The SA beef classification system in 2015 – a critical review of age classification

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This document aims to summarize a series of events since October 2009 when a first meeting of stakeholders was held to discuss the existing red meat classification system in South Africa. It culminated into the 12th Meat Symposium on 7 November 2014 publication of the research as peer-reviewed papers in 2015 in a special edition of the South African Journal of Animal Science (Volume 45, Issue 3). Subsequently participants from industry requested a more translated version, which this document attempts to do.

Background

The South African (SA) beef grading and classification systems have evolved over a many years since 1932. In earlier developments, carcass quality was described by a combination of factors such as conformation and fat cover of carcasses of animals of a certain age (according to permanent incisors) and sex. Various combinations of these criteria did however not clearly indicate to the consumer the physical, compositional and sensory characteristics of meat (Naude et al., 1990). Age of the animals has been used since 1936, presumably because carcasses of younger cattle were considered to be of "better" quality than those of older cattle (Government Notice No. 1548 of 1936). The number of permanent incisors was used for the first time in 1949 (Government Notice No. 992 of 1949). During these years extremely large and fat carcasses were grouped together in the target grades and were often produced from animals with 6 or more permanent incisors. "A grades " designated carcasses of younger animals with not more than 6 permanent incisors and "B" designated carcasses of older animals with more than 6 permanent incisors, but which were not older than 4 years.

In later developments, Klingbiel (1984) reported that A-age animals had significantly higher muscle collagen solubility, that muscle pigment concentration was significantly lower, and

that cooking loss (%) was significantly lower. These results could be generalised by saying that the meat of A-age animals (not more than 2 permanent incisors) was more tender, lighter coloured and juicier than meat from older animals. After a series of discussions held by various working groups and committees, a proposal was accepted to define the age classes as A: having 0 permanent incisors; B: 1 to 6 permanent incisors; and C: 7 to 8 permanent incisors (Government Notice No. R.1010 of 1981). Within each age class terms Super, for A, Prime, for B and Top, for C denoted carcasses with fat codes 3 and 4 (3 – 7 mm fat thickness) that was the most preferred fat levels by consumers at the time, while fatter and leaner carcasses were graded with less preferable (terms like A1, B1, B2, C2 etc.). The decision to exclude 2-teeth animals from the A-age and transfer them to B-age (2-teeth animals were graded as A in previous systems), was then based on the work of Boccard (1978) and Boccard et al. (1979) and the motivation was the differences in collagen solubility where mayor changes started to take place between 16 and 18 months. It is also noteworthy that during the late 70's and early 80's the value of high voltage electrical stimulation (ES) was acknowledged in South Africa in order to avoid within age variation in tenderness due to cold shortening of carcasses that were lean and small as opposed to those that were fatter and larger. Such systems were implanted in all 11 ABAKOR abattoirs throughout the controlled areas of South Africa where the bulk of cattle were slaughtered. This (ES and slaughter in controlled areas under controlled conditions) contributed to an accurate classification of carcasses of similar characteristics together in homogenous groups to facilitate a common language and understanding in the market place. The criteria used and the conditions where under slaughter took place could describe carcasses accurately so that viewing of the carcass by the buyer was unnecessary and by using the classification criteria, carcasses could be graded in order of excellence in accordance with the need of the day.

In subsequent years the "Grading" of carcasses was terminated and only the classification criteria remained to facilitate a Classification system moving to the idea of "description only" and leaving the choice to the buyer and ultimately the consumer according to their needs. Further alterations occurred until the current Classification system (not grading) was implemented in 1996 after the work of Crosley et al. (1994) and carcasses with 2 permanent incisors were in a separate age class (AB) than those with 3 to 6 permanent incisors (B) and 0 permanent incisors (A) (Government Notice No. R.342 of 1999). Although the classification system was not intended for the purpose of ranking carcasses, description of "Most Tender", "Tender", "Less Tender" and "Least Tender" were given to the 4 age classes, respectively.

The surveys of Vermeulen et al. (2015) showed that the most important attributes valued by consumers when purchasing red meat are expiry date, price, appearance (e.g. meat colour), clean meat, taste and a quality guarantee. Even though tenderness is not among these dominant attributes it can be argued that it is embedded in the general term of 'quality guarantee'. Results from such surveys should be considered in the right context and it should be kept in mind that a classification system has limitations with regards to the description of a product. For instance, its purpose is not to give any indication of safety, nutritional value or healthiness, freshness or visual appeal, which are just some of the attributes reported by Vermeulen et al. (2015) as being important, and even more important than, for example certain palatability attributes such as tenderness.

Comments by Prof Schönfeldt:

When considering a description of a product such as meat, various characteristics can be considered as important for the end-user. The surveys of Vermeulen et al. (2015) indicated that the marginalised group focussed mostly on health (45%) followed by affordability (40%) concerns. Interestingly, both the middle-class group and the wealthy consumers focussed mainly on affordability, followed by fattiness and health concerns for both beef and mutton/lamb. Health conscious consumers associate diet with the probability of non-communicable diseases resulting in a shift away from high-fat diets. Tenderness was a more prominent concern among wealthy beef consumers compared to middle-class beef consumers, and it was not a concern mentioned for mutton/lamb among middle-class and wealthy consumers.

Table 1 Dominant consumer concerns regarding red meat (open-question responses)* as a percentage of sub-groups

Marginalised group (LSM® 1-4)	Middle-class group (LSM® 5-8)		Wealthy group (LSM® 9-10)	
	Beef concerns	Mutton/lamb concerns	Beef concerns	Mutton/lamb concerns
• Health concerns (45.4%) • (e.g. fatty, cholesterol, blood pressure, heart problems, diabetes, allergies, gout) • Affordability (40.2%) • Long cooking time (2.1%) • Availability (1.0%) • General quality concerns (1.0%) • 'Mixed with strange meat' (1.0%) • Perishable (1.0%)	• Affordability (17.5%) • Fatty (5.8%) • Health concerns (7.0%) • Long cooking time (4.7%) • Dark colour (2.3%) • Not tender (1.8%) • Perishability (1.8%)	• Affordability (24.0%) • Fatty (11.7%) • Health concerns (4.0%) • Dark colour (1.2%) • Long cooking time (0.6%) • Not tender (0.6%)	• Affordability (35.7%) • Fatty (28.5%) • Not tender (13.7%) • Quality concerns (9.6%) • Freshness (7.6%) • Long cooking time (5.2%) • Health concerns (2.4%)	• Affordability (55.2%) • Fatty (37.1%) • Bad taste (6.0%) • Quality concerns (5.6%) • Colour (5.2%) • Health concerns (4.0%)

NOTE: the aspects mentioned by the respondents with links to red meat classification are highlighted in grey

Limitations of a grading or classification system
A carcass classification system is limited in the way that it can only describe those attributes that are measurable or detectable at the point of classification which takes place either on the day of slaughter or at the most the day after. Furthermore, most of the properties described or scored in a classification system are indirect measurements of the actual traits, e.g. age that is recorded as number of permanent incisors, while the other two scores, fat and conformation are only a visual appraisal (predicted) of actual fat content and muscularity or edible yield.

Considerations to take into account in the evaluation of the classification system
When considering changes to the current classification system or a totally new system the following must be considered and we shall attempt to address each point further on in this document:

- Does the current system still provide sufficient information for role players in every link of the value chain and ultimately for the end-user

- Have the environment wherein the classification system operates changed since its first implementation (linked to the first point)
- If the answer to the previous point is positive, the changes that occurred on the different levels or links of the value chain should be identified and the impact of factors influencing the quality or description of the final product should be quantified.
- Finally it should be verified whether these effects can be identified and scored or measured at the point of classification accurately and cost-effectively.
- What meaning or value this will have for the different role players in the value chain?

Terms of reference considered in this document

The terms of reference (ToRs) established at the 2009 meeting of the Red Meat Classification Committee included points such as consumer surveys and the concerns about consumer needs and the consumer's understanding of the current classification system and even meat safety issues. However, most of the ToRs referred to concerns about how well the present classification system serve the different role players (apart from the end-user) in the value chain and more specifically how the present system benefit or affect the different role players.

The present classification system mainly describes eating quality (age classification by dentition) and yield (fat and conformation scores) with certain references to the effect of gender on both these categories. While concerns were raised about fat classes, most research work over the past decade related to the classification system focussed on eating quality, and more particularly tenderness. Therefore this document will focus on the age aspect of the classification system and more particularly on the tenderness of quality. However, other aspects of quality will also be mentioned and discussed.

