How Much Progress Can Be Made Selecting For Palatability Traits?

T.A. Olson, D.D. Johnson, and R.L. West
Department of Animal Sciences
University of Florida
Gainesville, Florida

Introduction

Beef palatability traits include incidence of connective tissue, juiciness, and flavor but what I am going to focus on in this presentation are Warner-Bratzler shear values and taste panel tenderness. These latter two characteristics are those about which we hear the most discussion regarding problems in consumer trials. Warner-Bratzler shear is an objective method of measuring meat tenderness. Steaks are cooked, cores are removed from the steaks, and then a machine measures the force required for a knife-like device to cut through the core of meat. Taste panel tenderness is an evaluation of meat tenderness based on a 1 to 8 scale with 1 being essentially inedible because of its toughness to 8 being extremely tender. Earlier consumer studies have shown that 15 to 20% of steaks were deficient in tenderness and certainly this fact should negatively affect beef consumption. Retailers, in an effort to promote meat sales, guarantee the tenderness of the meat that they sell and restaurants do so as well. The USDA recognizes over 50 certification programs which have as their goal the assurance of some level of guaranteed palatability. The majority of the certification programs refer to Angus, or at least cattle that are black in color. Thus, the issue of meat tenderness and the possibility of improving it through selection, especially in Angus cattle, is highly relevant for this conference. In order to select successfully for a trait we first have to be able to measure the trait in some fashion, apply selection pressure by using the most desirable animals to a greater extent than the less desirable animals (that is, to apply selection pressure in animal breeding lingo) and also, the traits have to be at least moderately heritable. By heritable, I mean that the differences between animals for this trait must be at least partially controlled by genes whose effects are passed consistently on to their progeny, that is, additive genes. In this presentation I will discuss the measures by which we measure tenderness, the difficulties associated with doing so, the heritabilities of tenderness traits and the results to date of a study being conducted at the University of Florida aimed at selecting for Warner-Bratzler shear in Angus cattle.

Previous Studies

A recent study (Miller et al., 2001) indicated that Warner-Bratzler shear tenderness values of < 3.0, 3.4, 4.0, 4.3, and > 4.9 kg would result in 100, 99, 94, 86, and 25% consumer satisfaction for beef tenderness, respectively. It was determined that consumers could effectively distinguish between differences in beef tenderness and were willing to pay more for meat that was more tender. Clearly tenderness is an important attribute in determining consumer satisfaction. Another recent study at the U.S. Meat Animal Research Center (Wheeler et al., 2001) compared the tenderness and palatability traits of meat from steers sired by two *Bos indicus* breeds, the Brahman and the Boran, to Hereford X Angus crossbreds and other *Bos taurus* crossbreds sired by the Piedmontese, Belgian Blue, and Tuli breeds. The Tuli is an African breed of primarily *Bos taurus* ancestry. The meat from Brahman sired animals was evaluated as less tender by taste panel and had higher (less desirable) Warner-Bratzler shear values than the other breeds studied. The Boran, a zebu breed of African origin, produced generally more acceptable beef than that from Brahman steers as measured by taste panel or Warner-Bratzler shear values. This difference among zebu breeds suggests that selection for meat tenderness among the world's zebu breeds might be effective. Meat from Tuli-sired animals was generally comparable in tenderness characteristics to the other *Bos taurus* breeds in the study which indicates that heat tolerance is not necessarily antagonistic to tender meat. Thus, it does appear that there are reasons to be concerned about the tenderness issue in all cattle, and especially Brahman cattle, due to the economic importance of tenderness.

The average estimate of longissimus tenderness heritability across breeds is about 30% (Koch et al., 1982; Koots et al., 1994; Shackelford et al, 1994; O'Connor et al., 1997; Crews and Franke, 1998; Elzo et al., 1998). Thus, within a breed, about 30% of the variation in tenderness is due to (additive) genetic effects and 70% is due to nonadditive genetic effects and nongenetic effects. Some authors, however, have reported even lower estimates for the heritability of meat tenderness (Van Vleck et al., 1992; Gregory et al., 1995; Wulf et al., 1996). If the value of heritability for tenderness is as high as 30%, it means that selection progress could be made through the use of a progeny testing program. After all, the heritability of milk production is only .20 and tremendous genetic progress has been made in this trait. The difficulty is that progeny test information for tenderness has been difficult and expensive to obtain over the years. The cost of producing sets of contemporary steers from similar groups of dams, keeping track of their identities through the feedlot and slaughter process and then obtaining the basic carcass information back is very substantial. It is even more difficult to obtain tenderness information on the meat produced by the carcasses as this requires that steaks be removed from the carcass and evaluated. This process lowers the value of the carcass and the evaluations must be conducted by highly trained personnel. Thus, this type of information has not usually been available to use in selection.

Direct Selection For Meat Tenderness In Angus Cattle At The University Of Florida

