EFFECT OF BETA-AGONIST AND AGE ON TENDERNESS OF LONGISSIMUS DORSI AND BICEPS FEMORIS MUSCLES OF GRASSFED AND FEEDLOT STEERS

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Abstract – Tenderness of *M.longissimusdorsi* (LD) and *M. biceps femoris*(BF) muscles of three different age groups according to South African beef carcass classification system was evaluated. Fourty weaner Bonsmara steers (A-age group) from feedlot and 40 grass fed Bonsmara steers (AB-age and B-age groups) were used. Twenty A-age animals were supplemented with Beta-agonist (zilpaterol, AZ) and the remaining 20 animals were used as a control group (AC). Parameters measured included collagen properties, myofibrillar fragmentation lengths (MFLs) and Warner-Bratzler shear force (WBSF). Percentage collagen solubility decreased with increasing animal age for BF and LD. Zilpaterol treatment reduced total collagen and increased collagen solubility. AZ LD samples were tougher than AC, AB and B LD samples at 3 days aging period showing the negative effect of the beta agonist on tenderness. However, in the BF muscle collagen properties as influenced by age overshadowed the negative effect of the beta agonist on tenderness. Longer MFL for AZ were associated with higher WBSF in the LD, but not in the BF.

Key Words – Collagen, histological measurements, Shear-force measurements

I. INTRODUCTION

Meat tenderness in particular, is influenced by a combination of pre-harvest slaughter and post-harvest conditions and interventions [1]. For this reason it is difficult to describe or predict product quality such as tenderness based on a single factor like age or nutritional system alone. In South Africa beef is classified according to the age of the animal determined by dentition. A-age is younger animal (0 tooth) mostly found in feedlots, while AB - and B - ages represent older animals (1 – 2 and 3 – 6 teeth), respectively [2].

Since the implementation of the classification system in 1994, much have changed in the production and processing sectors that could affect quality, even within age classes. For example, beta-agonists are used as metabolic modifier by most feedlots in South Africa.

This study investigates the effect of beta-agonist and animal age on tenderness of 2 beef muscles.

II. MATERIALS AND METHODS

Twenty each of AB and B age Bonsmara steers [2] were purchased from a commercial farmer and represented the two grass fed groups. Fourty weaner steers which represented the A-age groups were grain fed under commercial feedlot conditions for approximately 110 days. Twenty steers (AZ) were supplemented with beta agonist (zilpaterol) for the final 30 days with 2 days withdrawal. The remaining twenty received no zilpaterol, and were used as control group (AC). All the animals were electrically stimulated and slaughtered at an optimum market condition (fat code 2-3) [2]. *M. longissimusdorsi* (LD)*, M. biceps femoris* (BF), were sampled, vacuum aged for 3 and 14 days, and stored frozen at - 20°C until used to measure WBSF and MFL. Collagen properties were measured on unaged frozen samples.

Collagen content and solubility were determined according to the methods of Weber [3] Bergman and Loxley [4], Boccard et al. [5] and Hill [6]. For WBSF frozen LD samples were processed into steaks of 30mm, vacuum packaged again and thawed at 4°C for 24 hours before preparation by oven broiling. BF muscle was prepared in sub-primal form in an oven casserole, 100 ml distilled water added. Both muscles were cooked at 160°C

to internal temperature of 70°C [7]. Shear force resistance was measured on cooked samples by means of a Warner-Bratzler shear device (Model 4301; Instron Corporation, 1990), according to the method described bythe American Meat Science Association (AMSA) [8]. MFLwas measured by means of VIA. Myofibrillar fragments lengths were extracted according to Culler et al. [9] as modified by Heinze and Bruggemann [10]. One hundred myofibril fragments per sample were examined and measured with Olympus BX40 system microscope at a 400X magnification.

For statistical analysis, differences between treatments were determined by using a one-way analysis of variance (ANOVA) procedure. Age groups were used for collagen, and differences between age and post mortem aging were used for MFL and WBSF. The Tukey-Kramer multiple comparison test (α =0.05) was used to determine differences between treatment means [11].

III. RESULTS AND DISCUSSION

Collagen properties of LD and BF are presented in Table 1 and 2. The AB and B age groups had significantly ($p<0.001$) higher collagen content than AZ in both muscles but did not differ from AC. The lower collagen content of AZ samples can probably be linked to muscle hypertrophy, and agrees with the study of Strydom et al. [12]. Collagen solubility decreased significantly with age for both muscles which agreed with the study of Shorthose and Harris [13] and Schönfeldt and Strydom, [14]. However, the effect was less pronounced between AB and B for BF.

