Results for today; Ideas for tomorrow

Meat Technology Update

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The causes of drip in meat

Lean fresh meat has a water content of approximately 70%. One of the major challenges of meat processing is concerned with preventing loss of liquid from lean meat tissue during storage. When meat is cut, a red solution of proteins that is known as drip (or weep or purge) oozes from the cut surfaces. For primals, the volume of drip produced in the first 48 hours or so after boning is typically quoted to be about 1 to 10 mL per kg of meat (0.1 to 1%), while for steaks or chops; it can be 10 times greater.

In meat that is stored for extended periods (e.g. vacuum-packaged primals), the drip loss gradually increases with time. A 'normal' amount of drip in commercial vacuum packs of chilled primals is usually regarded to be 1 to 2%. Drip of more than 1% is unusual for the main seam-boned primals, but it could be up to 2% for pieces of meat that are subject to cutting and trimming to achieve a specification. The amount will be greater in smaller packs where the surface area is proportionately greater per unit weight. In some of the scientific investigations upon which information for this article is based, the pieces of meat were small (for instance eighths of striploins in one trial) to ensure that different treatment effects were tested with practical quantities of meat. For some of these trials, drip losses of 5 to 10% are quoted.

This article briefly discusses the mechanism of drip formation in meat tissue and its eventual accumulation at the surface. It also considers a number of factors that people have demonstrated or implicated as contributors to drip loss.

Mechanism of drip formation

Muscle consists of bundles of muscle fibres (75-92 % of muscle volume), connective tissues, blood vessels, nerve fibres, and extracellular fluid. The fibres are the structural units (Fig. 1). They may stretch from one end of a muscle to the other. Within each fibre, there are usually at least 1000 sub-units called myofibrils that extend the entire length of the fibre. Each myofibril is made up of sarcomeres. The sarcomere is the repeating structural unit of the myofibril. It is the basic unit in which events of the muscle's contraction-relaxation cycle occur. Sarcomere length is not constant in pre-rigor muscle. The dimensions are dependent upon the state of contraction at the time the muscle is examined. When a muscle is at rest, the typical length of a sarcomere is 2.5 microns. Sarcomeres contract or shorten as muscles enter rigor. They shorten little if the muscle enters rigor at 10-15°C. Increased shortening occurs both at lower temperatures (cold shortening) and at higher temperatures

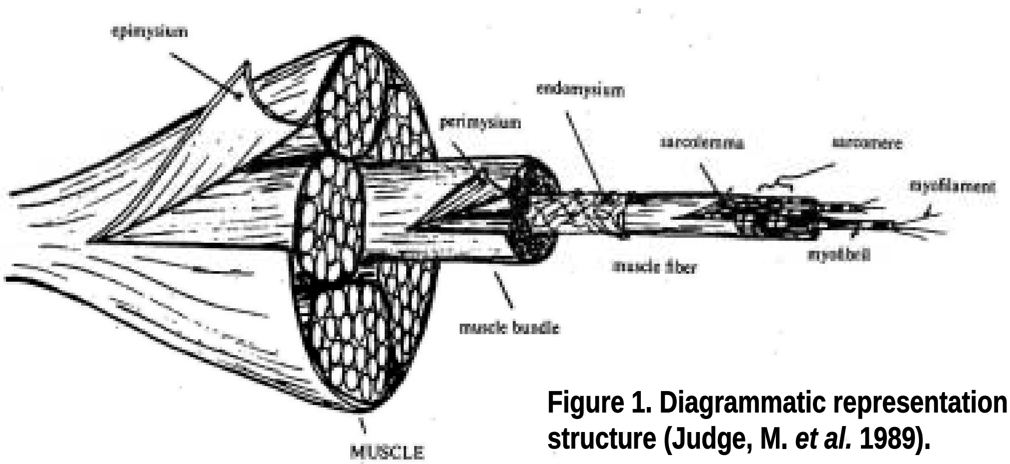

Figure 1. Diagrammatic representation of muscle structure (Judge, M. *et al.* 1989).