Methods of measuring tenderness and general considerations in research projects

Since the early years of the grading system the assumed interrelationship of age with fatness were considered the most important factors influencing the final quality (and yield) of the product. As time progressed,fat was mainly used together with conformation to define yield while age was used to define eating quality. The rationale behind the latter was based on the relationship between collagen properties and meat tenderness. Tenderness was regarded (rightfully) as the most important criteria of consumer acceptability. For the sake of further discussion, some clarity should be given regarding the measurement of quality, but more particularly, tenderness and how this may relate to consumer acceptability.

In most studies the mechanical measurement of tenderness by means of shear force resistance (SF) are used to describe the effects of different factors on tenderness. While this method is not faultless, it is commonly used in studies all over the world. Its repeatability is much higher than trained sensory panels. However its limitations relate to its one dimensional measurement of tenderness while sensory panel scores for tenderness has a human factor built into it that may be influenced by other attributes such as effects of fatness and moisture on mouth feel and overall ease of mastication (=satisfaction). Furthermore, while so-called peak values are mostly used in meat science experiments, studies have shown that these value more accurately reflects differences in tenderness due to connective tissue properties, rather than differences in myofibrillar properties. This is important since it may affect the outcome of experiments where different factors affect the myofibrilar definition of meat than those affecting the connective tissue definition of meat. For example, the application of electrical stimulation has a larger effect on the myofibrillar properties than on connective tissue properties, while the age of the animals have the opposite effects. Therefore, it may happen that differences in tenderness are recorded by sensory panel

members but these differences are not always supported by SF values. A second component to consider is threshold values for tenderness. While studies may show differences in SF or trained panel tenderness scores, it does not mean that consumers will discriminate to the same extent when confronted with the same samples. It is difficult to find absolute SF or sensory panel values that indicate thresholds for consumer acceptability. Consumer tests (which is different from trained sensory panel tests) are seldom performed as they are expensive and logistically difficult to execute.

Finally, since carcass classification describes the product at the point of slaughter, it is probably wise to describe the influence of various pre-slaughter and slaughter practices and factors on the quality of meat at **that point** as we have no knowledge what will happen to the product after the point of slaughter. For example in the worst scenario, meat may be on the shelf within 3 days after slaughter, or in best case scenarios, meat can be aged for more than 35 days rendering 2 products with the same initial potential (at the point of classification) but vastly different final qualities. For the purpose of this discussion, we shall limit the factors influencing meat tenderness to age of the animal combined with feeding regime (grass vs grain-fed), specific cut of the carcass (with specific reference to connective tissue content), the use of anabolic growth promoters (commonly referred to as hormone implants, HGP) as well as beta agonists (currently only references to zilpaterol), pre-slaughter stress (mainly nutritional stress) and electrical stimulation combined with optimum chilling conditions.

In the work of Crossley (1994) where the current classification system has its roots, age defined by dentition was regarded as the only likely cause of variation in tenderness in a population of cattle. As mentioned by Strydom et al. (2015) this was an accurate assumption at that time as it was based on a regulated production, slaughter and marketing system where abattoir practices for the bulk of the slaughter stock were similar (ABAKOR abattoirs). Pre-slaughter conditions and the application of electrical stimulation and chilling would have been very similar. For A-age grain-fed animals the use of hormonal growth promotants (HGP's) were also probably very similar and beta agonists were not yet in use. Even though the system then was vastly different from the grading systems that developed during the 50's, 60's and 70's, it was still based on the same criteria, although there was an attempt to distinguish more thoroughly between carcasses of different quality. Furthermore, it still remained a producer driven system.

According to Figure 1, based on dentition, loin cuts (*longissimus lumborum* muscle) (low connective tissue) did not show any differences in SF among carcasses with 0 (A) to 8 (C) permanent incisors (permanent incisors). In contrast the biceps femoris muscle (silverside, high connective tissue) of carcasses with no permanent incisors recorded lower SF than those with 2 (AB) and 4 permanent incisors (B4), while 6 permanent incisors (also B6) recorded higher SF than 2 and 4, but permanent incisors 8 (C) recorded the highest SF. In contrast, a trained sensory panel scored loin cuts of A-age carcasses significantly more tender than AB, while AB and B4 did not differ, B4 and B6, did not differ and B6 and C did not differ (Figure 2). For the *biceps femoris*, there was a larger difference between A and AB and between B6 and C, so that the effect of connective tissue properties showed much more clearly in this cut).
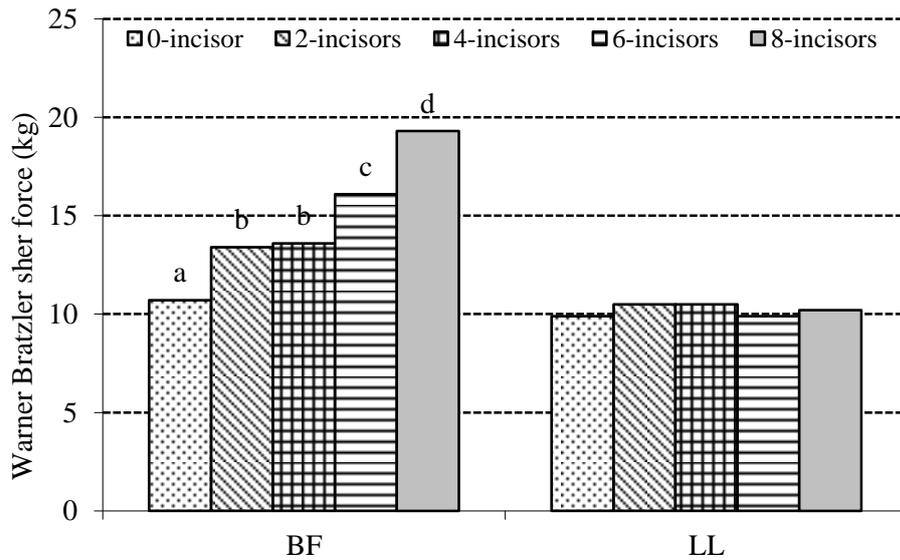
Figure 1 The effect of age class (by dentition) on Warner Bratzler shear force (SF) scores of *m. longissimus lumborum* (LL) and *m. biceps femoris* (BF)(Crosley *et al.*, 1994)

.[a,b,c] Bars with different superscripts differ significantly, *P*<0.05; SF done on 25 mm diameter cores and not 12.7 mm)
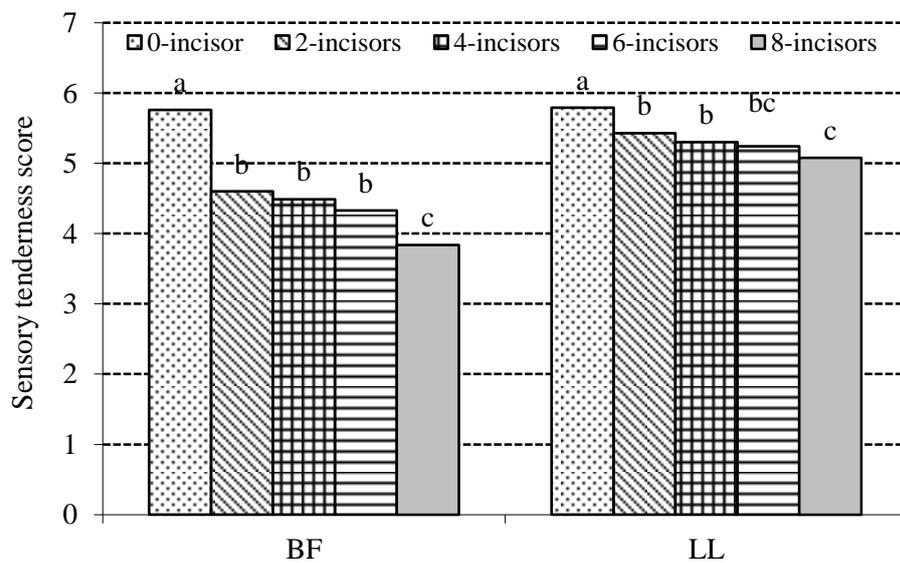

Figure 2 The effect of age class (by dentition) on sensory tenderness scores of *m. longissimus lumborum* (LL) and *m. biceps femoris* (BF)(Crosley et al., 1994)

