the muscle is converted to meat, lactic acid increases resulting in lowering of pH. A stage at which pH reaches iso-electric point (pl), the net charge drops to zero this shows that the amount of positive and negative charges on the proteins are equal. These positive and negative groups within the protein are attracted towards each other and result in a reduction in the amount of water that can be attracted and held. Since, similar charges repel, repulsion of structures within the myofibril is reduced allowing those structures to come more closer (Offer, 1992).

- **Steric effect**

The organelles comprise as much as 82-87% of the volume of the muscle cell. Most part of water is governed by capillary forces originating from the system of the thick and thin filaments within the myofibril. This water can be affected by alterations in volume as muscle undergoes rigor, cross-bridges form between the thick and thin filaments, thus lowering available space for water to reside. This reduces the space accessible for water within the myofibril.

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All of the above conditions manipulate the amount of water in the myofibril. But, reduction of the myofibrillar lattice alone could not be held responsible for the movement of fluid to the extracellular space and ultimately out of the muscle. The myofibrils are connected to each other and to the cell membrane via proteinacious connections. These connections, if they are maintained intact in post-mortem muscle, could transfer the reduction in diameter of the myofibrils to the muscle cell (Kristensen and Purslow, 2001).

Therefore, reduction of size of the myofibrils could potentially control the capacity of the muscle cell itself (Offer and Knight, 1988). This water that is excluded from the myofibril and eventually the muscle cell sooner or later collects in the extracellular space. Several other studies have also shown that gaps widen between muscle cells and between muscle bundles during the post-rigor period (Offer and Cousins, 1992). These gaps between muscle bundles are the primary channels by which purge are allowed to flow from the meat; some investigators have actually termed them “drip channels”.

- **Rate of pH decline**

Low water-holding capacity and inappropriately high purge loss are frequently due to pH decline at an increased rate and low final pH. When the muscle is still warm causes the denaturation (loss of functionality) of major proteins, including those concerned in binding water. The most severe purge or drip loss is frequently found in PSE (Pale, Soft, and Exudative) product from pigs that are inborn with a mutation in the ryanodine receptor/calcium release channel (halothane gene) in the sarcoplasmic reticulum. This mutation results in mutilation of the ability of this channel to be in command of calcium release into the sarcoplasm of the muscle cell, principally under periods of bodily stress. Increased release of calcium causes rapid contraction and a boost in the rate of muscle metabolism and in the rate of pH decline. This mutation in the halothane gene can be recognized in parent stock. Because a commercial test for this mutation exists.

Other factors can cause PSE meat to occur. Before harvest, short-lived stress in normal animals can accelerate their metabolism to a sufficient amount that the postmortem metabolism in the muscle is accelerated, resulting in a more rapid pH decline than is seen in non-stressed animals. While the condition may not be as brutal as that resulted by the Halothane gene, drip losses can be more than in muscle that has a normal, slower rate of pH decline. It should be noted that while the pH of these muscles falls rapidly than normal, the final pH may not be below normal ranges.

- **Pre-rigor temperature**

The major reason rapid pH decline has such a detrimental effect on muscle proteins is because acidic pH values are reached while the muscle is still warm. It is the mixture of comparatively acidic conditions and near body temperatures that merge to denature protein and weaken its functionality. Quick lowering of the temperature of the carcass can eliminate some of the effects of lower pH. In addition, reducing the temperature of the meat lowers rate of metabolic processes and lowers the rate of pH decline. so, chilling meat as soon as possible after exsanguinations is one way to efficiently alter the rate of temperature and pH decline. By lowering the rate of pH decline, the harshness of the denaturation and subsequent loss of functionality of proteins is reduced and the water-holding capacity of the meat can be improved.

