QUALITY MEAT FOR EXPORT

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Apparently, certain export markets prefer our young beef, mainly sourced from feedlots, as opposed to the beef from older animals typically found in the Australian, USA, and Brazilian export markets. There may be a perception among producers and exporters that young carcasses guarantee quality and buyer satisfaction. However, such assumptions overlook various factors that contribute to the production of quality beef.

Quality criteria may vary significantly among different importers, and it is important to acknowledge that this article cannot cover all these criteria comprehensively. However, the concept of quality remains universal, regardless of whether the meat is intended for local consumption or export. While the specific demands for quality parameters may differ between foreign and local consumers, the processes involved in producing quality meat are essentially the same.

In addition to ensuring food safety, which includes aspects such as microbiological and chemical safety (e.g., antibiotics, growth promoters), most end-users (importers and their clients), as well as any consumer (consciously or unconsciously), consider three main components of quality. These components are:

- Visual quality, primarily described in terms of meat colour and the ratio of fat (marbling and other types of fat) to meat.
- Yield, measured by the amount of loss in the form of purge or additional trimmings.
- Eating satisfaction (palatability), which encompasses tenderness, juiciness, and flavour.

Ethical production methods and a focus on low environmental impact may also be additional factors considered by consumers. In this article, we will concentrate on achieving the best quality results with a focus on these three aspects of the quality experience, which we will refer to as critical control points (CCPs). CCPs occur throughout the entire value chain and can be categorized into pre-slaughter, slaughter, and post-slaughter processes and conditions.

Pre-slaughter CCPs

Genetics are often believed, especially by geneticists, to play a major role in quality. However, their effect on quality is limited and influenced by other factors known as environmental effects. Just as with the production of good wine, good quality beef cannot be produced from poor genetics. Similarly, poor quality meat can be produced from animals with quality genetics if the rest of the value chain is neglected.

Research conducted in the 1990s and thereafter has shown that the Nguni breed has a favourable genetic potential for producing quality beef, particularly in terms of palatability, when compared to many European and British breeds, albeit with certain limitations (such as lower marbling compared to Angus). Decades of research have also demonstrated that higher levels of bos indicus genetics have a negative impact on eating quality, specifically tenderness, due to an inherent "impaired aging ability." The calpain enzyme system, responsible for the improvement of eating quality through meat aging or maturation, plays a crucial role in this process.

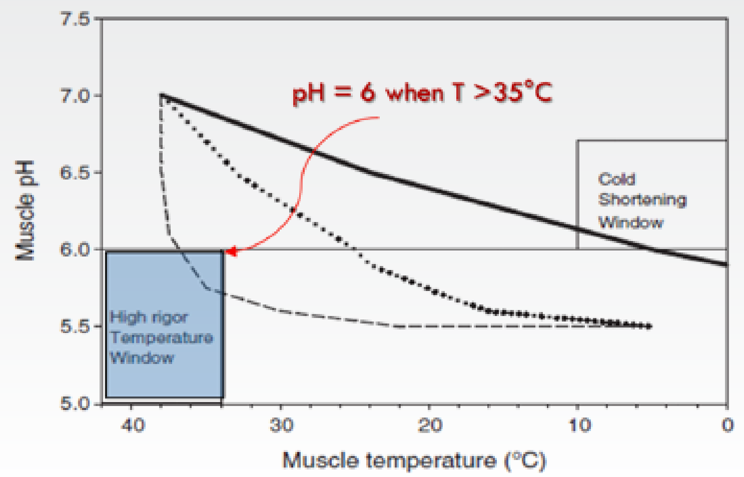


Figure 1: Glycolysis pathways for normal (dotted line), cold shortened (solid), and high rigor temperature (HRT; dashed line) conditions.

Without delving into technical details, this system involves the action of the calpain enzyme, which breaks down the structure of meat, and the calpastatin enzyme system, which works against this process. In essence, breeds or individual animals with a genetically compromised calpain system (in the context of meat quality) will require more time to reach similar levels of acceptable tenderness during post-mortem maturation compared to breeds with favourable genetics. It is important to note that Nguni and other indigenous breeds are often incorrectly referred to as bos indicus types. In fact, these breeds belong to the bos taurus africanus type and share similar meat quality-related genetics with bos taurus, rather than bos indicus.

Furthermore, it is essential to recognize that there is variation within any breed, including bos indicus, and therefore genetic improvement can be achieved through selection for better quality beef.

Level of feeding (nutritional status and growth rate) may influence eating quality, and it is generally accepted that animals with high/positive growth rates during their production life (without the use of growth promoters) will produce more tender meat. This is due to the presence of less heat-resistant muscle connective tissue ("younger" collagen) as a result of faster protein turnover. As a result, it is often argued that grain-fed animals are more tender than grass-fed animals due to better feeding conditions. However, the validity of this argument is still debated.

High rigor temperature meat showing colour defect (two-toning) and excessive drip loss

In the local market, almost all beef produced through grain-fed systems involves the use of different metabolic modifiers (MMs) to improve growth efficiency and carcass yield. These MMs include anabolic ear implants and beta agonists (BAs) such as zilpaterol and salbutamol. Typically, implants and BAs are used in combination, and BAs, in particular, can compromise the maturation process by increasing calpastatin activity, thereby working against the tenderizing enzyme calpain. Similar to the situation with bos indicus beef, meat produced with implants and specifically BAs will take longer to mature and may not reach its full genetic potential.

Most foreign markets (importers) have banned the use of MMs due to perceived food safety concerns. Consequently, these products do not play a role in determining the quality of exported beef.

Instrumental colour measurement

Slaughter practices

The processes and conditions leading up to slaughter, from the time animals are prepared to leave the farm/feedlot until the point of killing and the subsequent conversion of muscle into meat (known as rigor mortis, occurring 24 hours after killing), are crucial aspects of the quality value chain. Unfortunately, they are often underestimated. In simple terms, muscle requires an adequate supply of glycogen (energy) to successfully convert into meat. During this process, lactic acid is formed. Therefore, if an animal experiences prolonged stress before arriving at the slaughterhouse, it will produce poor-quality meat with a dark colour, similar to game meat. This condition is known as “dark, firm, and dry meat syndrome” (DFD) or dark-cutters.

Stress factors that contribute to DFD meat include depriving animals of feed too long before slaughter (resulting in depleted glycogen levels), transport stress (caused by careless driving, improper loading or unloading), adverse weather conditions (especially heat), extended lairage times at the abattoir, improper handling before and after transport, susceptibility to stress (easily excitable animals), seasonal changes (such as transitioning from winter to summer or vice versa), and the aggressive use of metabolic modifiers (MMs). Frequently, these factors may interact or accumulate, exacerbating the problem. DFD meat has an unattractive appearance, a short shelf life in vacuum-sealed bags (as it cannot undergo long-term maturation) and does not have desirable eating qualities (it may be tough and tasteless).

DFD meat can be moni-tored by measuring the pH (acidity) of the meat. A pH value of 7 is neutral and refers to the muscle of a live animal (pH 7.2). After 18 to 24 hours post-slaughter, the pH of the meat should range from 5.3 to 5.6. Any values above 5.8 indicate limited glycogen conversion to lactic acid, indicating the presence of dark-cutting meat.

Dark cutting steak

Not only is the final level of acidity important for good quality, but also the pathways of glycolysis, which involve the conversion of glycogen to lactic acid to fix muscle fibres in their final form as meat. If glycolysis is too slow and carcasses are chilled too quickly, the muscle can extensively toughen during the final stages of rigor mortis (muscle fibre fixation), and this condition is irreversible. This is typically observed in lamb carcasses due to their smaller size. However, in recent times, with generally higher carcass weights, the risk of cold shortening in beef is very low.

Over the last three decades, the average carcass weight in South Africa has increased from 210 kg to 310 kg (a 30% increase). Although the Nguni breed does not fall within these carcass size ranges, it may still be affected by these issues. This increase in carcass size is a global trend driven by the pursuit of higher efficiency. Larger carcasses, at the same level of fatness, are more efficient to produce and process into cuts. However, larger carcasses can have several disadvantages.

When the rate of glycolysis is too high, it means that the final pH or rigor mortis is reached too soon, creating unfavourable conditions for rigor mortis. This rapid decline in muscle pH and slow decline in muscle temperature can cause certain important muscle proteins to lose their functionality, resulting in significant quality problems. Three types of proteins are involved: myoglobin, responsible for colour development and colour shelf life; acto-myosin, responsible for retaining moisture inside the muscle; and once again, the calpain enzyme system, responsible for maturation and tenderness. These factors can be monitored during slaughter. The general rule is that if the pH (rate of glycolysis) reaches 6 before the muscle temperature falls below 35°C, it is referred to as high rigor temperatures ().

pH measurement

Due to the significant increase in carcass size over time, while chilling infrastructure has not kept pace with capacity improvements, more than 80% of beef carcasses produced in South Africa are affected by HRT issues (according to a survey).

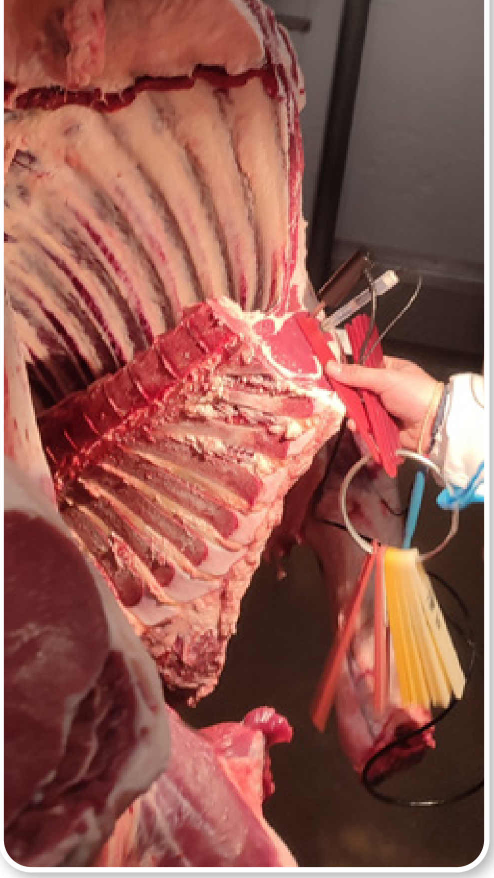
These problems can be identified by the pale brown colour often observed in vacuum-packaged beef or displayed on shelves, as well as by the phenomenon known as "two-toning," where the meat on one side of the cut appears pale brown while the other side retains a normal red/pink colour. This is particularly noticeable in deeper parts of the muscle, often seen in large cuts like rump, topside, and sirloin.

Additionally, these HRT beef cuts tend to have higher drip loss or purge, resulting in greater product loss since the purge is typically discarded when cuts are removed from vacuum bags. The reduced moisture content in the muscle also contributes to drier meat, which is less palatable. While purge usually occurs during the vacuum-packaging and maturation process (such as with export beef), HRT beef experiences significantly higher purge losses. Lastly, impaired maturation is another issue with HRT beef, as the calpain system is not functioning properly, preventing the meat from reaching its full maturation potential.

From the scenarios described above, the Nguni carcass, being smaller in size, is less at risk of developing high rigor temperatures (HRT). However, other processes can also contribute to HRT. Electrical stimulation (ES) was introduced in abattoirs to prevent cold shortening, as explained earlier. This condition primarily affected sheep meat and smaller carcasses (like in the 90s). ES involves applying an electrical current with specific parameters to the carcass before or after dressing. The specific parameters of the electrical current, typically running at 15 impulses per second (as opposed to 50 Hz), cause the muscle to contract and relax at a specific rate, resembling a shivering movement of the muscle and limbs. This accelerates rigor mortis, thereby increasing the rate of pH decline. Within certain limits, ES has advantages beyond preventing cold shortening, as it can facilitate or expedite maturation.

Unfortunately, many abattoirs lack the technical expertise to realize that the application of ES, as done 30 years ago, may now lead to HRT. This is because the pH decline is too fast while the chilling rate is too slow due to inadequate chilling capacity and overloading of chiller rooms. The solution is not to abandon the use of ES but rather to manage it by reducing the duration (e.g., from 45 to 60 seconds; to 15 to 20 seconds).

Nevertheless, with or without ES, both larger and smaller carcasses may still develop HRT due to substandard chilling facilities or poor management of the slaughter line, resulting in carcasses not reaching the chillers soon enough for effective initial chilling. ES also aids in proper bleeding out, as long as it is not applied too soon after exsanguination - there should be a minimum of 5 minutes between killing and ES application. Applying ES after dressing (just before carcass splitting) has the advantage of delaying the advancement of rigor mortis (pH decline) compared to early ES, which may assist in managing HRT.



Colour scoring during MSA grading

The loin muscle is always used as a reference muscle for quality control as it is one of the muscles that responds most significantly to the factors and processes discussed earlier.

The final step to achieve the best eating quality is proper maturation. From the discussion so far, it should be clear that proper management of all critical control points (CCPs) should be in place to facilitate proper maturation.

Although eating quality, particularly tenderness, will always improve with maturation, the final quality will be compromised if all CCPs are not followed. Meat is at its toughest after rigor mortis is reached (18 to 24 hours) and then begins to improve through maturation. The initial days (7 to 24 days) show significant improvement, which gradually tapers off as maturation continues. Extended aging times are often implemented to address biological variation across meat cuts. However, as mentioned before, if certain steps in the CCPs were missed, the product will not reach its maximum potential.

Maturation occurs faster at higher temperatures (e.g., 0 to 2°C compared to 5 to 7°C). However, maturation temperatures are typically kept as low as possible to prevent spoilage and extend shelf life. While there is no fixed number of days for maturation, over-maturation can occur, resulting in less palatable meat with a "mealiness" texture or lack of texture, as well as "livery" and "bloody" flavour overtones. Whether meat ages on the bone or in a vacuum bag off the bone does not affect the amount of maturation (tenderization).

While the processes and conditions described above apply to any situation where quality beef is the objective, the focus of this paper was specifically on export meat, with the Nguni breed as the animal model. The key takeaway message in this regard is that there are no concerns regarding the effect of metabolic modifiers (MMs) because they are prohibited in most cases.

Producers and processors should therefore concentrate on producing animals that are slaughtered in optimal condition after a sound growth phase. Long and short-term stress before slaughter must be limited, and detailed attention should be given to the conditions under which the muscle converts to meat (within 24 hours) after killing to ensure a good baseline product and achieve the best results through maturation.