MFLs for LD and BF of all age groups were significantly ($p<0.001$) longer at 3 days compared to 14 days post mortem aging (Fig. 1). In addition, the 3 days MFL's of AZ were the longest of all age groups for both muscles. Shorter MFLs are associated with higher degree of proteolysis and therefore tenderisation [15].

For WBSF (Figure 2), AZ LD samples were significantly tougher than AC LD at 3 days and had numerically higher values than AB and B. Post mortem aging to 14 days improved tenderness significantly for all age groups in

Table 1 Collagen characteristics of *M.longissimusdorsi*

Age	AC	AZ	AB	B
Collagen content[1]	1.92^{b}	1.33^{a}	1.78^{b}	1.74^{b}
% Collagen solubility	10.48^{c}	11.17^{c}	8.89^{b}	7.33^{a}

$P<0.001$
[a,b]Means with different supercripts differ significantly.
[1]Hydroxy-proline N/Total N x 10^3

Table 2 Collagen characteristics of *M. biceps femoris*

Age	AC	AZ	AB	B
Collagen content[1]	2.81^{ab}	2.32^{a}	3.04^{b}	3.09^{b}
% Collagen solubility	9.09^{b}	9.93^{b}	6.74^{a}	6.22^{a}

$P<0.001$
[a,b]Means with different supercripts differ significantly.
[1]Hydroxy-proline N/Total N x 10^3

the LD muscle. In addition, LD samples of AB and B aged for 3 days were tougher than AC samples and B was still tougher than AC at 14 days. Much of the disadvantage of zilpaterol was cancelled after 14 days aging in the LD although AC samples still had a slight advantage ($P>0.05$) over AZ. The observation agrees with other studies regarding the effect of beta-agonists on beef tenderness [16, 17]. The significant difference between AC and AZ recorded in LD was not repeated in the BF muscle, irrespective of aging duration. Strydom et al. [12] also showed that beta agonists had a smaller effect on shear force tenderness of higher collagen muscle (*m semitendinosus*), than on lower collagen muscles (*l. longissimus*). Animal age had a significant negative effect on tenderness of the BF which is in agreement with Shorthouse and Harris [13] for high connective tissue cuts. Aging also had little effect in lowering WBSF of this cut.

Both muscles showed myofibrillar breakdown as reflected in shorter MFLs [15]. However, differences in tenderness between A, AB and B groups for BF samples coincided with lower soluble collagen content for AB and B samples and since this cut contains higher collagen than

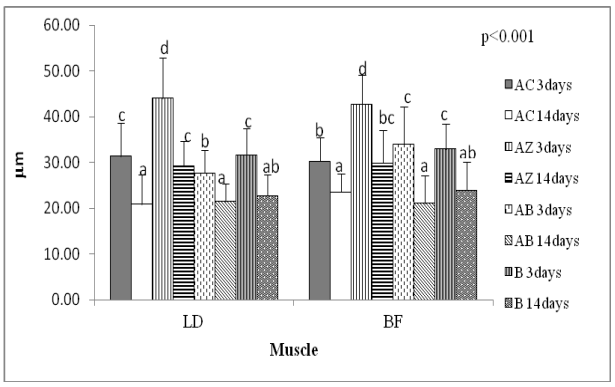

Figure 1. Myofibrillar fragmentation lengths
Means with different supercripts differ significantly.
Error bars represent standard deviation.

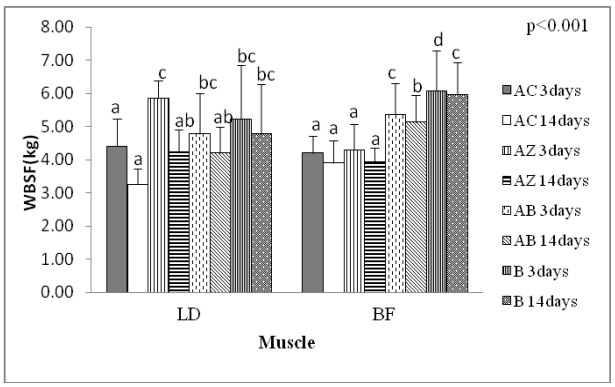

Figure 2. Warner-Bratzler shear force (WBSF)
Means with different supercripts differ significantly.
Error bars represent standard deviation.

the LD, it can be expected that the effect of reduction in MFL (therefore aging) from 3 to 14 days was overshadowed by higher collagen levels and lower solubility [13]. In contrast, the LD being a low connective tissue cut showed a higher response to myofibrillar breakdown for all age groups despite lower collagen solubility in older animals. The high initial MFL and WBSF values for AZ LD samples confirm the negative effect of zilpaterol on maturation potential and it is significant that aged AZ LD samples showed similar tenderness values than AB and still tended to be tougher than AC.