Here at the University of Florida, we began a study with Angus calves born in 1994 to determine if we could effectively select directly for meat tenderness. The method by which we chose to attempt to select for tenderness was to feed out our Angus bull calves, collect and freeze semen on them when they reached puberty, and then slaughter the bulls and evaluate their tenderness via Warner-Bratzler shear force evaluation. The bulls were sired by bulls available via AI in 1993 and 1994. The dams of these bulls were purebred and grade Angus cows from the Santa Fe Beef Unit Angus herd. From 30 to 35 bulls were evaluated each year in this fashion from the calf crops born from 1994 through 2000. Each year semen was saved and utilized from those three to four bulls with the highest and three to four bulls with the lowest Warner-Bratzler shear values. The reason that selection was for both tender and tough sires is to more effectively determine if effective selection for this trait was possible. The type of selection utilized is referred to as divergent selection; that is, selection in both directions for a particular trait. Starting in 1995, the calves in this study were sired by the bulls selected based on their tenderness values. One of the problems that we encountered in this study is that not all the bulls had reached puberty or produced freezable semen at 13 to 14 months of age when it was necessary to slaughter them. As a result, we were not able to utilize very strong selection pressure for this trait. In spite of these problems, we were at least partially successful in selecting for differences in tenderness. Table 1 shows the mean Warner-Bratzler shear values for the bulls sired by bulls selected as tough vs tender by year of birth. Because year was so important an influence on the Warner-Bratzler shear values, it is important to report the values that were obtained by year. It should be emphasized that because differences among machines and other environmental effects that it is virtually impossible to compare Warner-Bratzler shear values from one location to another, and as mentioned, even from year to year. In our study, Warner-Bratzler shear values declined over the years but this, surely is due to factors other than genetic ones. This effect of year occurred in spite of the fact that the same machine, and for the most part, the same individuals conducted the evaluations each year. In each year of the study, the bulls sired by bulls selected as tender produced sons whose shear values were lower than those of bulls whose sires were selected as tough. Across years, the difference in tenderness was significant ($P < 0.01$). The mean difference in Warner-Bratzler shear force was 1.05 pounds across all years. Given the relatively low heritability expected for Warner-Bratzler shear and the relatively low intensity of selection for tenderness that it was possible to utilize in this study, we are pleased with the degree of separation that was achieved in this experiment. The bulls born in 2001 were also sired by tender and tough bulls and were castrated at weaning. They are currently on test and their evaluation will determine the effectiveness of this type of selection in steers. This evaluation is, of course, critical as little bull beef is consumed in the U.S.

So, where does this leave us regarding my assigned topic? Can we effectively select for improved meat tenderness? I am afraid that the answer is that yes, it is possible, but not likely to be feasible. The heritability is not high enough to make selection extremely successful and the lack of an easy, inexpensive method of determining tenderness limits the collection of data. The only possible mechanism that offers some hope for the future is the possibility of use of marker-assisted selection, that is DNA evaluation. Unfortunately, however, in spite of large, well-designed studies that have been conducted at several locations, it does not appear that any markers have been identified that will be particularly useful to the beef industry. Even if what are called microsatellite markers can be identified as indicators of genes for tenderness in certain families of cattle, they may not be useful in another family. Until specific genes can be identified that are responsible for tenderness, I am afraid that little effective selection for improved tenderness is possible. This leaves post-slaughter technologies as the most effective short-term mechanism to improve tenderness.

Literature Cited

Crews, D.H., Jr. and D.E. Franke. 1998. Heterogeneity of variances for carcass traits by percentage Brahman inheritance. J. Anim. Sci. 76:1803-1809.

Elzo, M.A., R.L. West, D.D. Johnson, and D.L. Wakeman. 1998. Genetic variation and prediction of additive and nonadditive genetic effects for six carcass traits in an Angus-Brahman multibreed herd. J. Anim. Sci. 76:1810-1823.

Gregory, K.E., L.V. Cundiff, and R.M. Koch. 1995. Genetic and phenotypic (co)variances for growth and carcass traits of purebred and composite populations of beef cattle. J. Anim. Sci. 73:1920-1926.

Koch, R.M., L.V. Cundiff, and K.E. Gregory. 1982. Heritabilities and genetic, environmental and phenotypic correlations of carcass traits in a population of diverse biological types and their implications in slection programs. J. Anim. Sci. 55:1319-1329.

Koots, K.R., J.P. Gibson, C. Smith, and J.W. Wilton. 1994. Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. Anim. Breed. Abstr. 62(5):309-338.

Miller, M.F., M.A. Carr, C.B. Ramsey, K.L. Crockett, and L.C. Hoover. 2001. Consumer thresholds for establishing the value of beef tenderness. J. Anim. Sci. 79:3062-3068.

O'Connor, S.F., J.D. Tatum, D.M. Wulf, R.D. Green, and G.C. Smith. 1997. Genetic effects on beef tenderness in *Bos indicus* composite and *Bos taurus* cattle. J. Anim. Sci. 75:1822-1830.

Shackelford, S.D., M. Koohmaraie, L.V. Cundiff, K.E. Gregory, G.A. Rohrer, and J.W. Savell. 1994. Heritabilities and phenotypic and genetic correlations for bovine postrigor calpastatin activity, intramuscular fat content, Warner-Bratzler shear force, retail product yield, and growth rate. J. Anim. Sci. 72:857-863.

Van Vleck, L.D., A.F. Hakim, L.V. Cundiff, R.M. Koch, J.D. Crouse, and K.G. Boldman. 1992. Estimated breeding values for meat characteristics of crossbred cattle with an animal model. J. Anim. Sci. 70:363-371.

Wheeler, T.L., L.V. Cundiff, S.D. Shackleford, and M. Koohmaraie. 2001. Characterization of biological types of cattle (Cycle V): Carcass traits and longissimus palatability. J. Anim. Sci. 79:1209-1222.

Wulf, D.M., J.D. Tatum, R.D. Green, J.B. Morgan, B.L. Golden, and G.C. Smith. 1996. Genetic influences on beef longissimus palatability in Charolais- and Limousin-sired steers and heifers. J. Anim. Sci. 74:2394-2405.

Table 1. Warner-Bratzler Shear Values of Progeny of Tender vs. Tough Angus Bulls by Year.

Year of Birth	Line	Day 14 Warner-Bratzler Shear, lbs
1996	Tender	8.83
1996	Tough	10.71
1997	Tender	7.10
1997	Tough	7.94
1998	Tender	7.55
1998	Tough	7.65
1999	Tender	5.94
1999	Tough	6.28
2000	Tender	5.98
2000	Tough	7.82

Notes: