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Effect of age and cut on tenderness of South African beef

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ABSTRACT

The tenderness characteristics of 15 primal cuts of beef of three different age groups were assessed, and the most reliable cut to predict carcass tenderness was determined. Fifteen wholesale cuts from each age group, representing the full variation in fatness, were aged, cooked and underwent sensory evaluation, shear force resistance and proximate analysis. Collagen content and solubility was determined.
Percentage fat was used as a covariant during statistical analyses. Tenderness, residue and collagen solubility of all cuts decreased significantly with animal age. Collagen solubility was the largest discriminant between the three age groups, while animal age had no significant effect on collagen content. Tenderness of primal cuts from the same carcass varied considerably, with collagen content and shear force resistance as the largest discriminants between the cuts. Cuts most representative of total carcass tenderness were M. vastus lateralis, M. semimembranosus, M. gluteobiceps, M. semitendinosus and M. triceps brachii caput longum.

1. Introduction

Tenderness is a primary determinant of the eating quality and acceptability of meat (Voges et al., 2007; Destefanis, Brugiapaglia, Barge, & Molin, 2008). This is easily confirmed by the positive relationship between the price of a cut of meat and its relative tenderness (Miller, Carr, Ramsey, Crockett, & Hoover, 2001). Consumer preference studies of sensory attributes in samples of whole cuts of beef usually rate tenderness as the most important criterion, compared to flavour and juiciness (Tornberg, 1996; Destefanis et al., 2008).

Meat tenderness is evaluated by both sensory and instrumental methods. The Warner–Bratzler shear method is the most widely used and yields the best correlation with sensory panel scores for tenderness within muscles. However, the results are widely variable (Destefanis et al., 2008), dependent on experimental conditions and are difficult to interpret in structural terms. Since meat is eaten, tenderness evaluation by the human senses (by consumers and/or trained sensory panels) is the ultimate test (Tornberg, 1996; Destefanis et al., 2008). When sensory measurements are related to consumer preference, it is evident that texture, and especially tenderness and juiciness, have a substantial effect on meat cut preference.

Meat tenderness originates in the structural and biochemical properties of skeletal muscle fibres, especially myofibrils and intermediate filaments, and in the intramuscular connective tissue, the endomysium and the perimysium, which are composed of collagen fibrils and fibres (Takahashi, 1996). According to Koohmaraie (1994) the tenderness of meat is influenced by the following variables: animal age and gender, rate and extent of glycolysis, amount and solubility of collagen, sarcomere length, ionic strength and degradation of myofibrillar proteins by the proteinases. In addition Belew, Brooks, McKenna, and Savell (2003) states that post-mortem proteolysis, intramascular fat and marbling, connective tissue and the contractile state of the muscle is the characteristics that mostly influences tenderness. In young animals the relationship of connective tissue relative to myofibrils are important, especially in cuts such as the loin. As the animal ages, connective tissue becomes more prominent in cuts with high amounts of connective tissue, e.g. the rump.

Numerous researchers (Young & Braggins, 1993; Xiong et al., 2007) have investigated the relationship between the age of the animal and the palatability traits of the beef. The results of these studies have consistently shown that as the age of the animal advances the beef palatability (in terms of tenderness) decreases due to decreasing amounts of heat-labile collagen. Shorthose and Harris (1990) confirmed that animal age is an important factor in determining the tenderness and acceptability of meat. Their findings showed that the mean tenderness of twelve beef muscles from animals of eight age groups (ranging from one to approximately 60 months old), decreased significantly ($p<0001$) with age and that the rate of toughening of these individual muscles was related to their connective tissue strength. It should be noted that these carcasses were pre-treated to minimize pre-rigor myofibrillar shortening. The South African beef carcass classification system incorporates two variables, namely age by dentition (indicating tenderness) and

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carcass fat cover (indicating fatness and lean yield) (Government Gazette No. 5092, 1993). Age by dentition was the variable incorporated in this study, as it was deemed essential to elucidate how the tenderness of different cuts varies with age, and how the tenderness of one cut relates to that of others.

Fifteen wholesale beef cuts (Meat Science Section, 1981) are traditionally identified by the industry as representative of the portioned carcass. These cuts may be divided into two categories: those traditionally associated with a dry heat cooking method, and those traditionally associated with a moist heat cooking method.

The main objective of the study was to determine the effect of age on the tenderness-related quality characteristics of seven and eight primal cuts of beef cooked according to a dry and moist heat method respectively, from beef animals of three different age groups. This study formed part of a greater research project which formed the basis for the South African classification system for beef, and based on these results an additional age class was introduced. The carcass classification system was originally developed using young animals (n = 25) and the prime rib cut and extrapolated to include all carcasses produced and sold in the country (Naudé, 1994). It was deemed imperative to investigate if this still holds true. All data were statistically analysed with carcass fat content as a covariant to adjust for initial differences in carcass fat content as carcass fatness influences tenderness (Belew et al., 2003).

Since the beef carcass classification system in South Africa is a dynamic system and changes according to consumer demand, it could be useful to develop statistical models that adapt to changes in age groupings. Therefore, a second objective was identified namely the prediction of the tenderness characteristics of various age groups. Determining the most reliable cut in order to predict the tenderness of the carcass was investigated as the third objective.