([a,b,c] Bars with different superscripts differ significantly, P<0.05; Sensory tenderness: 1 – extremely tough; 8 – extremely tender)

Collagen solubility confirmed these differences with the same downward trend in both muscles but because the amount of collagen in the biceps muscle is much higher than in the

loin *(m. longissimus lumborum)* muscle the effect of increase in age was more intense due to higher proportions of heat stable collagen (Figure 3). The conclusion drawn after this study was that carcasses with 2 permanent incisors were closer in tenderness to those with 4 permanent incisors, but 0 permanent incisors was more tender than both and therefore that the classification at that time distinguishing between A, B and C was correct. Nevertheless, distinction was made between 2 (AB), and 3-6 permanent incisors (B) in the subsequent classification system (Government Notice No. R.342 of 1999).
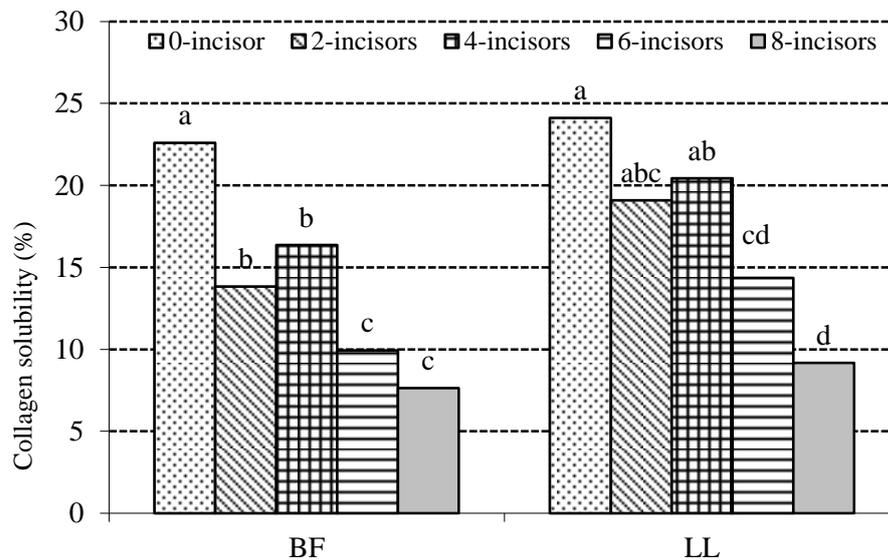

Figure 3 The effect of age class (by dentition) on collagen solubility (%) of *m. longissimus lumborum* (LL) *and m. biceps femoris* (BF) (Crosley *et al.*, 1994)

([a,b,c,d] Bars with different superscripts differ significantly, *P*<0.05)

After 1994, deregulation and other developments in all sectors of the industry lead to more sources of variation in quality and probably new challenges in describing the product as discussed in more detail by Strydom et al. (2015). When considering what happened to the feedlot industry, one can conclude that a large portion of this sector (that at the moment contributes to 85% of the formal beef market) is vertically integrated having feedlots, slaughter plants (ownership or dedicated) and meat processing plants. Furthermore state-owned abattoirs are now either owned by private companies or have closed down, while various smaller abattoirs and new larger abattoirs came into operation.

Crossley et al. (1994) worked with carcasses that were selected only on the basis of number of permanent incisors and did not distinguish between feeding regimes in their sampling (grass vs. grain). Therefore their A and AB carcasses could have originated from grain or grass-fed systems. Subsequent studies showed that diet within age group may influence meat tenderness as well. The results of Frylinck et al. (2009) and Van Wyk et al. (2008) in Figure 4 and 5 show that loin steaks of carcasses of grain-fed animals with either 0 (Class A) or 1 - 2 (Class AB) permanent incisors were more tender (sensory panel and Warner Bratzler shear force) than loin steaks of carcasses from grass-fed animals A, AB and B age classes at 1 day post mortem aging. A-age carcasses coming from pasture also produced tougher loins than A and AB carcasses from grain-fed systems and AB (not sensory scores) and B

carcasses from grass-fed systems. This was mainly due to poorer growth rates in A age grass-fed animals that lead to smaller poorly fattened carcasses (162 kg) that caused muscle shortening during chilling despite efforts to prevent it by application of electrical stimulation. Lower growth rate as such may also contribute less tender meat as reported by other studies (see Strydom et al. 2015 for further description). This does not mean that A-age pasture reared carcasses are inferior but it could mean that carcass and fat condition could contribute to tenderness in extreme cases (Compare the results of the Namibian studies discussed in the next section). Curiously the collagen solubility was not only age related but was also influenced by feeding regime. A-age grass and grain-fed loins had the highest collagen solubility, but grain-fed samples had the highest values, i.e. lowest heat stable collagen, while both AB groups were similar and B-age had lower solubility. The positive tenderness outcomes of B-age was probably the result of intermuscular fat, while it is clear that the advantage of high collagen solubility in A-age pasture samples was overshadowed by muscle shortening and lack of aging ability.
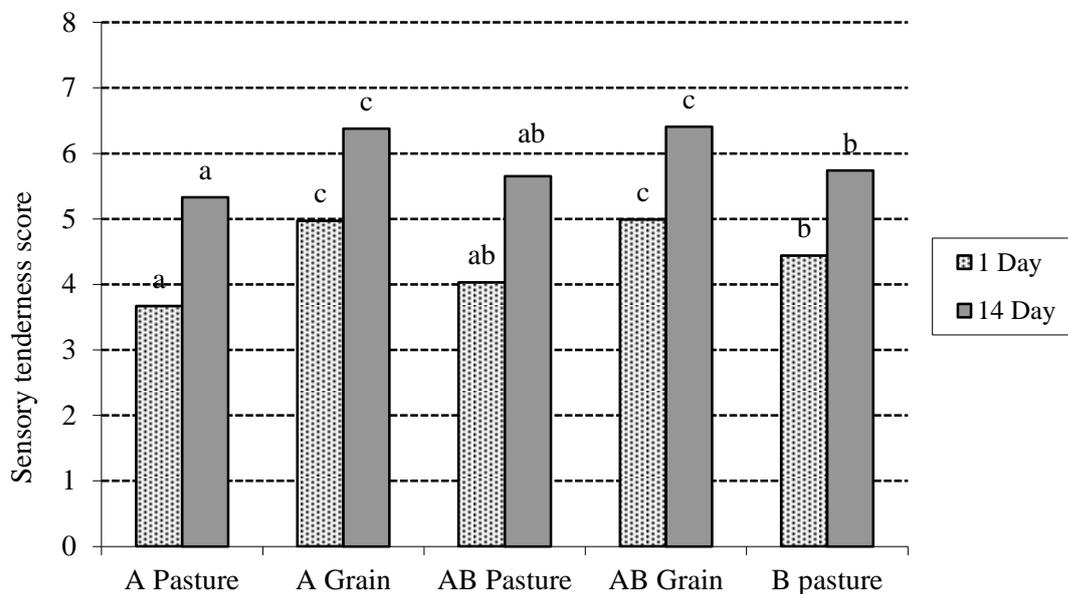

Figure 4 The effect of age class (by dentition) and production system on sensory tenderness scores of *m.longissimus lumborum or* loin (Van Wyk *et al.*, 2008; Frylinck *et al.*, 2009)(A = 0 permanent incisors; AB = 1 to 2 permanent incisors; B = 3 to 6 permanent incisors;

[a,b,c] Bars with different superscripts in the same aging period, differ significantly, *P*<0.05; Sensory tenderness: 1 – extremely tough; 8 – extremely tender)
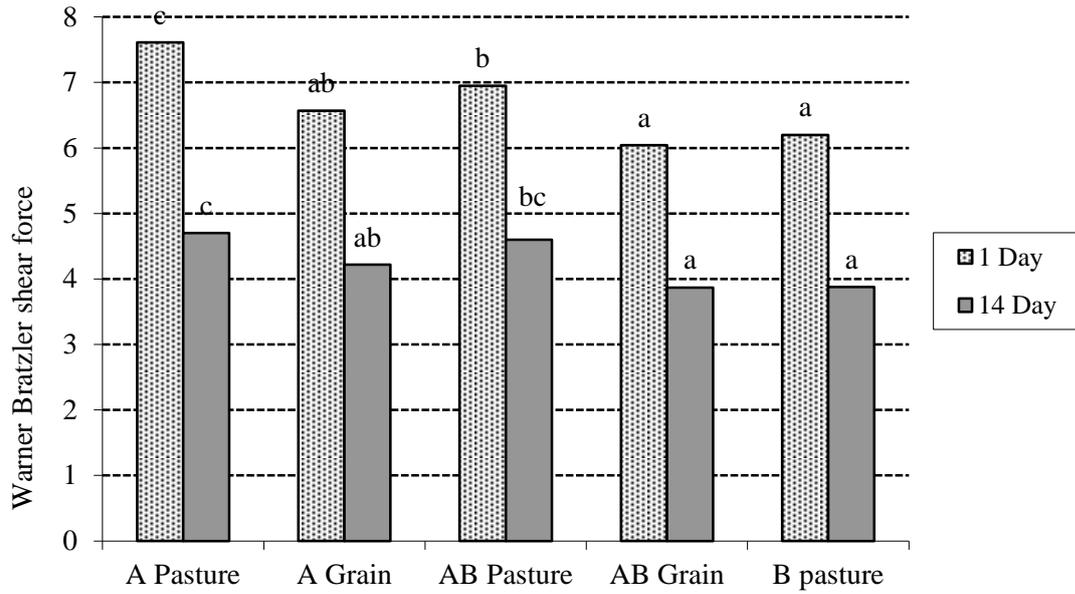
Figure 5 The effect of age class (by dentition) and production system on Warner Bratzler shear force of *m.longissimus lumborum* or loin (Van Wyk *et al.*, 2008; Frylinck *et al.*, 2009)(A = 0 permanent incisors; AB = 1 to 2 permanent incisors; B = 3 to 6 permanent incisors;

[a,b,c] Bars with different superscripts in the same aging period, differ significantly, *P*<0.05)
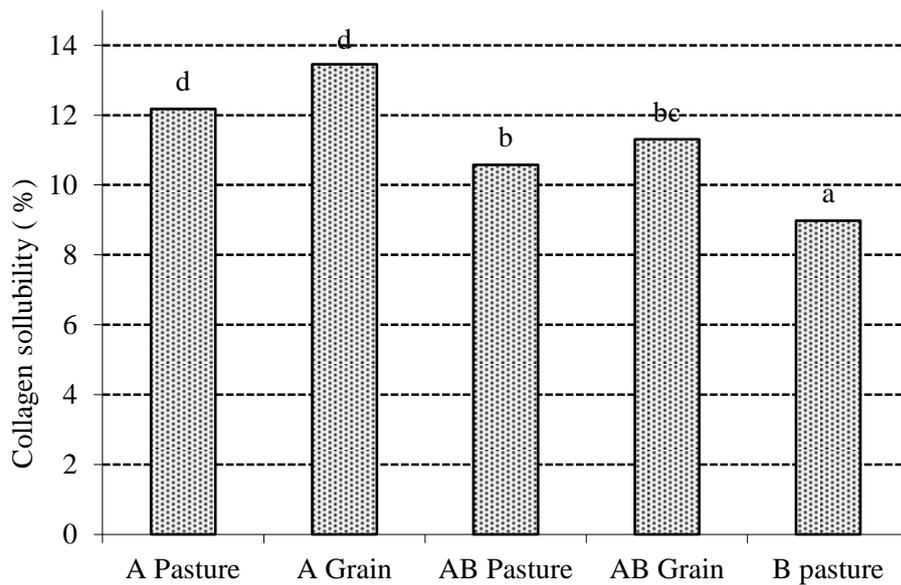

Figure 6 The effect of age class (by dentition) and production system on collagen solubility of *m.longissimus lumborum* or loin (Van Wyk *et al.*, 2008; Frylinck *et al.*, 2009) (A = 0 permanent incisors; AB = 1 to 2 permanent incisors; B = 3 to 6 permanent incisors;

[a,b,c] Bars with different superscripts in the same aging period, differ significantly, *P*<0.05)

Feedlots: The use of hormonal growth promotants (HGP's)

It is assumed that all feedlot operations in South Africa utilise anabolic implants and therefore almost all A-age grain-fed beef is produced with HGP's. Since some on-farm feeding systems do occur where older cattle (past A- class) are rounded off on a grain-supplemented diet, HGP's may also be used in older animals, but probably to a lesser extent. It is worth mentioning that HGPs do have a significantly negative effect on meat tenderness (Hunter, 2010). The aggressiveness of the implant programmes (types and dosages of active ingredients) also influences the magnitude of the effect on quality, but this is difficult to quantify and differences may be confounded with other pre-slaughter effects. Considering the fact that almost all A-class animals are produced with HGP's it will not make sense to distinguish (by means of classification) quality based on the use of HGP's within age class. Within the South African context, all studies on the effect of age/feeding regime will therefore have included HGP's for A-age grain-fed animals. There is of course also the possibility that HGP's are used for older animals classed as AB, and even B.

The studies by Strydom (2006) and (2013) are the only two studies and done on Namibian beef, where age groups were compared and no HGPs were used (yet HGPs were not compared with no HGP's). No differences were found for SF of loins from A and AB grain-fed and A, AB, B and C grass fed cattle, although the meat was aged for a minimum of 14 days in the 2006 study and 35 days in the 2012 study and therefore do not represent results for a worst scenario case, i.e. aging for 3 days. All animals in this study had good carcass conditions and carcass weights as opposed to the studies of Van Wyk *et al.* (2008) and Frylinck *et al.* (2009) referred to previously where carcasses of A-age pasture animals were low in weight and very lean.

Beta agonists and its effect on variation in quality within -age class

Beta agonists, referring to zilpaterol at present (but various other products are either recently registered or in process of registration), have a significant effect on meat tenderness (and also other meat quality characteristics). According to Figure 7 and 8 this effect could be up to 1.4 kg for SF and 1 tenderness score (out of 8) after 3 days of aging (worst case) for loin muscle indicating a major effect on the myofibrilar component of muscle. Considering the fact that most feedlots are using zilpaterol at present loin muscle of most A-age grain-fed carcasses will score the same for sensory tenderness as AB and B-age grass fed carcasses after 3 days ageing and only after 14 days (not considered here) will zilpaterol treated loins score higher than B-age loins (Figure 7), which contrasts the results of Crossley (1994) before the use of beta agonists. According to Figute 8, SF values show that zilpaterol loins are significantly tougher than AB and B loins at 3 days post mortem.
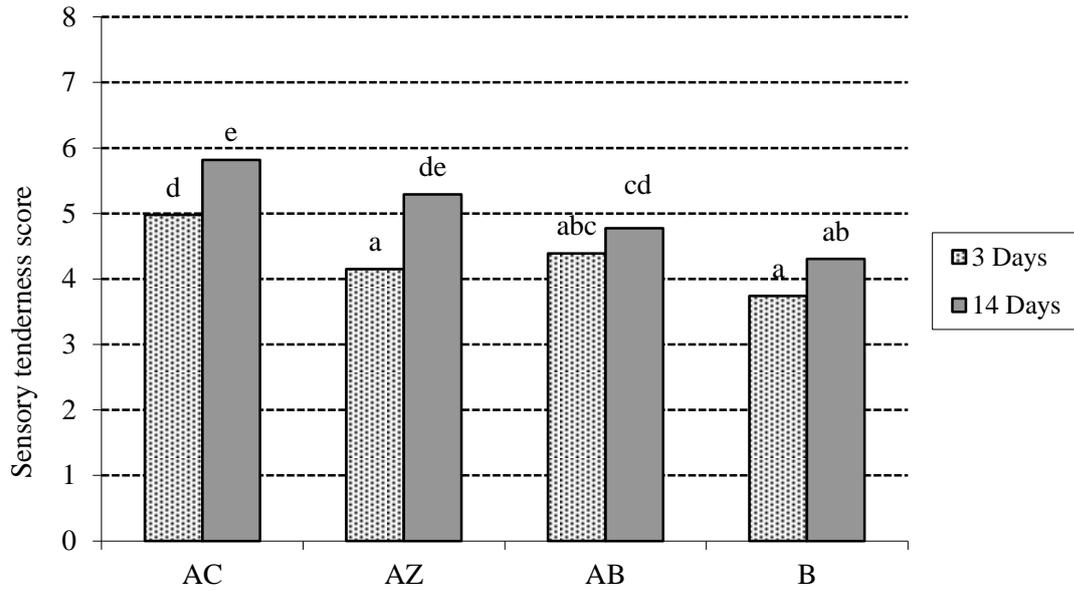
Figure 7 Sensory tenderness values of *m. longissimus lumborum* from 4 age/treatment groups at 3 and 14 days post mortem

([a,b,c] Bars with different superscripts differ significantly, *P*<0.05; Sensory tenderness: 1 – extremely tough; 8 – extremely tender; AC = A age with no zilpaterol treatment, grain-fed; AZ = A age with zilpaterol treatment, grain-fed; AB = AB age, grass-fed; B = B age, grass-fed)

Figure 8 Warner Bratzler shear force of *m. longissimus lumborum* from 4 age/treatment groups at 3 and 14 days post mortem ([a,b,c] Bars with different superscripts differ significantly, *P*<0.05; AC = A age with no zilpaterol treatment, grain-fed; AZ = A age with zilpaterol treatment, grain-fed; AB = AB age, grass-fed; B = B age, grass-fed).
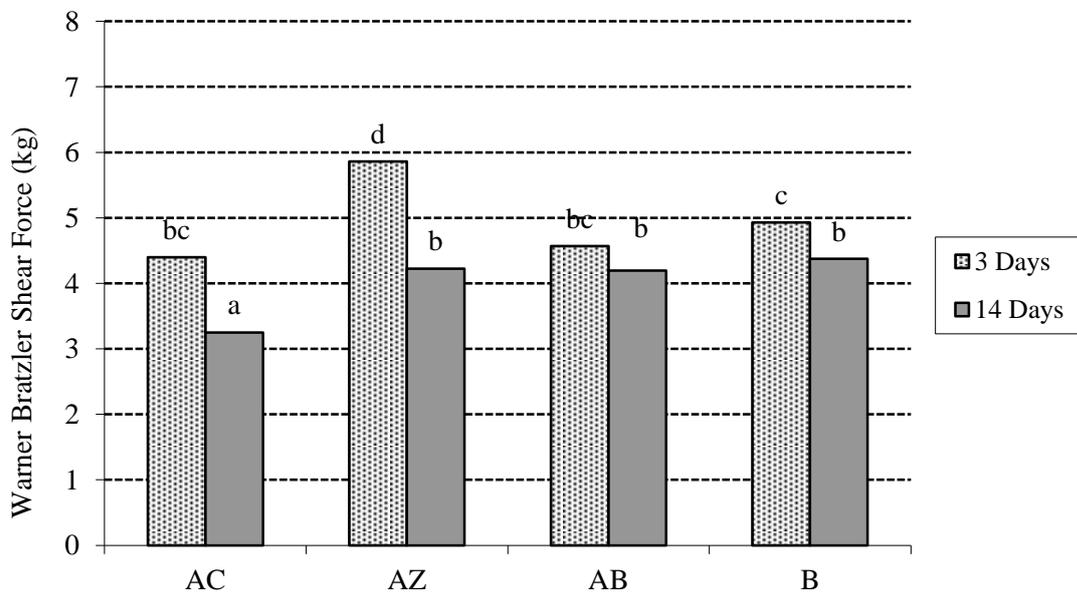
In high connective tissue cuts like the *biceps femoris* (square muscle of the silverside), age driven by connective tissue properties overshadowed the effect of zilpaterol and the same differences among ages were found as in Crossley's study (Figure 9 and 10). This was despite the use of a moist cooking method.

How this should influence decisions about the classification system is debateable. One can argue that there should be a distinction between carcasses produced with beta-agonists and those that are not. However, a counter argument could be that the proportion of non-users in commercial feedlots are relatively small or insignificant. There seems to be a trend by some larger producers to change part of their production output to beta-agonist-free carcasses for the purpose of servicing a specific market segment. Therefore it may happen in future that the proportion of non-beta agonist carcasses will increase. The use of beta agonists and the effect on eating quality of at least the low connective tissue cuts (loin, rump, fillet and rib-eye) complicates the decision concerned with distinguishing between A and AB carcasses (and even B carcasses) because it is clear that the low connective tissue cuts of the older animals may now have the same or higher level of acceptability as the same cuts from beta agonist A age carcasses. But the argument against such a proposition would be that the rest of the carcass (the remaining higher connective tissue cuts) that is mainly affected by age is correctly classified as different from those of A age carcasses. It is also common knowledge that certain feed supplements used outside the commercial feedlot operation may include zilpaterol (Zilmol from Voermol) so that on the farm feeding may also include the use of zilpaterol and it may happen that older animals are rounded off (final feeding days) on a grain-based diet complemented with this feed mix.
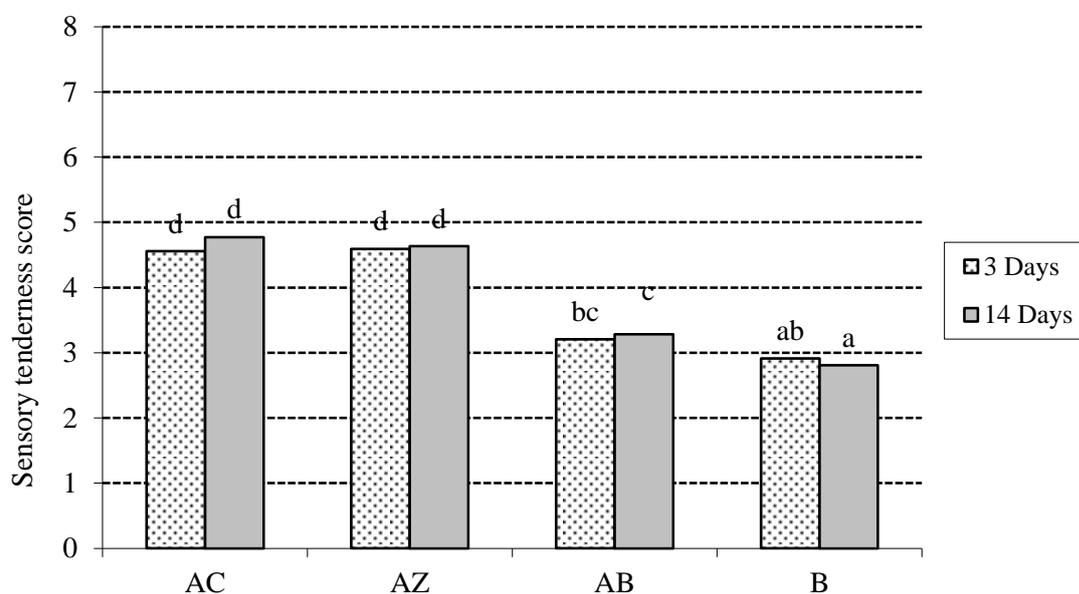

Figure 9 Sensory tenderness values of *m. biceps femoris* (silverside) from 4 age/treatment groups at 3 and 14 days post mortem ([a,b,c] Bars with different superscripts differ significantly, *P*<0.05; Sensory tenderness: 1 – extremely tough; 8 – extremely tender; AC = A age with no zilpaterol treatment, grain-fed; AZ = A age with zilpaterol treatment, grain-fed; AB = AB age, grass-fed; B = B age, grass-fed)

Figure 10 Warner Bratzler shear force of *m. biceps femoris* (silverside) from 4 age/treatment groups at 3 and 14 days post mortem

([a,b,c] Bars with different superscripts differ significantly, *P*<0.05; AC = A age with no zilpaterol treatment, grain-fed; AZ = A age with zilpaterol treatment, grain-fed; AB = AB age, grass-fed; B = B age, grass-fed)
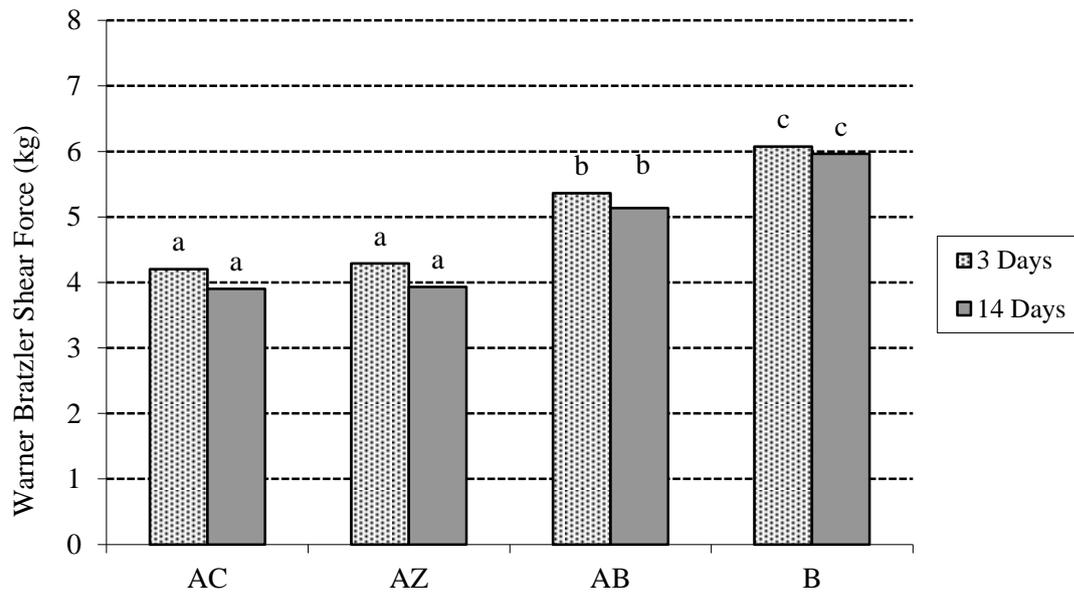
Pre-slaughter practices

Correct pre-slaughter management may also affect tenderness and other meat quality characteristics. While it is often common procedure at abattoirs to keep animals overnight before slaughter the work of Frylinck et al. (2007) showed that shorter lairage rather than long overnight keeping of animals gave better tenderness results (Figure 11). This effect was not as significant as for example ES or the use of beta agonists but is based on the energy status of the animal just before slaughter and like ES can be measured by pH the day after slaughter. This measurement is often required by retailers of specialised products (brand named) to prevent dark cutting meat that also have a poor colour and shelf life.
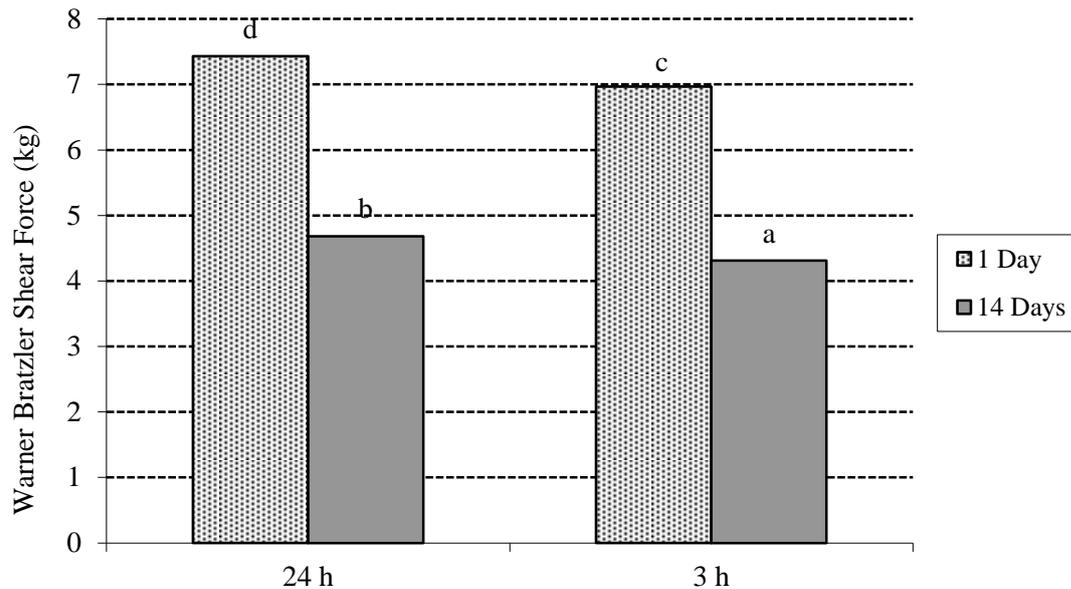
Figure 11 Warner Bratzler shear force of *m. longissimus lumborum* from two feed withdrawal groups (3 h and 24 h before slaughter) at 3 and 14 days post mortem

([a,b,c] Bars with different superscripts differ significantly, *P*<0.05)

Slaughter practices: Chilling, electrical stimulation

We have no recent systematic documented information about the standard slaughter practices in South Africa, with specific reference to practices such as pre-slaughter stress (producer-abattoir interaction), electrical stimulation and chilling. However, as a result of deregulation, it is very likely that abattoir practices are not standardised throughout the industry as it used to be in the days where ABAKOR abattoirs operated in the main centres of the country. This could be due to lack of technical knowledge, lack of commitment to a quality product, i.e. when basic service delivery is the only goal, or lack of infrastructure and little or no incentives to aim at optimisation of such procedures.

Although there is convincing evidence that the application of electrical stimulation improves meat tenderness, particularly of high quality cuts, the proper control of the rigor process, or the conversion of muscle to meat, i.e. management of rigor at correct temperatures, is actually more important for maximum quality with regard to tenderness, water binding properties of meat and colour. The rigor process is the most important link in the quality of meat quality chain. Managing the rigor process correctly implies that applications like electrical stimulation should be regulated together with rate of chilling so that a balance between rigor development (measured as decline in pH) and temperature decline is reached.

Figure 12 demonstrates that electrical stimulation (ES) is always beneficial, at least in a scenario where post mortem ageing is limited, the difference in SF could be as much as 2.4 kg, and at least 1 kg. Figure 12 shows that the correct procedure with consideration of length of stimulation is also important and that shorter, rather than longer durations are in most cases (guided by the type of animals and pre-slaugher practices) beneficial and that over stimulation may negate the advantage of stimulation especially if meat is aged for longer. It may be that ES is standard practice in many but not all abattoirs and that this

procedure is not necessarily always given priority. Should it form part of a classification system, it may be difficult to verify since it may require a pH measurement on the slaughter line which requires a fairly technical skill and knowledge, but with proper training this could be achieved. It will, however have cost implications since a dedicated person is needed on the slaughter line as well as a well-functioning instrument. An alternative may also be to verify whether a stimulator is in use and that it is functioning at all times.
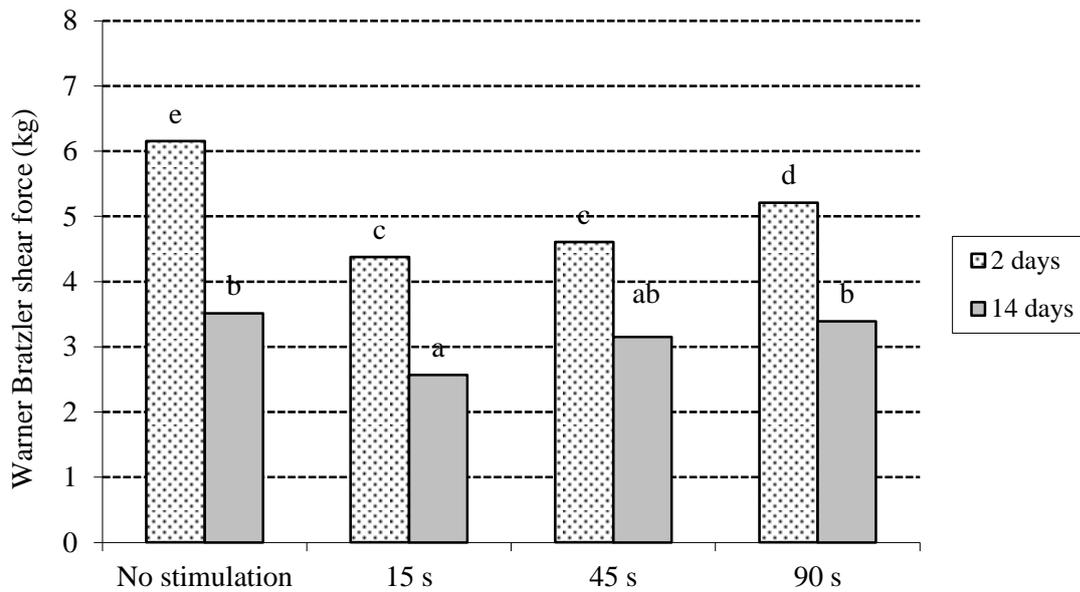

Figure 12. Interaction between electrical stimulation treatment and post mortem aging for Warner Bratzler shear force (WBSF) of *m. longissimus lumborum.* (No electrical stimulation was applied or low voltage electrical stimulation was applied for 15 s, 45 s and 90 s, respectively. Samples were aged for 3 or 14 days post mortem; [a, b, c, d] Bars with different superscripts differ significantly, *P*<0.05)

Based on earlier research, it is commonly believed that the negative effect of beta agonists can be overcome by correct slaughter (ES) and post-slaughter procedures (aging). Although ES reduces the difference in tenderness at 3 days post mortem from 2.6 kg to 1.8 kg, the difference according to Figure 13, the negative effect is still highly significant and probably detectable by the consumer.
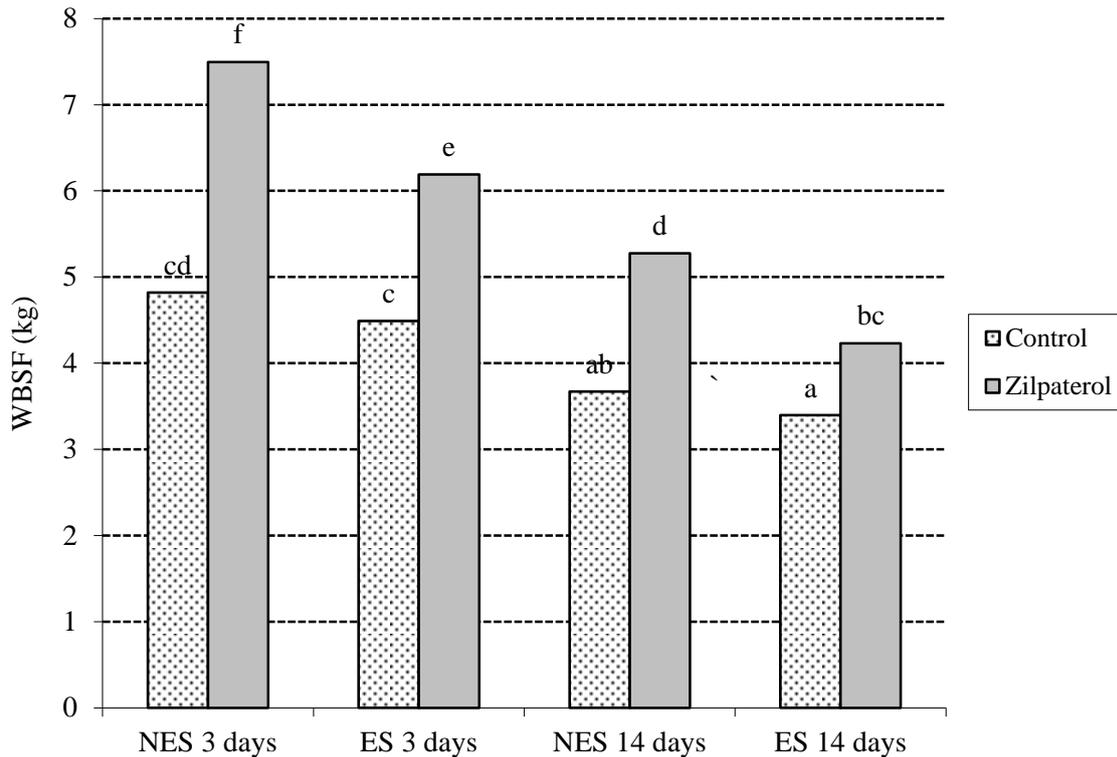
Figure. 13. Interaction between treatment (control and zilpaterol), electrical stimulation and post mortem aging (3 and 14 days) in relation to Warner Bratzler shear force (WBSF) of *m. longissimus lumborum*

([a,b,c,d] Bars with different superscripts differ significantly, $P<0.05$; ES and NES = stimulated and non-stimulated)

Consumer trials

We have previously mentioned the effect of different measuring tools and how the use of scientific tools such as SF or trained sensory panels may or may not relate to consumer acceptance. Thompson et al. (2010) did a study where meat of A-age Bonsmara grain-fed cattle were compared to that of B age grass-fed Nguni cattle. Trained panel and SF values were unfortunately not recorded in this project, but consumers from both rural and urban areas, scored grilled loin samples the same for older grass-fed compared to younger grain-fed cattle using a combined score of tenderness, juiciness, flavour and overall acceptability. In addition, cuts with high connective tissue content such as the shoulder (*triceps brachii*) and chuck (*serratus ventralis*) were scored less acceptable in the older grass-fed animals compared to the younger grain-fed animals. Considering all the other effects that were discussed earlier, the grain-fed animals in this study were implanted with HGP's but did not receive zilpaterol as further growth promotant. Both groups of animals had limited pre-slaughter stress, were slaughtered at the same abattoir and received the same electrical stimulation and chilling prcedures, while samples were aged for the same number of days (5 days – not best and not worst scenario). Apart from the effect of zilpaterol that was not verified here, this study indicates that at a consumer level, older grass-fed animals may be as acceptable to the consumer as younger grain-fed animals when low connective tissue cuts are considered, but not for high connective tissue cuts and this corresponds in broad

terms with most previous studies that only investigated age, i.e. young grain-fed vs. older grass-fed under ideal slaughter conditions with no zilpaterol in the treatment groups.

Conclusions on meat tenderness research and other considerations

It is probably safe to conclude that the South African classification system at present distinguishes between grain-fed animals (mostly A-age, with 1 to 2% AB-age animals and very few A-age pasture animals), younger grass-fed animals (AB-age), older grass-fed animals (B-age) and cull animals (C-age).

When all the studies describing various sources of variation in tenderness are considered, it is evident that these sources are much broader than can be described by age alone, in particular within the A-age grain-fed product. Although the general definition of classification is that it only describes according to certain measurements or scores and does not rank carcasses according to quality and price, the probability of experiencing a "bad steak" (specifically referring low connective tissue cuts) in the A-class (feedlot) has probably increased since the implementation of the current South African classification system. This could undoubtedly be attributed to the use of zilpaterol but also to variation in pre-slaughter and slaughter practices, such as chilling, ES and pre-slaughter stress that became more variable since deregulation. Since carcass weight has increased over the past two decades the challenge of proper processing (pre-, slaughter and post-slaughter) for optimum quality is becoming more evident. Variation in quality (tenderness) at shelf level is obviously also a function of the amount of ageing of meat (in this case low-connective tissue cuts), in other words the post-abattoir practice that can not be covered by any classification system. Variability caused by a lack of consistency in post-abattoir practice is a major problem and in our opinion the consumer suffers as a result of poor information provided by the retailer, causing a lack of trust in the final product. However, it should be emphasised that pre-slaughter and slaughter practices also influence aging potential (development of quality) of meat.

Considering these different factors that influence quality or may influence consumer decision and may have to be considered in adjustments of a classification system:

- It would make no sense to distinguish between carcasses produced with or without zilpaterol as almost all A-age grain-fed carcasses are produced with zilpaterol and the small proportion that are produced without the product are marketed through brand named products.
- Verifying the correct pre-slaughter management and the use of electrical stimulation and chilling proves to be technically difficult (pH/temperature measurements). Considering that large operations are normally using ES (not necessarily optimally in combination with chilling), then it can be assumed that a large proportion of carcasses benefit from reasonably good abattoir practice. However, the variation in meat quality recorded in a recent audit suggested otherwise and in addition, smaller operations may not fare as well as larger operations for reasons mentioned earlier.
- Breed and breed type has never been considered, but due to a significant level of crossbreeding in South Africa, breed factor will also be difficult to describe in a system. Hump height (i.e. measuring the amount of *Bos indicus*) as used by the MLA (Australian) grading system, will have poor results in South Africa since other tropically adapted breeds without indicus genes, such as Bonsmara, Nguni, Afrikaner, Tuli, Drakensberger will be unfairly penalised.

- Fat colour may contribute to a better description of the carcass and may solve some of the discriminatory issues from retailers regarding fat colour. This trait has nothing to do with palatability and there is not sufficient local evidence that consumers do or do not discriminate against yellow fat. Buyers may use fat colour to negotiate lower prices.

The fact that the classification system indirectly distinguishes between pasture- and grain-fed animals may be more relevant when referring to the tenderness of cuts which are particularly high in connective tissue (Crosley *et al.,* 1994 and recent studies). It has to be considered that these cuts contribute a large proportion of the total meat of the carcass.

To distinguish between pasture- and grain-fed animals is also relevant when other quality characteristics are considered, such as fat colour and flavour. Wood *et al.* (2003), Campo *et al.* (2006) and our own studies (Strydom et al., 2013, Moholisa et al., 2014; Strydom, 2014) found that the fatty acid compositions of pasture and grain fed animals differ and that these differences relate to differences (not preferences) in taste (flavour, juiciness, aroma). Sañudo *et al.* (1998) described the significance of culinary cultural background in relation to the acceptance of meat produced from pasture or feedlots, thereby indicating preferences for flavour or taste based on experience. These studies emphasised the fact that the description (through classification) of two products that could be experienced differently by different consumers but without one-sided preference, is probably the main objective of classification if variation in consumer preferences are expected. The study of Strydom *et al.* (2013) and Strydom (2014) clearly showed that flavours related to a grass diet (as opposed to grain) were more likely to be noticed in meat of older pasture reared cattle (AB and B) than in cuts of grain- (A and AB) and young grass-fed animals (A) (Figure 14). The problem of the current classification system in this regard is that AB class animals on different feeding regimes may produce a completely different product with regard to taste. Given the small proportion of AB carcasses this may not have a large impact on consumer acceptability.
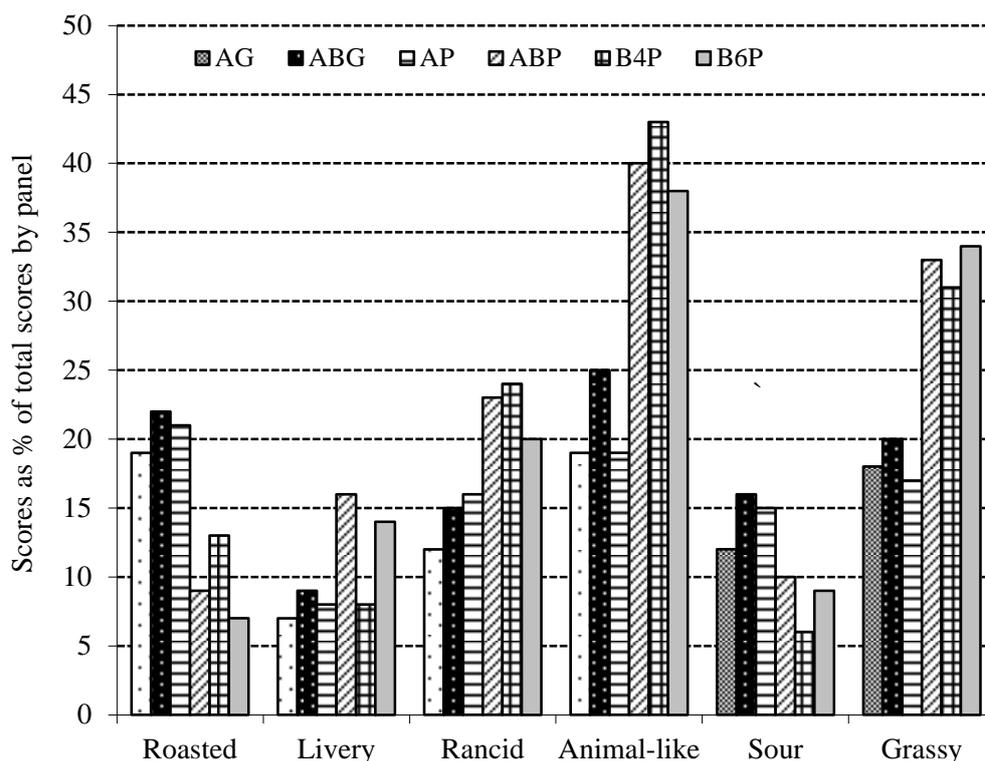
Figure 14 Frequencies of scores for different flavour overtones noted in loin cuts of different age and feeding regime groups. (Frequencies indicate the number of times a specific attribute was noted in a steak by a ten member sensory panel as % of total steaks (10 per group) tested by all members – 100 opportunities; Age groups A, AB B4, B6, respectively indicating 0, 2, 4 and 6 permanent incisors; Feeding regime described as "G" for grain-fed and "P" for pasture-reared)

Further considerations unrelated to research

It was argued in the popular press that a classification system should accommodate equitably reward various production systems. It is suggested that different age classes should be combined sin order for the producers of older animals (e.g. AB) to also benefit from a higher price category for instance what producers of A-class (i.e. grain-fed) carcasses enjoy. In response, one may argue that the % of AB carcasses are so small that it may not matter whether these are included in the A-class, although it is unknown if this practice will promote the production of AB carcasses from pasture (e.g. by current weaner calf producers) and whether our natural resources can accommodate such a change in production system in a sustainable manner (also considering the demand for beef). From the research on tenderness and various sources of variation in tenderness as discussed before, the argument may have some merit, but a stronger argument against it is that pasture vs. grain-fed animals have proven to be a unique product with regards to visual appeal but also overall eating quality, in particular flavour, so that the unique qualities of either product may be lost when combining them into a single class, especially when considering that the classification system describes and not ranks carcasses with regards to different characteristics. It should further be emphasised that retailers (probably not smaller buyers) are increasingly willing to pay A-age prices for older grass-fed carcasses. It may therefore be a question of proper

marketing of a unique product that may solve price issues rather than changing the classification system for this purpose.

Further arguments that the current system discourage the farming of smaller indigenous cattle breeds that are beneficial for acting against climate change simply does not make sense as a combination of age classes will simply not encourage feedlot operations to offer higher prices for weaners from indigenous breeds. Furthermore, the fact that these breeds are very suitable for pasture rearing systems emphasise the need to establish proper marketing channels for grass-fed cattle.

The consumer

Should the consumer be educated in the classification system? Vermeulen et al. (2015) reported that very few consumers understand the South African red meat classification system, even though up to 58% of middle-class and higher-income consumers give attention to it when purchasing red meat. On the one hand it could be argued that a proper understanding of red meat classification, the links of the system to product quality characteristics and visible on-pack labelling indicating the classification of meat, could empower consumers to make more informed product decisions. On the other hand it could also be argued that while there is no harm in understanding by the general public about the functioning of the classification system, there is probably limited value of placing the classification mark (e.g. age and fatness) on meat labels, for example, and educate the consumer what these codes mean. At the point of sale the consumer purchase with their eyes and fatness will be judged by what they see and not by a labelled fat code. Furthermore, considering the discussed research projects in this document, knowing the age of the animal will give very limited information to the consumer regarding expected eating quality. More specific information, normally provided by **proper** brand naming, such as the number of days aged, the feeding regime (grass vs grain, use of growth promotants, or not), or even the slaughter process will inform consumer much more of expected eating quality

Conclusions, recommendations and the way forward.

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Prof Arno Hugo's commented as follows on the document:

There are problems with the current South African meat classification system.

The Meat Standards Australia (MSA) system seems to hold the most potential for implementation in South Africa. Dr Strydom mentioned that it will have to be adapted for the South African situation (less emphasis on marbling and a beta-agonist factor will have to be included). He mentioned that the MSA system requires high technical skills, well organised infrastructure , proper traciblity, high level of integrity of role players. None of these requirement can be bad for the South African meat industry. He mentioned that it can be costly and would require high additional personnel cost. The meat industry must decide if they want such a system and must then be prepared to accept the challenge to implement it and be willing to carry the additional cost over the long term. It is important to realize that at some point something like a proper traceability system will anyway have to be implemented.

If the meat industry is not willing to implement a more costly MSA like system we will have to live with the current classification system and make the best of it. It may be possible to change it slightly. What about including a mark indicating if the carcass was electrically simulated or not? What about a mark that give a visual score fat fat colour (white to yellow)?

There is a few things that the current classification system will never be able to address. SAMIC have a system of "auditable claims that I believe may be used to supplement the current classification system. Such a system may be used to verify and audit claims on a product. A feedlot for example may feed some cattle beta-agonist free and market the cattle as such with SAMIC auditing the claim. Similirlay, grassfed cattle can be marketed as such wit a SAMIC audited claim. Similarly a a special antemortem or special post-mortem treatment like special animal treatment, electrical stimulation, a special ripening or maturation procedure or meat cutmay also be audited by SAMIC.

Maybe herein lay the answer - to keep the classification system simple. This cheap and simple system can then be used for basic price formation based on age, fatness, conformation etc. A supplementary system of auditable claims to produce a product that can adhere to some consumers requirements for consistency and quality. SAMIC can audit the claim and the producer of such a product or "brand" is responsible for marketing it.

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