IV. CONCLUSION

Zilpaterol supplementation has marked influence on tenderness and caused variation in tenderness of the LD within the younger age group mostly due to retarded aging. For shorter aged LD steaks this effect may cause tougher cuts than steaks from older pasture raised animals. It was confirmed that zilpaterol did not have the same effect on high connective tissue cuts and that age of the animal may play a dominant role in WBSF in these cuts. Therefore if age classification is intended to distinguish between classes of tenderness based on number of incisors, then the South African Beef Carcass Classification will fail to distinguish between certain cuts among A age carcasses if zilpaterol is used or not.

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REFERENCES

1. Ferguson, D. M, Bruce H. L., Thompson J. M., Egan A. F., Perry, D. & Shorthose W. R.(2001). Factors affecting beef palatability - farm gate to chilled carcass. Australian Journal of Experimental Agriculture 41: 879–891.
2. Government notice No. R.342 of March 1999. Regulations regarding the classification and marketing of meat. Goverment Gazzette of the Republic of South Africa.
3. Weber, R. (1973). The determination of hydroxyproline and chloride in meat and meat products: Simulteneous operation with nitrogen and phosphorus determinations. Technicon International Division SA. Tecnical Report 7.
4. Bergman, I. & Loxley, R. (1963). Two improved and simplified methods for the spectrophotometric determination of hydroxyproline. Analytical Chemistry 35: 1961-1965.
5. Boccard, R. L, Naudé, R. T., Cronjé, D. E., Smith, M. C., Venter, H. J. & Rossouw, E. J. (1979). The influence of age, sex and breed of cattle on their muscle characteristics. Meat Science 3: 261-280.
6. Hill, F. (1966). The solubility of intramuscular collagen on meat animals of various age. Journal of Food Science 31: 161-166.
7. AMSA. (1978). Guidelines for Cookery and Sensory Evaluation of Meat. Chicago. Illinois. National Livestock and Meat Board.
8. AMSA. (1995). Research Guidelines for Cookery, Sensory Evaluation of Meat and

Instrumental Tenderness Measurements of Fresh Meat. Chicago. Illinois. National Livestock and Meat Board.
9. Culler, R. D., Parrish, F. C., Smith, G. C., & Cross, H. R. (1978). Relationship of myofibril fragmentation index to certain chemical, physical and sensory characteristics of bovine longissimus muscle. Journal of Food Science 43: 1177-1180.
10. Heinze, P. H., & Bruggemann, D. (1994). Ageing of beef: Influence of two ageing methods on sensory properties and myofibrillar proteins. Sciences Des Aliments 14: 387-399.
11. NCSS. (2007). Statistical System for Windows. Number Cruncher Statistical Systems. Kaysville, Utah, USA.
12. Strydom, P. E., Frylinck, L., Montgomery, J. L. & Smith, M.F. (2009). The comparison of three β-agonists for growth performance, carcass characteristics and meat quality of feedlot cattle. Meat Science 81: 557-564.
13. Shorthose, W. R. & Harris, P. V. (1990). Effect of animal age on thetenderness of selected beef muscles. Journal of Food Science 55:1–8.
14. Schönfeldt, H. C. & Strydom, P. E. (2011). Effect of age and cut on tenderness of South African beef. Meat Science 87: 206-218.
15. Olson, D. G., Parish, F. C. & Stromer, M. H. (1976). Myofibrillar fragmentation and shear resistance of three bovine muscle during post mortem storage. Journal of Food Science 40: 1036-1041.
16. Avendanño-Reyes, L., Torres-Rodríguez, Meraz-Murillo, F. J., Peréz-Linares, C., Figueroa-Saavedra, F. & Robnsin, P. H. (2006). Effects of two beta-agonists on finishing performance, carcass characteristics, and meat quality of feetlot steers. Jounal of Animal Science 84: 3259-3265.
17. Delmore, R., Hodgen, J. M. & Johnson, B. J. (2010). Perspective on the application of zilpaterol hydrochloride in the United States beef industry. Journal of Animal Science 88: 2825-2828.