2. Materials and methods

2.1. Source of materials

The beef carcasses ($n = 102$) used ranged in weight from 190 kg to 240 kg. No specific breed was chosen. Only steers and heifers were included in the study. The three age groups were the 0 (no permanent incisors) or A-age group, the 2 (permanent incisors) or B-age group, and the 8 tooth or C-age group. Carcasses representing the full spectrum of fat classes available in the South African market within each age group were selected. The research design is given in Table 1.

The carcasses were obtained on the commercial market and had been selected by qualified classifiers. The carcasses were electrically stimulated (500 V) within 10 min of stunning, dressed, halved, chilled overnight at between 0 °C and 5 °C and were labelled and transported to the Animal Nutrition Animal Products Institute of the Agricultural Research Council (ARC-ANPI) in a refrigerated truck at between 5 °C and 7 °C.

Table 1
Experimental design for determination of tenderness and collagen characteristics of beef carcasses.

Carcasses	Age group			Total number of carcasses
	A	B	C	
All right sides				
Physical composition and chemical analysis	35	34	33	102
Left sides				
Tenderness determinations	21	20	20	61
Collagen determinations	14	14	13	41

2.2. Sample preparation

Each of the 102 right sides of beef was subdivided three days after slaughter into 15 wholesale cuts to determine its physical composition and for chemical analysis. This involved subdivision of the cuts into subcutaneous fat, meat and bone. The subcutaneous fat plus meat were cubed, thoroughly mixed and then minced first through a 5 mm and then through a 2 mm mesh plate. A representative sample of 300 g of the subcutaneous fat plus meat tissue obtained from each cut was analysed to determine the percentages of total moisture, fat, nitrogen (N × 6.25 = protein) and ash. These determinations were performed according to Association of Official Analytical Chemists (1995). The chemical analysis results were combined with the subcutaneous fat and meat (muscle and inter- and intramuscular fat) content results obtained from the physical dissections for the calculation of muscle and total fat content of each specific cut, and expressed as a percentage of carcass mass (Carroll & Conniffe, 1967). The muscles included in this study were silverside (M. semitendinosus (ST)), hind shin (M. flexor digitorum medialis (FDM)), topside (M. semimmbranosus (SM)), silverside (M. glutebiceps (GB)), thick flank (M. vastus lateralis (VL)), fillet (M. psoas major (PM)), rump (M. gluteus medius (GM)), thin flank (M. obliques abdomimus externus (OAE), loin (M. longissimus lumborum (LL), wing rib (M. longissimus thoracis (LTW)), prime rib (M. longissimus thoracis (LTP)), brisket (M. pectoralis profundus (PP)), chuck (M. serratus ventralis (SV)), shoulder (M. triceps brachii caput longum (TBCL)), fore shin (M. extensor carpi radialis (ECR)) and neck (M. biventer cervicis (BC)).

Forty-one of the left beef sides were used for total collagen content and solubility determinations. The sides were separated three days after slaughter into 15 wholesale cuts (at 10 °C), vacuum-packaged and aged at 4 °C for 10 days post-slaughter. The cuts were then deboned if applicable and analysed as indicated: chuck (hump and thick elastin sinew removed), PP, neck (visible fat removed), thin flank (visible fat removed), and shins (thick collagen sinew and visible fat removed). The epimysium was removed from the following muscles: LTP, LL, LTW, GM, SM, ST, PM, TBCL, GB and VL. Whole cuts or muscles were homogenised, vacuum-packaged and stored at −40 °C until analysed for collagen content and solubility.

Sixty-one left sides were used for sensory analysis and shear force measurements. They were portioned into 15 wholesale cuts with the rump and topside deboned. The cuts were then vacuum-packaged, aged at 4 °C for 10 days post-slaughter and stored at −40 °C prior to sensory analysis and shear force resistance measurements. The cuts were defrosted at 6 °C–8 °C for periods varying between 24 and 36 h (depending on size) until the internal temperature reached 2 °C–5 °C (American Meat Science Association, 1978).

The largest muscle in each cut was selected for evaluation of tenderness. During the various pilot studies, it became clear that the internal temperature of certain muscles, e.g. M. semimembranosus, was considerably different from that of the rest of the topside cut due to its anatomical position. It was therefore decided to measure the internal temperature only of the muscle to be evaluated. A J-type thermocouple placed in the geometric centre of each muscle to be evaluated, linked to a centrally controlled computer system, was used to record internal temperature. A hand-model Kane–Mane probe equipped with a T-type thermocouple was used to check the final temperature (70 °C) of the cut prior to removal from the oven.

2.3. Cooking methods

2.3.1. Dry heat cooking methods

The following cuts (*muscles*) were used: Prime rib—8th to 10th rib (M. longissimus thoracis (LTP)); Loin (M. longissimus lumborum (LL)); Wing rib—11th to 13th rib (M. longissimus thoracis (LTW)); Rump (M. gluteus medius (GM)); Topside (M. semimembranosus (SM)); Silverside (M. semitendinosus (ST)) and Fillet (M. psoas major