- **Final pH**

pH that is attained after the muscle is in rigor can manipulate the water-holding capacity of meat. Meat that has a very high final pH (i.e. > 6.3) tends to be dark in color and the surface of the meat appears comparatively dry. This dark, firm and dry product has a very high water-holding capacity. The product is also very firm textured and it can be difficult to discern the separations between bundles of muscle fibers visually. This product is formed when the animal undergoes long-term pre-harvest stress and was harvested before it could rest and restock these stores. This long-term stress results in depletion of glycogen in the muscle. Since glycogen is the substrate for lactate production in muscle, the less glycogen that is present at harvest, the less lactate is produced after harvest, and consequently the less the pH will decline in post-mortem muscle.

Explanation for this low pH can be the existence of a high level of glycogen in the muscle. An estimate of the amount of glycogen can be made by measuring the amount of glycogen and its major metabolites in muscle immediately prior to or soon after slaughter. The value that is obtained is known to as glycolytic potential (Monin and Sellier, 1985). An elevated glycolytic potential indicates that the muscle had a comparatively high amount of glycogen at slaughter and/or had a genetic abnormality that resulted in dysfunction of an enzyme passageway concerned in glucose metabolism.

- **Processing Factors**

In addition to live animal supervision and untimely postmortem handling of the meat, detailed factors that may be imposed on the product after the achievement of rigor can certainly impact water retention. Some of these factors consist of storage time, physical disruption of the product and storage conditions.

- **Time post-mortem**

In broad terms, very less drip loss occurs in pre-rigor meat. Yet, at later times after slaughter, after the muscle is in rigor, the drip losses tend to elevate (Jolley et al., 1980-81). As the muscle reaches rigor, the pH of the tissue nears the isoelectric point of many of the major proteins (especially myosin), thus influencing the amount of water that is attracted to protein structures in the myofibril. These two factors combined could deeply increase the amount of drip loss.

- **Storage Conditions**

Quite a lot of factors during storage can also manipulate the water-holding capacity of meat. One of these is the storage temperature. The significance of lowering the carcass temperature as quickly as possible has been emphasized. However, it is also important to regulate the temperature of fresh meat as low as possible (without freezing) to keep up water-holding capacity. For example, increasing the storage temperature from 0 to 4°C can cause a significant increase in drip loss (Sayre et al, 1964).

- **Freeze/Thaw**

Freezing and thawing of fresh meat can have a thoughtful impact on the amount of moisture that is lost as drip. Ice begins to form when meat approaches a temperature of approximately -1°C. At -5°C approximately 75% of the water in meat is ice. Maximum ice formation occurs at -20°C, at which point about 92% of the water in meat is ice. The remaining 8% is comparatively resistant to freezing at temperatures even as low as -35°C (Cooke and Wien, 1971). This fraction of water is thought to be the fraction that is closely linked or bound to the proteins in the tissue. The conversion of water to ice has a profound effect on the chemical features of the meat. At -15°C, it has been estimated that the concentration of solute in the liquid phase of the meat at that temperature is about 2M, several fold more concentrated than in fresh, non-frozen meat.

- **Water in cells of muscle**

Water being a charged molecule is attracted to charged species like proteins in some cases water is very closely bound to proteins. Bound water is water that is in the vicinity of non-aqueous constituents (like proteins) and has lowered mobility, i.e. does not easily move to other compartments. This water is very resistant to get freezed and to being driven off by conventional heating (Fennema, 1985). Another tiny proportion of water that can be found in muscles and in meat is termed entrapped (also referred to as immobilized) water (Fennema, 1985). This water is seized within the structure of the muscle but is not bound to protein. In early post-mortem tissue, this water does not run freely from the tissue, yet it can be removed by drying, and can be easily transformed to ice during freezing.

Free water has feeble surface forces. They mainly hold this fraction of water in meat. Free water is not readily seen in pre-rigor meat, but can develop as surroundings changes that allow the entrapped water to move from the structures. Factors that can manipulate the retention of entrapped water include exploitation of the net charge of myo-fibrill proteins and the structure of the muscle cell and its sub-parts (myofibrils, cytoskeletal linkages and membrane permeability).

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