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(rigor, or heat shortening). Severely cold-shortened sarcomeres can be less than half their normal length.

Once an animal is slaughtered, oxygen supply to the muscles ceases. Thereafter, the main biochemical activity is the conversion of glycogen to lactic acid and other products – a process called glycolysis. Glycolysis will continue until a pH is reached (ultimate pH) where the enzymes that facilitate it become inactivated or the muscle glycogen is used up. As post-mortem glycolysis proceeds, the muscle loses the ability to extend and contract as it becomes set in rigor mortis.

In living muscle most of the volume of a muscle fibre is occupied by myofibrils. There is little space between them. The water and the associated protein are located within the myofibril. About 4 to 6 h post mortem the fibre bundles have shrunk away from one another leaving gaps. After 24 h there are also gaps between individual fibres. Post mortem then, myofibrils shrink laterally, and it is likely that the drip originates by being expelled from the sarcomeres, particularly shortened ones, as they shrink. The exudation of drip from the meat surfaces does not take place abruptly at the onset of rigor; rather it is a gradual process. It appears that the fluid expelled from the myofibrils at onset of rigor initially accumulates within the muscle, from where it gradually migrates to its exterior. Shortening of the myofibrils and fibres hastens this migration.

Pre-slaughter factors that affect drip

From the very few studies where it has been investigated as a factor in drip loss, diet does not seem to affect the eventual loss of drip from vacuum packs or retail packs. Animal age may be a factor, but the evidence is inconclusive however, with drip being higher in vacuum-packaged muscles of older cattle in one study; but lower in another study.

Acute stress prior to slaughter has been shown to increase drip loss and cooking loss in meat that has had no ageing. Moderate stress of cattle before slaughter is also believed to be a cause of drip, although there is no direct evidence of this. There is evidence that when glycogen levels in muscle are low, drip loss is higher - and low glycogen levels are often related to stress. Investigations in this area at the Cooperative Research Centre (CRC) for Cattle and Beef Quality are ongoing.

If animals are stressed to the point they produce high pH meat, drip loss could actually be reduced. The proteins in high pH meat have an increased ability to hold water and, while water may be expelled from sarcomeres, some of it can be bound to proteins. While high pH meat produces less drip, obviously this is not an acceptable option for reducing drip in vacuum packs.

Post slaughter factors

Electrical stimulation does not appear to affect drip loss provided the meat goes into rigor at the same temperature as non-stimulated meat.

If meat – electrically stimulated or not – goes into rigor at too high a temperature, drip loss can be increased. Biochemical changes and physical disruption in muscle that is in rigor is more pronounced if the temperature stays high for too long. A combination of low pH and high temperature can promote re-arrangement or denaturation of proteins. It is known that protein denaturation leads to greater drip loss and pale meat. Rigor shortening, or heat shortening, can occur when meat enters rigor at a high temperature (see below). This also contributes to drip loss. With heavy sides, if the chilling rate is slower than desirable, electrical stimulation can worsen the problem of drip, because the sides do not cool sufficiently before they enter rigor.

It is important to stay within the Meat Standards Australia (MSA) 'abattoir window' to optimise tenderness. It may benefit drip as well but an appropriate study has not yet been done.

There is no published evidence that the use of organic acids (e.g. acetic or lactic) as food safety intervention treatments has any detrimental effect on drip. In fact in one study there was less drip loss from striploins that were treated with a mixture of acetic and lactic acids than from those that weren't treated. However in some commercial trials in Australia with vacuum-packed pork and beef treated with hot (55ºC) acetic acid solution, there were indications of elevated drip loss in the packed product. The extra drip may have been due to denaturation of the surface tissue or it may simply have been due to inadequate drain times after treatment.

Chilling and time to boning

If carcases that aren't electrically stimulated are cooled too slowly, some muscles can shorten significantly due to rigor shortening. It is known that drip loss increases if rigor shortening has occurred.

If carcases that aren't electrically stimulated are chilled too quickly, severe cold shortening of some muscles will occur. Drip losses will increase. If they are restrained by, for instance, aitchbone hanging (Tenderstretch), muscles can be prevented from cold shortening.

Little muscle shortening and drip loss occurs if the muscles are cooled to, and retained in, the range 10°C to 15°C. Minimum shortening occurs at around 12°C.

From published data, spray chilling of beef sides does not appear to adversely affect drip loss from primals. However, one Kansas study with sub-primals (insides) found a slight increase in drip (2.0% compared with 1.7%) after 15 days when spray chilling was employed.

Hot or warm boning (accelerated boning) per se doesn't appear to affect drip loss. In studies where hot boning has been associated with increased drip loss, cold-induced muscle shortening has probably occurred because electrical stimulation wasn't used.

If the meat temperature at boning is high (some deep muscles will have temperatures near 20°C after normal overnight chilling), it is important that after the cuts have been packaged, a good rate of chilling is continued until the stipulated temperature for shipping is reached.

There is no information on whether there is an influence of the period of chilled holding (one, two, three or more nights) on drip loss.

Rapid fall in pH is an indicator of rapid onset of rigor. As already mentioned, if carcases go into rigor too quickly – before the meat temperature has fallen – subsequent drip loss may be increased. It is important that pH does not fall too rapidly. Researchers at the CRC for Cattle and Beef Quality who have developed (and continue to refine) the desirable abattoir window for rates of pH and temperature decline, have not specifically focused on drip loss. However, there is good reason to believe that if steps are taken in an abattoir to adhere to the MSA guidelines (the window) then drip loss will not be excessive. An example is to optimise electrical stimulation and other electrical inputs on the slaughter floor. Current research funded by MLA is helping to better determine the effects of the inputs on various quality traits including drip.

Cutting style and differences between cuts

The amount of drip is likely to be higher for cuts where much of the meat surface is freshly cut than from those that are seam-boned. Investigators have reported much higher drip losses from retail portions or sub-primals (i.e. portions with relatively large areas of cut tissue) than from whole primals – 5% or higher compared with 1-2%. As many surfaces as possible should be left covered by connective tissue and/or fat. It appears that some cuts tend to lose more drip than others. Published evidence of this is limited but it is documented that drip loss is lower for beef outside flats than insides.

Packaging

It has been suggested on occasions that delays between boning and packaging contribute to excessive drip through the effect of stacking of cuts on tables or in containers. There is no direct evidence for this but it seems likely that inappropriate pressure would encourage movement of any drip from around the meat fibres out to the surface (Fig. 2).

Vacuum packaging results in higher drip loss than other modified-atmosphere techniques. In a New Zealand study, sealed non-vacuumed samples had the lowest drip formation of all samples from a range of treatments that included shrunk (Barrier Bags) and non-shrunk (conventional and aluminium foil) vacuum packs, standard carbon dioxide atmosphere packs and also packs in which the meat samples were supported away from the films within rigid tubes.

The degree of vacuum affects drip loss. In the New Zealand trial referred to above, a full vacuum tended to cause more drip than lesser vacuums. This was explained in part by the physical squeezing of the meat. Although it is not stated in the paper, a snorkel machine was probably used. The rate of vacuum application during packaging doesn't appear to have a significant effect on drip loss. A modified cycle, in which the rate of evacuation was slower and the full vacuum held for a much shorter time, caused slightly more drip than the normal cycle.

Drip formation in heat-shrunk vacuum packs is less than in non-shrunk packs. It has variously been suggested that it is because: a) heat-shrinkable films tend to be softer and more pliable than non-shrinkable ones; or b) there are fewer voids and 'ears' into which drip can emerge from the meat and accumulate.

Figure 2. Drip in vacuum-packed beef rump.

