The energy status, ultimate pH, and colour of post-mortem muscle of three different beef breed types

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Introduction

Meat tenderness depends on three aspects namely, 1. the physical structure of muscle, 2. the nature of inherent composites that determine the physical structure of muscle and 3. the post-mortem processes in muscle (enzymatic and non-enzymatic degradation). The nature of the inherent composites will influence the extent with which the processes in muscle will influence the physical structure of meat. These aspects are influenced by external factors such as breed, gender, age and stress among others (Tornberg et al., 1996). An external factor may influence more than one aspect in various degrees (Tornberg et al., 1996). Time and the passing of time can be seen as an overall factor that influences many or all of the external factors as well as many or all of the aspects. The energy levels in post-mortem muscle over time, influences the extend of the processes of enzymatic and / or non-enzymatic degradation, and therefore the nature of the inherent composites and consequent tenderness of meat.

Enzymatic degradation of cytoskeletal proteins such a nebulin, titin and vinculin, during post-mortem storage is caused primarily by the calpain system (Koohmaraie and Geesink, 2006). Non-enzymatic degradation of cytoskeletal proteins is possibly as a result of post mortem elevated Ca^{2+} levels and specifically necrosis, apoptosis and the caspases (Ouali et al., 2006).

The above mentioned processes involved in meat "tenderisation" are greatly affected by the energy status of the animal and the perimortal rate of ATP consumption. The structural and enzymatic changes in muscle fibres influencing water-holding capacity, tenderness and colour of meat are due to the complicated interplay between pH, temperature and time (Dransfield, 1993; Poso & Polouane, 2005).

After slaughter, when the circulation is stopped, anaerobic carbohydrate metabolism provides the homeostatic mechanism for the resynthesis of ATP. This results in "acidification" of muscles, which depends on the carbohydrate content and structural buffering capacity, during the decline in pH values of 5.5 or less (Robergs et al., 2004). Determining the factors that result in a low ultimate pH (pHu) and establishing the limits of residual glycogen levels obtained under various conditions (Immonen and Puolanne, 2000), are central to understanding stress in livestock and the related effects on meat quality. A contributing factor towards meat tenderness is animal breed type. The present study focuses on the post-mortem energy levels in the muscle of three different beef breeds types (Brahman-x, Simmental-x and Nguni-x), pHu and colour of meat.

Materials and methods

One-hundred-and-eighty animals were slaughtered at the specified A-age (no permanent incisors) and fatness-class 2-3 (code which relates to 5-7mm subcutaneous fat thickness). Three different beef breeds Brahman-x (Br-x), Simmental-x (Sm-x) and Nguni-x (Ng-x) were treated in exactly the same manner during the growth and feeding period and fed the same feed. Sixty Br-x, sixty Sm-x and sixty Ng-x animals were used. Slaughter of animals was as with standard slaughter procedures for South African legislation. pHu was measured 20 hours post-mortem with a digital handheld meat pH meter (Sentron, Model 1001) fitted with a polypropelene spear type gel electrode. pH measurements were done on the *m.longissimus thoracis* of the carcasses. At 20 hours post-mortem the colour of the meat was measured with a Minolta colorimeter as described by Dunne *et al*. (2005). 20g of muscle for the determination of energy in the *longissimus* muscle were taken at 1, 3, 6 and 24 hours post-mortem covered with aluminium foil, frozen by means of liquid nitrogen and then ultra frozen –70 °C until analysis. The samples from the 4 specified time intervals were used for biochemical (glycolytic potential) analysis and were pooled and used in a Bonferoni test for statistical analysis.

Results and discussion

Table 1. Biochemical parameters in Brahman-x, Nguni-x and Simmentaler-x post-mortem muscle

	Bh-x	Ng-x	Sm-x
Glucose (umol/g)	3.4696[b]±	3.2247[a]±	3.5602[b]±
Glycogen (umol glycosyl units/g)	28.4090[a]±	24.8085[b]±	25.8570±
G6P (umol/g)	4.4461[b]±	3.8425[a]±	4.1542±
ATP (umol/g)	4.8678[a]±	5.4312[b]±	5.1754±
CP (umol/g)	7.0233[a]±	8.3173[b]±	7.8935[b]±

[a,b]Different superscripts in the same row differ ($p<0.05$)

Livestock exposed to stressors during immediate pre-slaughter period possibly depletes excessive amounts of muscle glycogen (Lacourt and Tarrant, 1985). Muscle glycogen depletion is a result of epinephrine release which activates muscle adenylate cyclase and thereby stimulates glycogen breakdown (Voet and Voet, 1995). In turn, lowered glycogen prevents an acceptable decrease in pH and attainment of pHu for optimal conversion of muscle to meat (Purchas et al., 1999; Warriss, 1990). The decrease in carcass pH was marginally slower for Ng-x compared to Br-x and Sm-x (O'Neill et al., 2006). This corresponds with the lower biochemical parameters in Table 1. The pHu values also tended to be higher in the Ng-x compared to Br-x and Sm-x. Colour measurements for Ng-x indicated significantly darker scores for Ng-x compared to Br-x and Sm-x (O'Neill et al., 2006). The results suggest that the indigenous Ng-x has a lower glycolytic potential and this agrees with the results obtained for indigenous goats in South Africa (Webb et al., 2005).

Conclusions

Nguni cattle descends from both Bos taurus and Bos indicus cattle. These animals are adaptable and can survive under harsh conditions with limited food and water (Campher et al., 1998). Ng-x cattle had lower overall energy reserves in post-mortem muscle as well as significantly higher pHu values. It is concluded that Nguni breed is more stress responsive with a subsequent lower glycolytic potential. This does not mean that this breed will yield tougher meat as other parameters with regard to meat tenderness may be involved. This aspect is currently under further investigation.

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