It has been claimed that avoidance of evacuation and exertion of pressure using highly shrinkable film can reduce drip. There is evidence from trials in Germany with cold-boned beef and pork that a packaging technique, Pi-Vac (a system that despite its name, does not involve evacuation), resulted in less drip after 35 days chilled storage than vacuum packaging. With this technique, loins of beef or pork are placed into sleeves that shrink tightly onto the meat, after which the ends are clipped or heat-sealed. A recent investigation of the Pi-Vac system for hot-boned beef also showed it to be an effective method for restricting muscle shortening during rapid chilling. Although it was not mentioned, the avoidance of cold shortening would have also lessened drip loss.

The importance of a good rate of chilling of the vacuum packs has already been mentioned. The primals should reach 5°C within about 20 hours of boning. If necessary, the rate of cooling of vacuum packs in carton chillers can be improved by leaving the lids off for 24 h.

It has been stated that squashing of lower cartons in chilled shipments – due to instability problems – leads to increased drip. There is no published evidence that this is the case. While such excessive uncontrolled pressure may exacerbate drip, the finding from investigation of the Pi-Vac system (above) suggests that reasonable pressure at the appropriate orientation to the meat fibres may in fact reduce drip.

Load-out and storage

It has been stated that meat should not be loaded out until its temperature is uniformly down to the carriage temperature (0°C or below) otherwise drip loss may be increased.

There is no definitive information however, on the effect of storage temperature on drip loss; however the gradual protein denaturation and proteolysis that occur during the ageing process (and which leads to gradual accumulation of drip) occurs more slowly at lower storage temperatures.

Small fluctuations in temperature (say ± 1°C) are unlikely to cause a noticeable increase in drip in vacuum packs. Significant fluctuations in retail display cabinets might be expected to exacerbate drip but there is no published evidence. Drip loss gradually increases with storage time. In some of the investigations, drip loss seems to have reached plateaus after around 4 to 5 weeks. In others it continued to increase for the duration of the trials (15 weeks in one trial). There are no published data on whether the duration of storage in vacuum packs subsequently affects the amount of drip during retail display.

Frozen storage

In meat that has been frozen, there is considerable denaturation of proteins that are associated with the myofibrils. The effects on the muscle microstructure and the proteins are the results of both freezing and thawing processes. Very rapid freezing (4ºC per minute or faster) causes minimal protein denaturation but in practice the rates of freezing of primals is vastly slower than this. When meat is frozen pre-rigor, the detrimental effect of freezing and thawing is aggravated. Extended periods of frozen storage affect meat that is frozen pre-rigor more than when it is frozen post rigor.

In vacuum-packaged meat that is aged, then frozen, then thawed, drip loss will be greatly increased. There are no published data however.

Conclusions

In summary, it appears that the main factors in drip loss in vacuum packs are:

- inappropriate rates of carcase chilling – leading to cold shortening if chilling is too fast or to heat shortening and protein denaturation if too slow;
- which cuts we are talking about and how severely they are trimmed of connective tissue and fat;
- The vacuum packaging process;
- temperature of storage of vacuum packs;
- time of storage; and
- whether they are frozen after ageing.

The existence of drip loss from meat as an ongoing phenomenon is evidenced by the widespread use of soaker pads in vacuum packs and retail packs. Drip loss – particularly from meat that has been frozen or vacuum-packaged, or both – is of considerable commercial significance.

From this brief discussion of some of the factors that contribute to drip, it is clear that too little known about how to vary these factors in order to minimise drip loss. Current research will provide some information, however additional investigations are required.

For more information, contact one of the Meat Industry Services staff listed below.

Food Science Australia Meat Industry Services Section

The Meat Industry Services (MIS) Section of Food Science Australia is an initiative supported by Meat and Livestock Australia (MLA) and the Australian Meat Processor Corporation (AMPC) to facilitate market access for, and support world-class practices in, Australia 's meat industry.

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