Project Summary

Development of a beef muscle "aging index" for purposes of managing beef palatability at the consumption level – short term muscles

Principal Investigators: S. L. Gruber, K. E. Belk, J. A. Scanga, J. D. Tatum, and G. C. Smith
Colorado State University

Study Completed
May 2004

BEEF ® *Funded by The Beef Checkoff*

Development of a beef muscle “aging index” for purposes of managing beef palatability at the consumption level – short term muscles: Project Summary

Background

Postmortem aging to improve palatability of cooked beef is a common practice. Many studies have evaluated the tenderness of various subprimal cuts, the *longissimus dorsi* muscle, or other individual beef muscles after various postmortem aging times (Smith et al., 1978; Lorenzen et al., 1998; Meis et al., 1998; Johnson, 2003). George et al. (1999) reported a range of 89 days in post -fabrication age of striploin and top sirloin steaks sold at retail stores in eight differing U.S. cities.

As the industry moves towards merchandising individual beef muscles, standardized postmortem aging times for muscles must be determined. Unfortunately, the majority of studies have been unable to discern differences in the amount of postmortem aging time required for individual beef muscles varying by USDA quality grade. Furthermore, most previous studies have relied on Warner-Bratzler shear force (WBSF) measurements obtained following freezing and thawing of beef steaks. This study was designed to develop standardized wet-aging time recommendations for fresh (never-frozen) individual beef muscles. Thus, allowing packers, retailers, and food service operations to manage the palatability of a wide range of beef muscles differing in USDA quality grade.

Methodology

Product selection. USDA Select (n = 40) and upper two-thirds USDA Choice (n = 40) beef carcasses were selected over a seven month period from Swift and Company Greeley, CO (Table 1). Two days postmortem, the following subprimals were removed from the right side of each carcass by in-plant fabrication: shoulder clod (IMPS 114), chuck roll (IMPS 116 C), chuck tender (IMPS 116 B), top round (IMPS 168), bottom round (IMPS 171 B), eye of round (IMPS 171 C), knuckle (IMPS 167), sirloin (IMPS 181), tenderloin (IMPS 189), and striploin (IMPS 180); the shoulder clod (IMPS 114), chuck roll (IMPS 116 C), chuck tender (IMPS 116 B), knuckle (IMPS 167), and bottom sirloin (IMPS 185) were removed from the left side of each carcass (NAMP, 1997). Subprimals were then transported to the Colorado State University Meat Laboratory for further processing.

Muscle fabrication and steak allocation. The following individual muscles were removed from subprimal cuts: (a) *Biceps femoris* – long head, (b) *Gluteus medius*, (c) *Infraspinatus*, (d) *Longissimus dorsi*, (e) *Psoas major*, (f) *Rectus femoris*, (g) *Tensor facia latae*, (h) *Teres major*, and (i) *Triceps brachii* – long head (Table 2). Following fabrication, individual muscles within a carcass were cut into one-inch-thick steaks and the seven most suitable steaks within a muscle-type were randomly assigned to one of the following aging periods: 2, 4, 6, 10, 14, 21, and 28 days. Steaks assigned to the 2-day aging period were immediately evaluated by Warner-Bratzler shear force, and the remaining six steaks per muscle-type were vacuum packaged and stored and 2°C until the assigned aging-period was complete.

Warner-Bratzler shear force determination. Upon completion of designated aging-time, steaks were removed from storage (2°C, never-frozen) for shear force analysis. Steaks most similar in thickness were cooked in groups of three on electric grills (model GGR64, Salton,Inc., Mt. Prospect, IL) that heated steaks from both sides simultaneously to a final internal temperature of 70°C. A Type K thermocouple (Omega Engineering Inc., Stamford, CT) was placed in the geometric center of each steak, and the internal temperature of each steak was monitored during cooking using a microprocessor thermometer (model HH21, Omega

Engineering Inc.,Stamford, CT). After cooking each steak was allowed to equilibrate to room temperature (22°C) and up to 10 cores (1.27 cm in diameter) were removed from each steak parallel to the muscle fiber orientation. Each core was sheared once, perpendicular to the muscle fiber orientation, with an Instron testing machine fitted with a Warner-Bratzler shear head; peak shear force measurements of each core were recorded and averaged to obtain a single shear force value for each steak.

Statistical methods. Analysis of Warner-Bratzler shear force (WBSF) was conducted using the least squares, mixed models procedure of SAS (SAS Inst. Inc., Cary, NC). The ANOVA model included the three-way interaction between the fixed independent effects of quality grade (grade), postmortem aging period (age), and muscle type (muscle). Random effects included carcass nested within grade, and the two-way interactions of carcass within grade × muscle, and carcass within grade × age. Because this preliminary analysis resulted in a significant interaction between grade, muscle, and age, WBSF data was subsequently analyzed within each of the two quality grades (upper 2/3 Choice and Select). The final statistical model included the two way interaction of muscle × age as a fixed effect. Random effects included carcass, carcass × muscle, and carcass × age. Peak internal steak temperature served as a covariate for all analyses of WBSF.

Within each quality grade, least squares means were generated for each muscle by aging period subclass, and aging curves were fit for each muscle using the least squares, nonlinear models procedure of SAS (SAS Inst. Inc., Cary, NC.). Aging time was used as the independent variable in each regression equation.

Findings

Aging response

Least squares means of WBSF for each aging period by muscle subclass within a quality grade are presented in Tables 3 and 4. The non-linear equations fit to each muscle within a quality grade are illustrated in Figures 1 – 18.

To estimate an optimal aging time for each muscle within a grade the following must be examined: a) WBSF at two days post-mortem, b) the maximum decrease in WBSF that can be expected ("aging response")(Table 5), and c) the time that it takes for this reduction to occur. Based on the non-linear models fit to each muscle, within a quality grade, a predicted shear force value at two days postmortem, the change in shear force from day 2 to day 28, and the proportion of that change that has occurred at each of 6 aging periods is displayed in Tables 6 and 7. Estimates of decrease in shear force past twenty-eight days are not warranted in this data set and should not be extrapolated; however, the predicted instantaneous rate of change in WBSF for each muscle was $\leq$0.05 kg on day 28. The combination of these data determines the extent to which aging can improve tenderness (as determined by WBSF), and the time required for each muscle to obtain this improvement. Although postmortem aging will decrease WBSF values, if consumers cannot detect a change in beef palatability, postmortem aging has not added value to a muscle. Several studies have attempted to examine the impact of changes in WBSF on consumer acceptance of steaks (Miller et al., 2001; Lorenzen et al., 2003); Platter et al. (2003) reported predicted probabilities of consumer steak acceptance of 50 and 68% at approximate WBSF values of 4.4 and 3.7 kg, respectively. Although these probabilities of consumer acceptance are based on WBSF values of *longissimus dorsi* steaks, the WBSF values associated with them could be used as conservative thresholds. These thresholds could prove valuable in determining the length of time in days a beef muscle should be aged.

Regardless of quality grade, *biceps femoris* muscles never reached WBSF values (4.4 kg) corresponding to 50% consumer acceptance. Upper 2/3 Choice *biceps femoris* muscles had the smallest response to postmortem aging (0.5 kg) and approximately 100% of this decrease in shear force was complete 14 days postmortem. Select *biceps femoris* muscles decreased 1.1 kg by day 28 postmortem, but only 82% of this response was complete after 21 days of aging.

Although popular at food service operations and supermarkets because it is often more affordable than *longissimus dorsi* and *psoas major* steaks, according to Platter et al. (2003), neither top choice nor Select *gluteus medius* steaks reached WBSF values corresponding to 68% consumer acceptability. *Gluteus medius* muscles removed from upper 2/3 Choice carcasses in the present study reached 4.4 kg (50 % consumer acceptance) by day 15. Select *gluteus medius* muscles in our study had a 1.6 kg aging response after 28 days of postmortem aging, but only 78% of this total reduction in WBSF value was complete after 21 days of aging.

The *infraspinatus* is often reported as the second most tender muscle in beef the carcass (Ramsbottom et al., 1945; McKeith et al., 1985), both Select and premium choice "top blade" steaks had a 1.4 kg aging response, and reached shear force values (3.7 kg) projected to correspond to 68% consumer acceptance of steaks. High grade *infraspinatus* steaks reached this threshold at 7 days postmortem, and Select top blade steaks required an additional 10 days of aging to obtain shear values corresponding to 68% of consumer acceptance.

The aging response of the *longissimus dorsi* muscle varied greatly by quality grade. Top choice *longissimus dorsi* muscles decreased 2.0 kg in 28 days, and approximately 99% of this change was complete by day 21. Top choice *longissimus dorsi* muscles reached a 68% consumer acceptance (3.7 kg) by day 16. Conversely, *longissimus dorsi* steaks from a Select carcass reached WBSF levels of 4.2 kg after 28 days postmortem, and only 87% of this reduction in shear force was complete by day 21.

Psoas major muscles, regardless of grade, had the lowest WBSF values at all but one postmortem aging period. Capable of achieving shear values corresponding to 68% consumer acceptance, both top choice and Select *psoas major* steaks had WBSF of 3.2 kg at 28 days postmortem.

Upper 2/3 Choice *rectus femoris* muscles decreased 1.0 kg after 28 days of postmortem aging, and approximately 98% of this change was complete after 21 days; however, according to Platter et al. (2003) the upper 2/3 Choice *rectus femoris* was only capable of obtaining shear force values that would correspond to 50% of consumer steak acceptance. In our study, WBSF values corresponding to this acceptance (4.4 kg) were reached 6 days postmortem. *Rectus femoris* muscles from USDA Select carcasses had an aging response of 1.3 kg, and reached approximately 87% of this reduction 21 days postmortem. WBSF values of approximately 4.4 kg were reached at 15 days postmortem.

Premium choice *tensor facia latae* muscles decreased 1.0 kg after 28 days of postmortem aging, and greater than 90% of this change was complete day by 14. Select *tensor facia latae* muscles had a 28 day aging response of 1.1 kg, 94% of which was complete by 21 days postmortem. Upper 2/3 choice *tensor facia latae* muscles reached WBSF values corresponding to 68% consumer acceptance (3.7 kg) at 13 postmortem.

Premium choice *teres major* muscles at two days postmortem were observed to have WBSF levels below those corresponding to 50% consumer acceptance of steaks. The 3.7 kg threshold for 68% consumer acceptance of steaks was reached approximately 11 days postmortem. A regression line was unable to be fit to least squared means of Select *teres major* muscles (Figure 16). Inability to fit a regression line to the Select *teres major* could be attributed to sampling difficulties associated with small muscles.

Upper 2/3 Choice *triceps brachii* muscles decreased 1.4 kg after 28 days of postmortem aging, and approximately 91% of this change was complete after 14 days; however, according to Platter et al. (2003), the *triceps brachii* was only capable of obtaining shear force values that would correspond to 50% of consumer steak acceptance. WBSF values in our study corresponding to this acceptance (4.4 kg) were reached 7 days postmortem. *Triceps brachii* muscles from USDA Select carcasses had an aging response of 1.6 kg, and reached approximately 95% of this reduction 21 days postmortem. WBSF values of approximately 4.4 kg were reached at 13 days postmortem.

In general, muscles from USDA Select carcasses had higher initial (two days postmortem) WBSF values, exhibited greater decreases in shear force values after 28 days of postmortem aging, and required more days of postmortem aging to complete the majority of this decrease in WBSF than did muscles from upper 2/3 USDA Choice beef carcasses.

Muscle tenderness

A rank of beef muscles by Warner-Bratzler shear force (WBSF) within a quality grade at each of seven postmortem aging periods is located in Tables 8 - 21. Although numerous studies have characterized the tenderness of individual beef muscles (Ramsbottom et al., 1945, McKeith et al., 1985, Johnson et al., 1988; NCBA, 2000), properties of the *longissimus dorsi* muscle are still the most widely recognized. Therefore, an index value was created in this study for each muscle to facilitate comparisons in tenderness (as determined by WBSF). Within a quality grade, at each postmortem aging period, this index (Tables 8-21) identifies muscles that can be expected to perform similarly to the *longissimus dorsi*, in terms of tenderness, as well as those muscles that can be expected to out-perform the *longissimus dorsi* (Gruber et al., 2003). Also, an index has been created that compares the tenderness of individual muscles at each aging period to the tenderness of the *longissimus dorsi* aged 14 days (Tables 22 and 23). Caution, however, should be used when comparing muscles by index value alone. Because the index value is a proportion ((WBSF of the *longissimus dorsi* /WBSF of the individual muscle) * 100), small differences are magnified, and index values that may appear different are not significantly different ($P < 0.05$). Mean WBSF values are labeled with superscript letters identifying significant differences, and should always be used to test for tenderness differences between muscles.

Implications

Postmortem aging can be used to maximize tenderness potential of individual beef muscles. Combining initial WBSF measurements, aging responses within a 28-day period, and the rate at which this response occurs can facilitate estimation of optimal aging time of individual beef muscles differing in quality grade. The conservative use of WBSF thresholds in consumer acceptability also may prove useful in identifying muscles that can be marketed as steaks, and distinguish palatability improvements throughout postmortem aging.

Table 1. Simple means for carcass traits of sample population stratified by quality grade

	Upper ⅔ Choice			Select		
Trait	n	Mean	SEM	n	Mean	SEM
Carcass weight, kg	40	375	5.2	40	356	2.4
Adjusted fat thickness, cm	35	1.32	0.05	40	1.06	0.05
Ribeye area, cm^2	35	91.1	1.5	40	93.8	1.6
Kidney, pelvic, and heart fat %	35	2.2	0.06	40	2.1	0.06
Calculated yield grade	35	2.8	0.1	40	2.3	0.1
Marbling[a]	40	575.3	7.7	40	351.3	3.0

[a]300 = slight, 400 = small, 500 = modest.

Table 2. Individual beef muscles removed from a carcass, the number of each muscle excised from each carcass, and the subprimal from which each muscle was removed

Muscle	n	Subprimal	IMPS[a]
Biceps femoris - long head	1	Bottom round	171B
Gluteus medius	1	Sirloin	181
Infraspinatus	2	Shoulder clod	114
Longissimus dorsi	1	Striploin	180
Psoas major	1	Tenderloin	189
Rectus femoris	2	Knuckle	167
Tensor fascia latae	2	Bottom sirloin[b]	185
Teres major	2	Shoulder clod	114
Triceps brachii - long head	2	Shoulder clod	114

[a]IMPS = Institutional Meat Product Specification (NAMP, 1997).
[b]*Tensor fascia latae* was excised from the sirloin (IMPS 181) removed from the right side of each carcass, and excised from the bottom sirloin (IMPS 185) of the left side of each carcass.

Table 3. Least squares means ± SEM of Warner-Bratzler shear force (kg) for upper 2/3 USDA Choice beef muscles at seven postmortem aging periods

	Days postmortem						
Muscle	2	4	6	10	14	21	28
Biceps femoris - long head	5.08 ± 0.14^{u}	4.72 ± 0.13^{v}	4.66 ± 0.13^{v}	4.70 ± 0.13^{v}	4.48 ± 0.15^{v}	4.56 ± 0.13^{v}	4.58 ± 0.13^{v}
Gluteus medius	5.45 ± 0.14^{u}	5.05 ± 0.13^{v}	4.89 ± 0.13^{vw}	4.64 ± 0.13^{wx}	4.53 ± 0.14^{x}	4.44 ± 0.13^{x}	4.15 ± 0.13^{y}
Infraspinatus	4.62 ± 0.14^{u}	3.77 ± 0.14^{vw}	3.89 ± 0.13^{v}	3.57 ± 0.13^{w}	3.25 ± 0.14^{x}	3.26 ± 0.13^{x}	2.99 ± 0.13^{x}
Longissimus dorsi	5.64 ± 0.14^{u}	4.90 ± 0.13^{v}	4.31 ± 0.13^{w}	3.94 ± 0.13^{x}	3.97 ± 0.14^{x}	3.67 ± 0.13^{xy}	3.55 ± 0.13^{y}
Psoas major	4.30 ± 0.14^{u}	4.11 ± 0.13^{uv}	3.96 ± 0.13^{vw}	3.74 ± 0.14^{wx}	3.57 ± 0.14^{xy}	3.38 ± 0.13^{yz}	3.19 ± 0.13^{z}
Rectus femoris	5.03 ± 0.14^{u}	4.52 ± 0.13^{v}	4.25 ± 0.13^{v}	4.30 ± 0.13^{v}	4.32 ± 0.15^{v}	3.82 ± 0.13^{w}	3.90 ± 0.13^{w}
Tensor fascia latae	4.70 ± 0.14^{u}	4.23 ± 0.13^{v}	4.05 ± 0.13^{vw}	3.84 ± 0.13^{w}	3.84 ± 0.14^{w}	3.77 ± 0.13^{wx}	3.51 ± 0.13^{x}
Teres major	4.18 ± 0.14^{u}	4.04 ± 0.13^{uv}	3.81 ± 0.13^{vw}	3.91 ± 0.13^{uv}	3.55 ± 0.15^{x}	3.61 ± 0.14^{wx}	3.45 ± 0.13^{x}
Triceps brachii - long head	5.42 ± 0.14^{u}	4.60 ± 0.13^{uv}	4.55 ± 0.13^{vw}	4.30 ± 0.13^{wx}	4.19 ± 0.14^{xy}	3.99 ± 0.13^{yz}	3.77 ± 0.13^{z}

^{u,v,w,x,y,z}Means in the same row lacking common superscript letters differ (P < 0.05).

Table 4. Least squares means ± SEM of Warner-Bratzler shear force (kg) for USDA Select beef muscles at seven postmortem aging periods

	Days postmortem						
Muscle	2	4	6	10	14	21	28
Biceps femoris - long head	6.01 ± 0.16^{v}	5.67 ± 0.15^{vw}	5.45 ± 0.15^{wx}	5.32 ± 0.15^{x}	5.46 ± 0.16^{wx}	4.98 ± 0.15^{y}	4.76 ± 0.15^{y}
Gluteus medius	6.12 ± 0.16^{v}	6.29 ± 0.15^{v}	5.68 ± 0.15^{w}	5.48 ± 0.15^{w}	5.50 ± 0.16^{w}	4.97 ± 0.15^{x}	4.59 ± 0.15^{y}
Infraspinatus	4.79 ± 0.16^{v}	4.51 ± 0.15^{vw}	4.35 ± 0.15^{wx}	4.14 ± 0.15^{x}	3.78 ± 0.16^{y}	3.67 ± 0.15^{y}	3.31 ± 0.15^{z}
Longissimus dorsi	6.64 ± 0.16^{v}	6.36 ± 0.15^{v}	5.91 ± 0.15^{w}	5.50 ± 0.15^{x}	5.01 ± 0.16^{y}	4.52 ± 0.15^{z}	4.21 ± 0.15^{z}
Psoas major	4.49 ± 0.16^{v}	4.47 ± 0.15^{v}	4.48 ± 0.15^{v}	3.94 ± 0.15^{w}	3.88 ± 0.16^{wx}	3.57 ± 0.15^{x}	3.21 ± 0.15^{y}
Rectus femoris	5.27 ± 0.16^{v}	5.22 ± 0.15^{v}	4.96 ± 0.15^{vw}	4.67 ± 0.15^{wx}	4.46 ± 0.16^{xy}	4.16 ± 0.15^{yz}	4.04 ± 0.15^{z}
Tensor fascia latae	5.07 ± 0.16^{v}	4.73 ± 0.15^{vw}	4.60 ± 0.15^{wx}	4.19 ± 0.15^{y}	4.30 ± 0.16^{xy}	4.06 ± 0.15^{yz}	3.83 ± 0.15^{z}
Teres major	4.16 ± 0.16^{vw}	4.26 ± 0.15^{v}	4.36 ± 0.15^{v}	4.12 ± 0.15^{vw}	4.16 ± 0.16^{vw}	4.19 ± 0.15^{vw}	3.87 ± 0.16^{w}
Triceps brachii - long head	5.77 ± 0.16^{v}	5.17 ± 0.15^{w}	4.95 ± 0.15^{w}	4.57 ± 0.15^{x}	4.53 ± 0.16^{x}	4.27 ± 0.15^{x}	3.93 ± 0.15^{y}

^{v,w,x,y,z}Means in the same row lacking common superscript letters differ (P < 0.05).

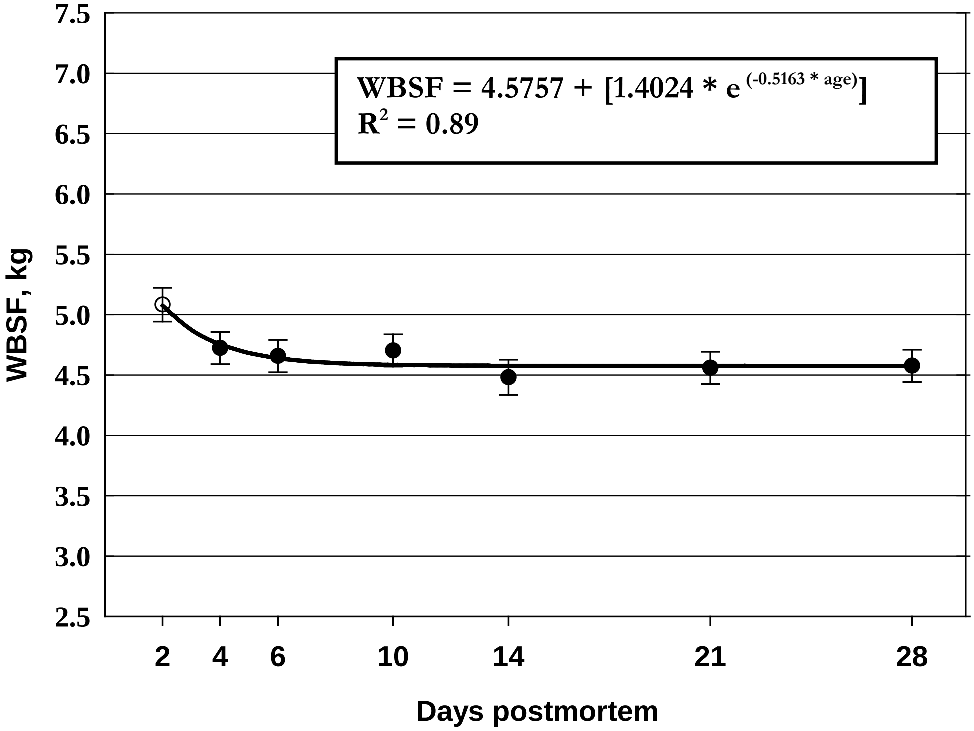

Figure 1. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *biceps femoris* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

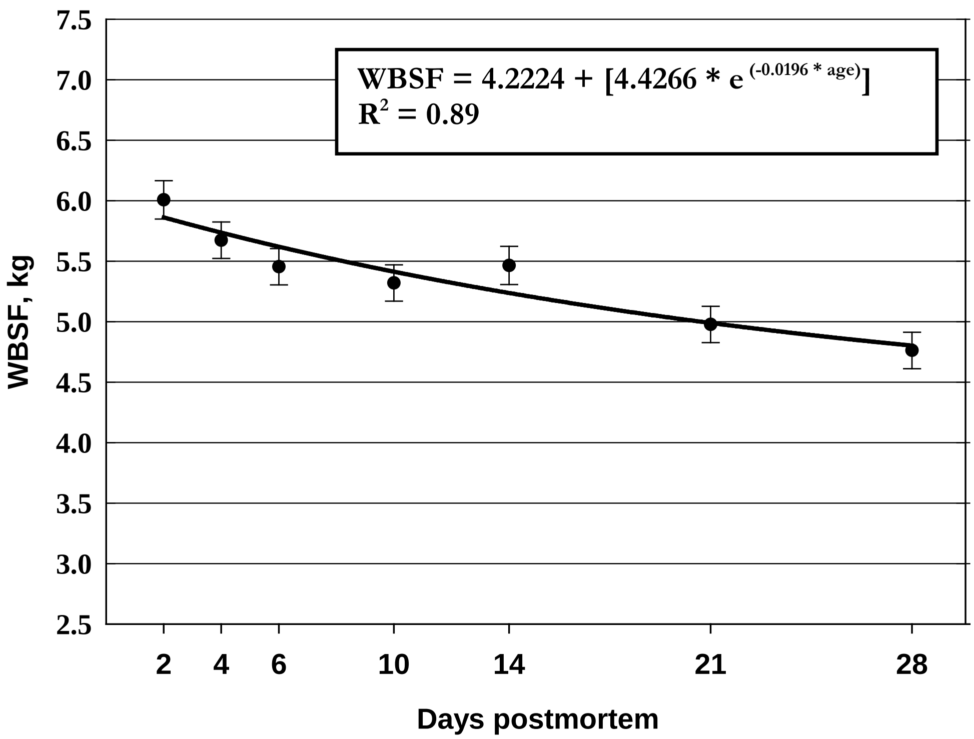

Figure 2. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *biceps femoris* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

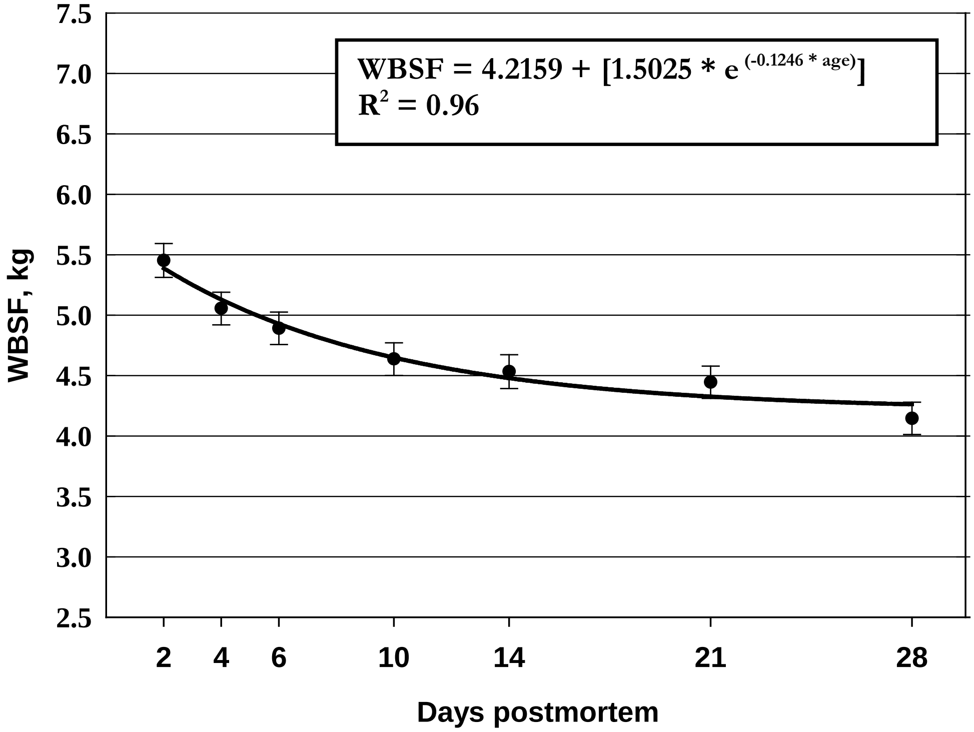

Figure 3. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *gluteus medius* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

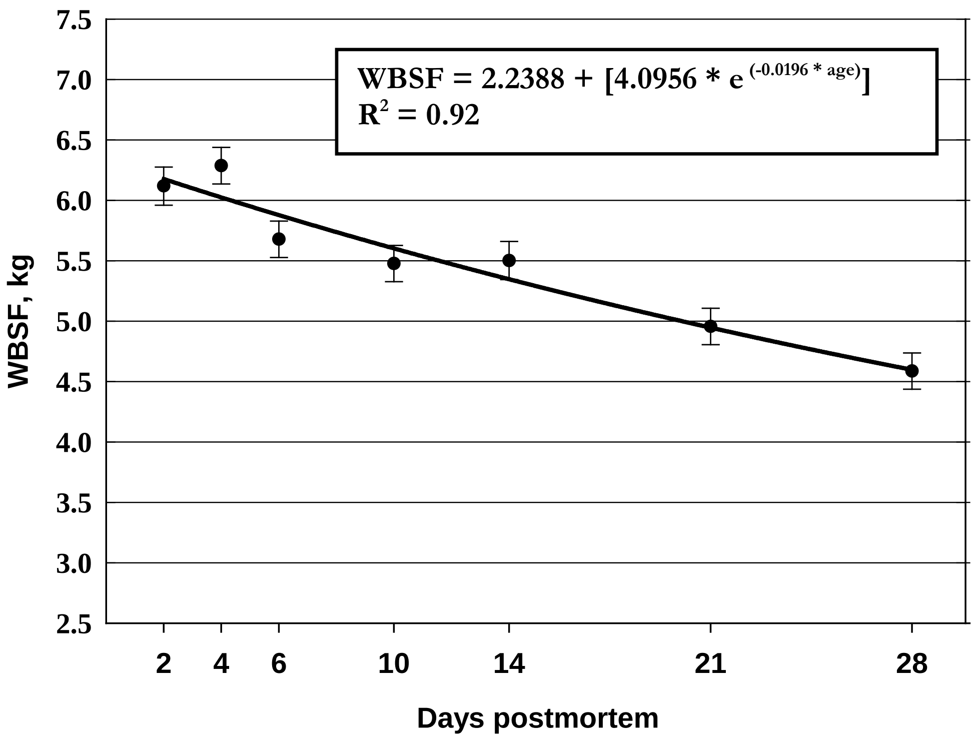

Figure 4. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *gluteus medius* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

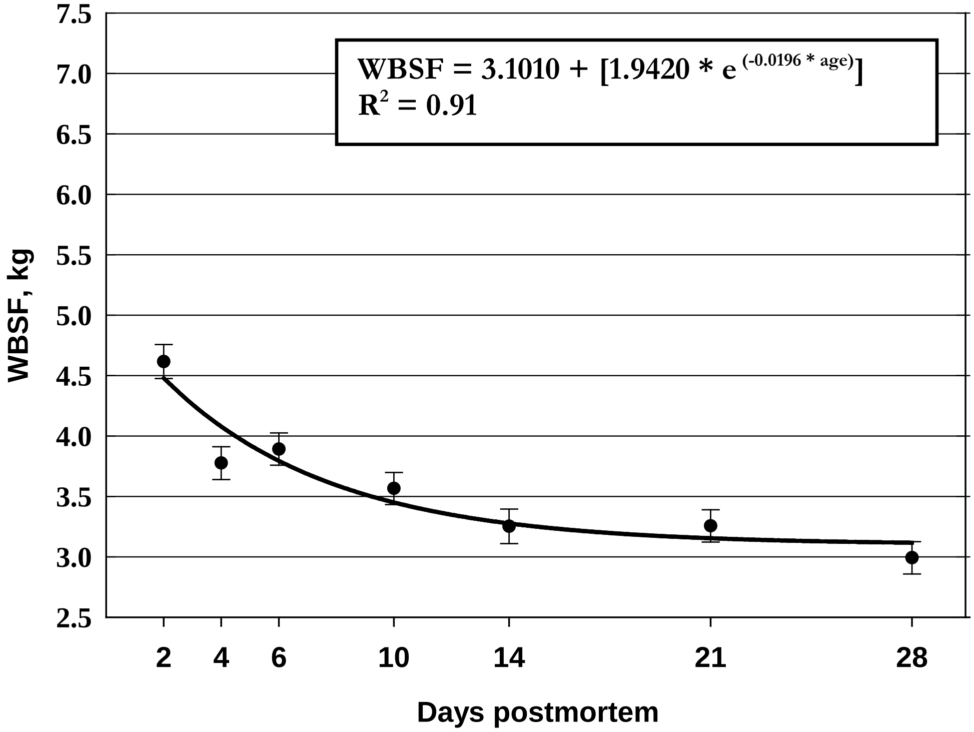

Figure 5. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *infraspinatus* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

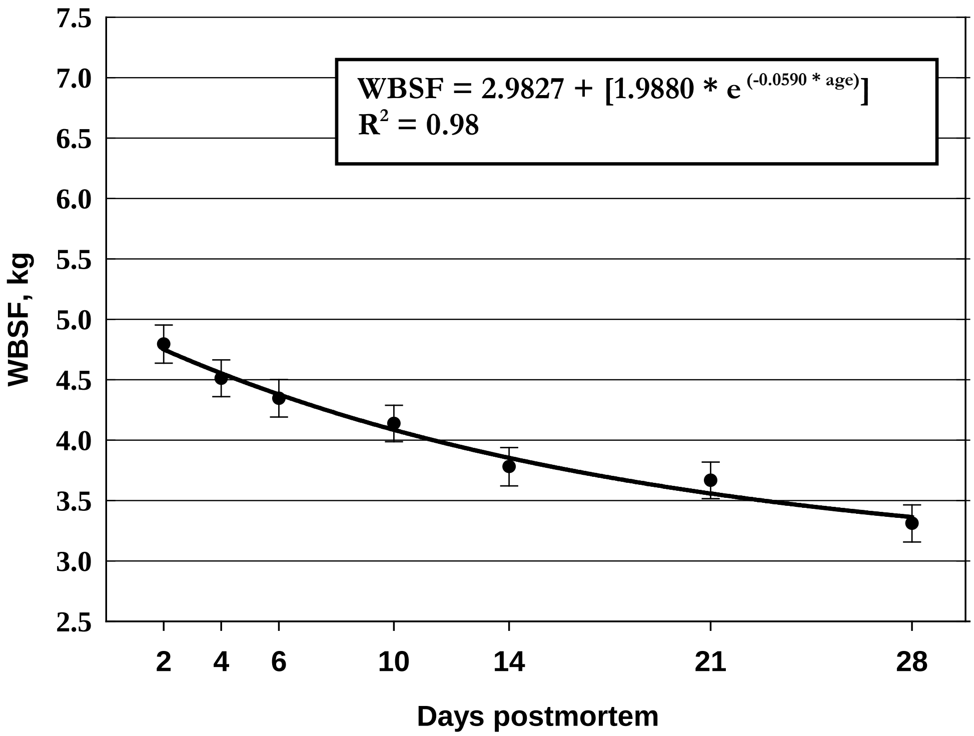

Figure 6. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *infraspinatus* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

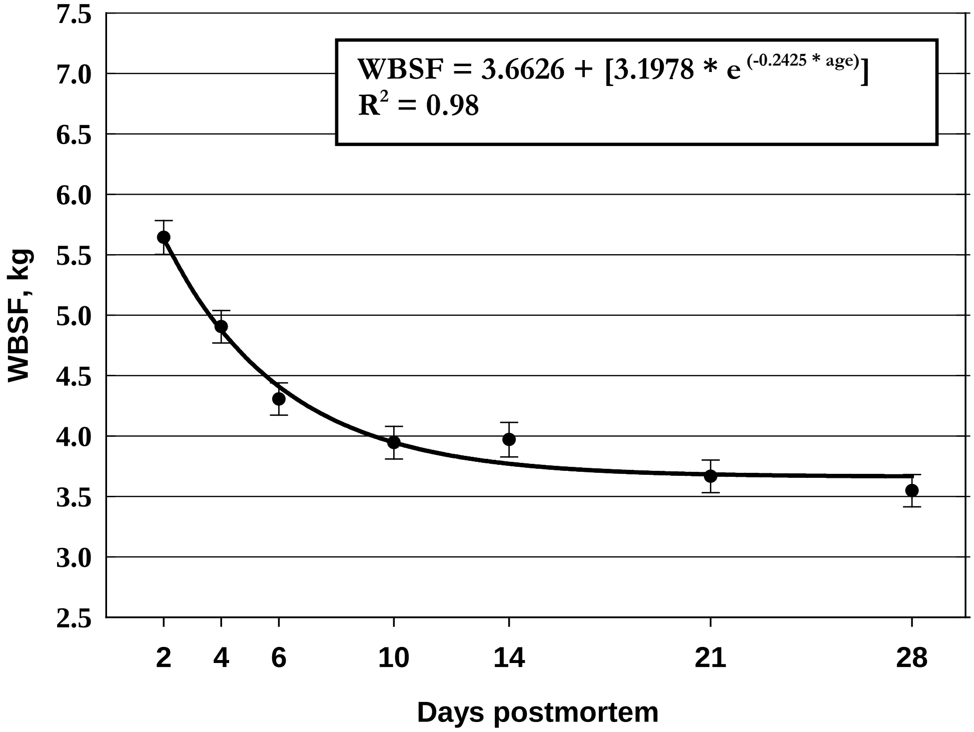

Figure 7. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *longissimus dorsi* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable “age” is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

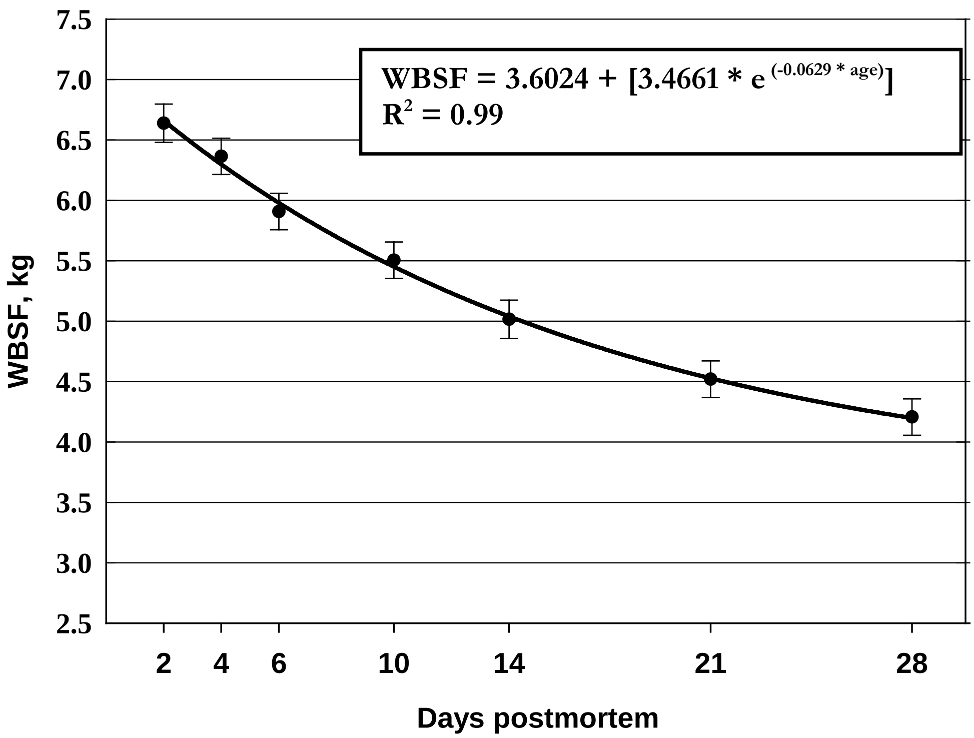

Figure 8. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *longissimus dorsi* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable “age” is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

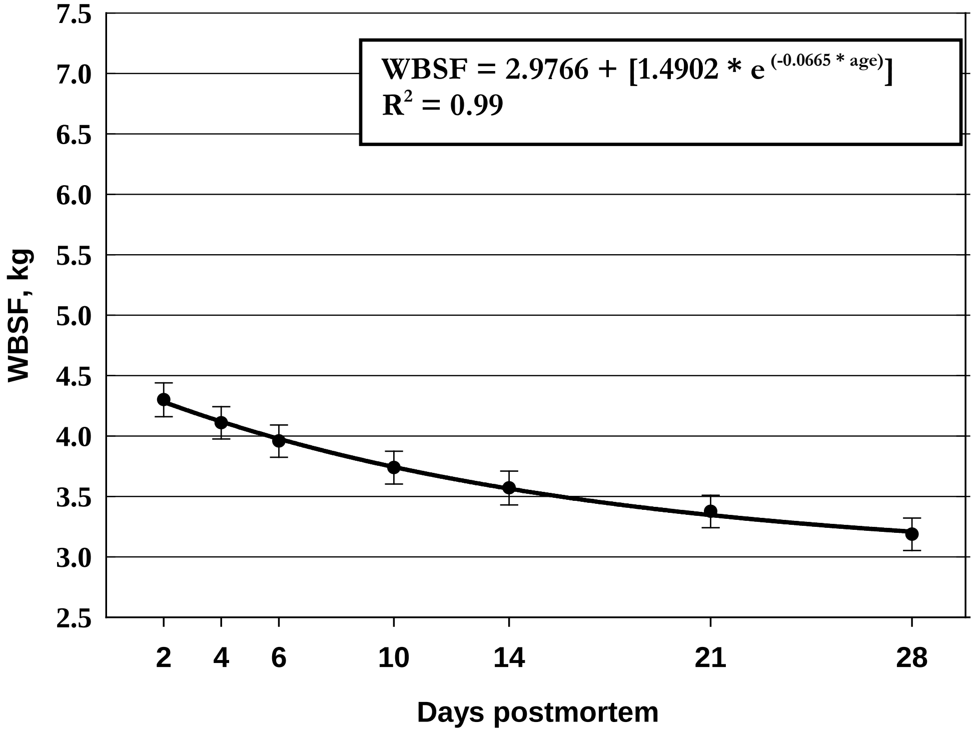

Figure 9. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *psoas major* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

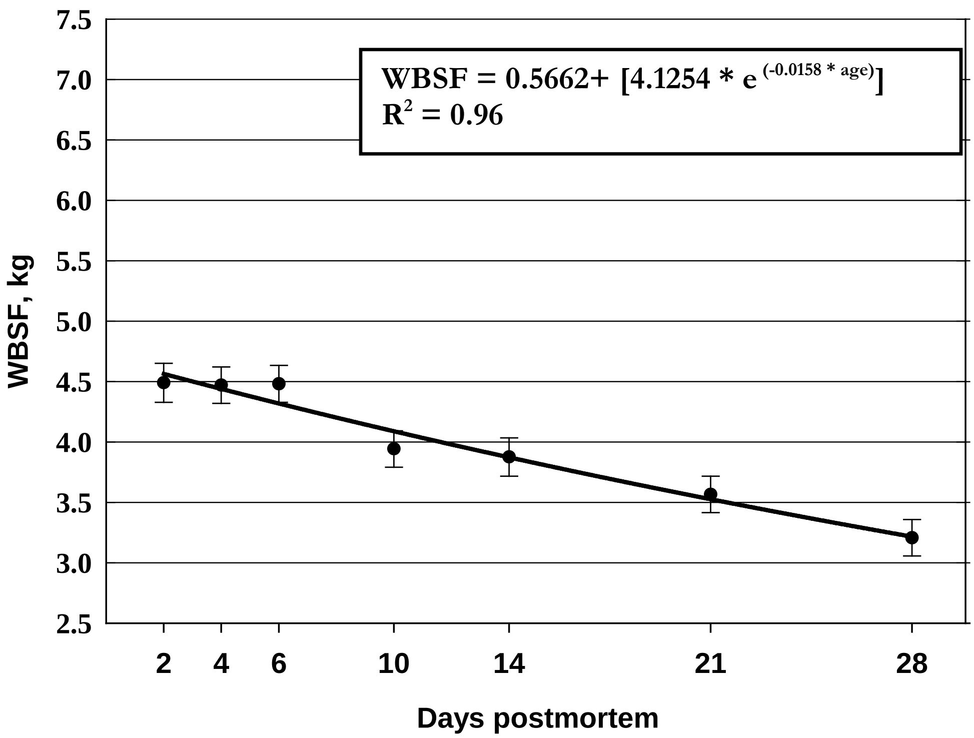

Figure 10. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *psoas major* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

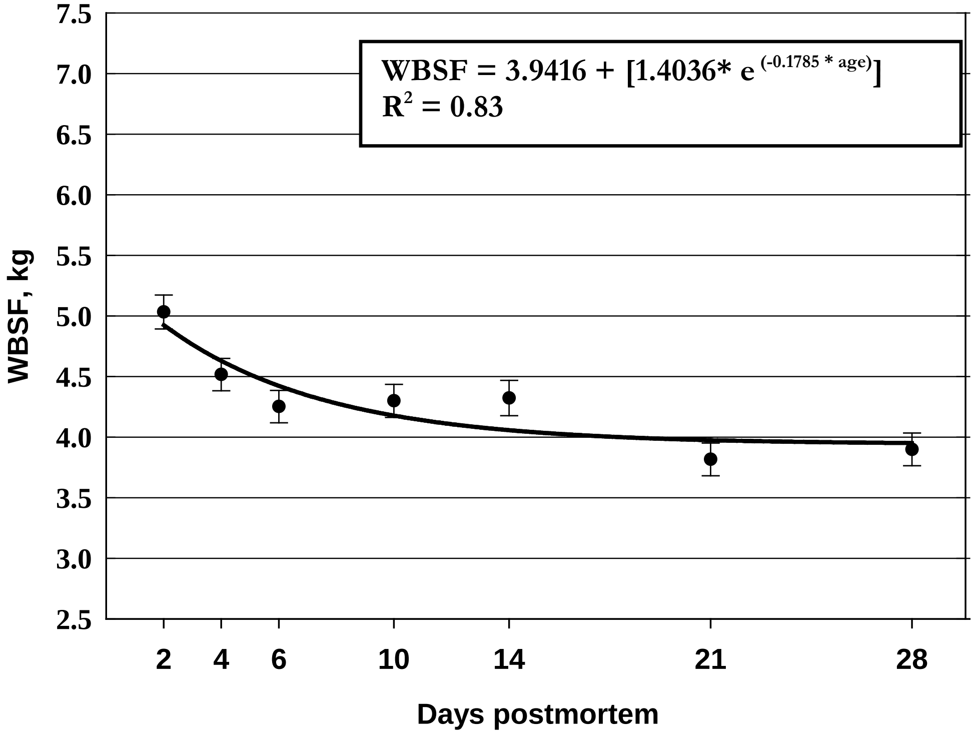

Figure 11. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *rectus femoris* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

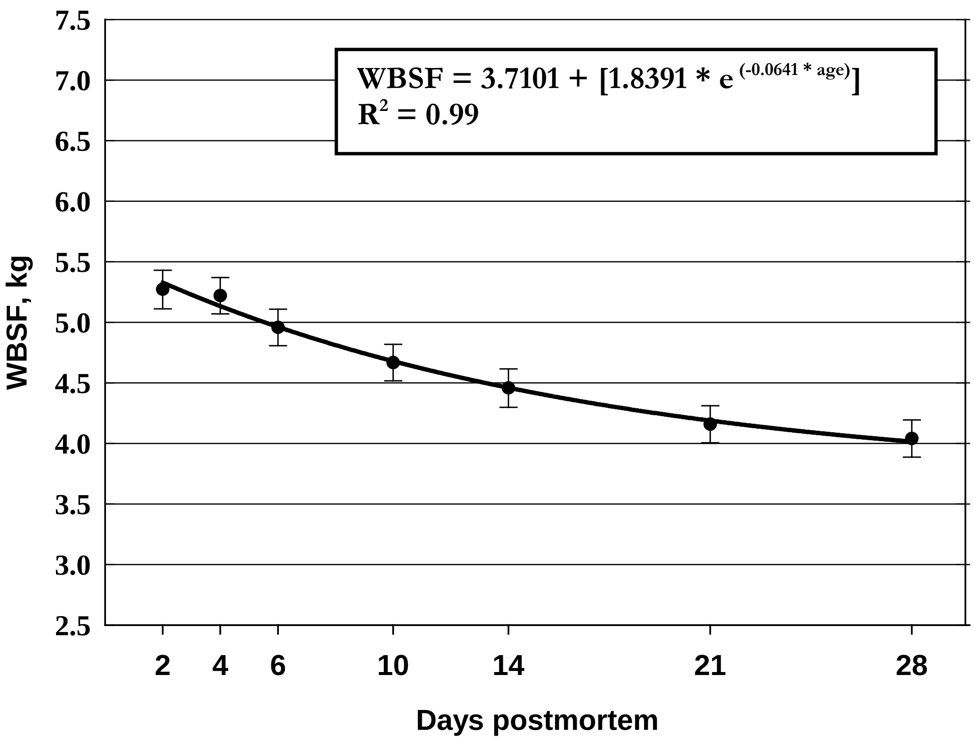

Figure 12. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *rectus femoris* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

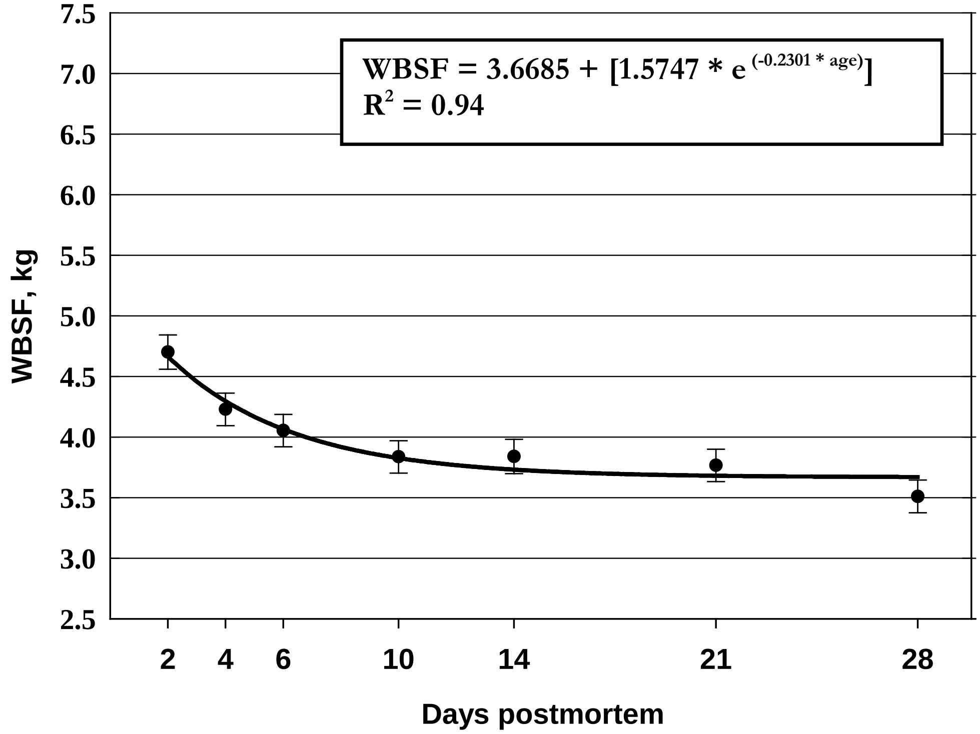

Figure 13. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *tensor facia latae* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

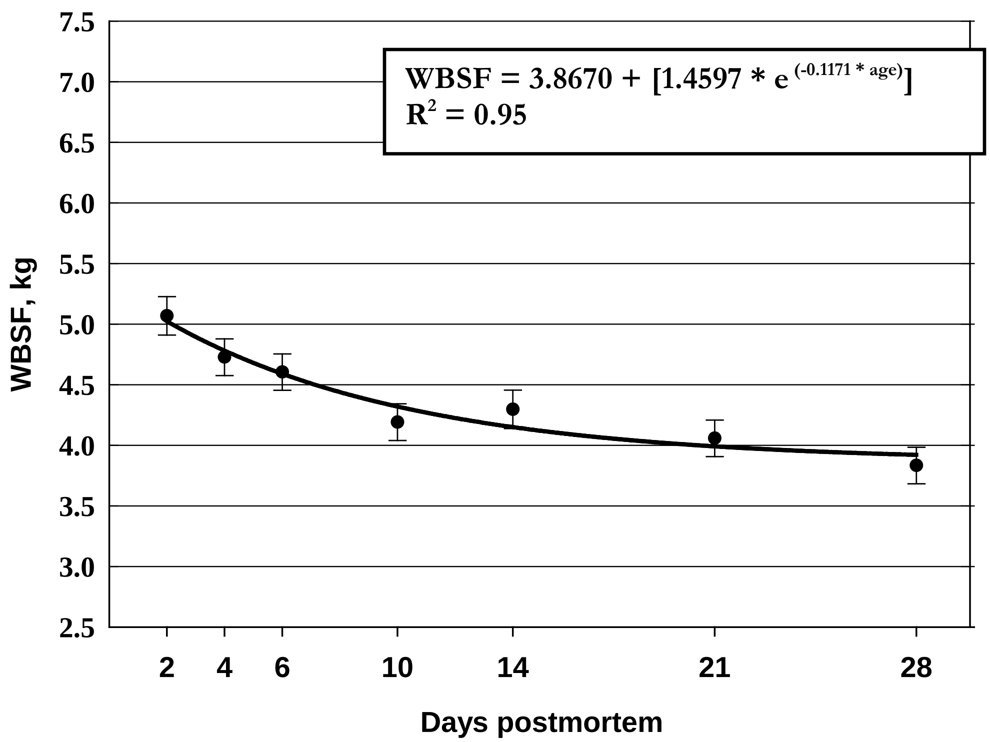

Figure 14. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *tensor facia latae* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

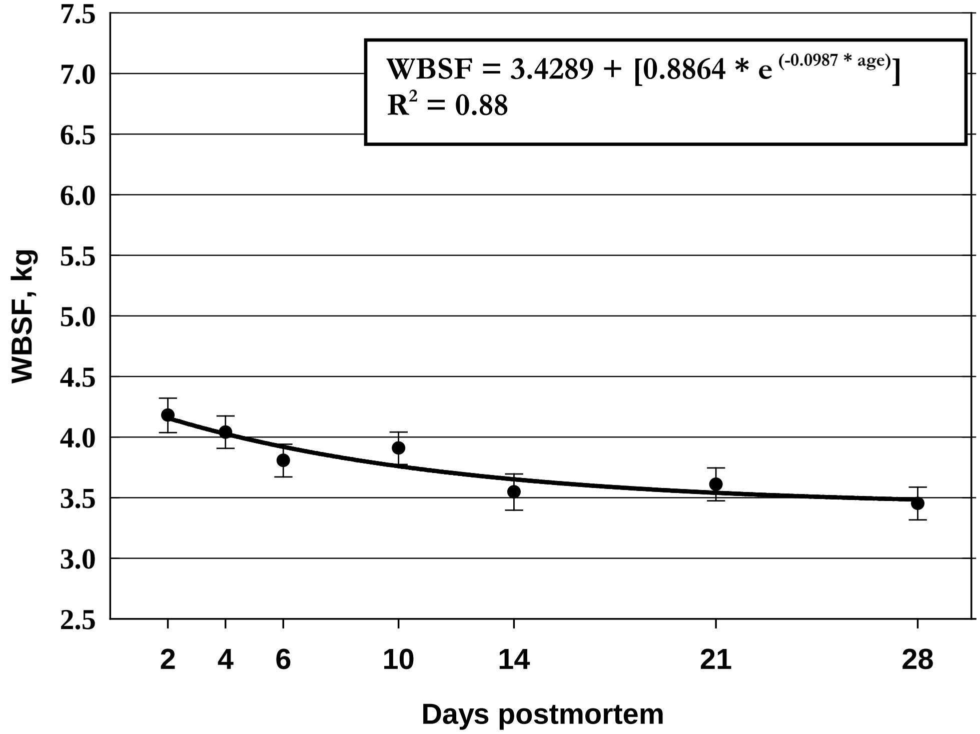

Figure 15. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *teres major* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

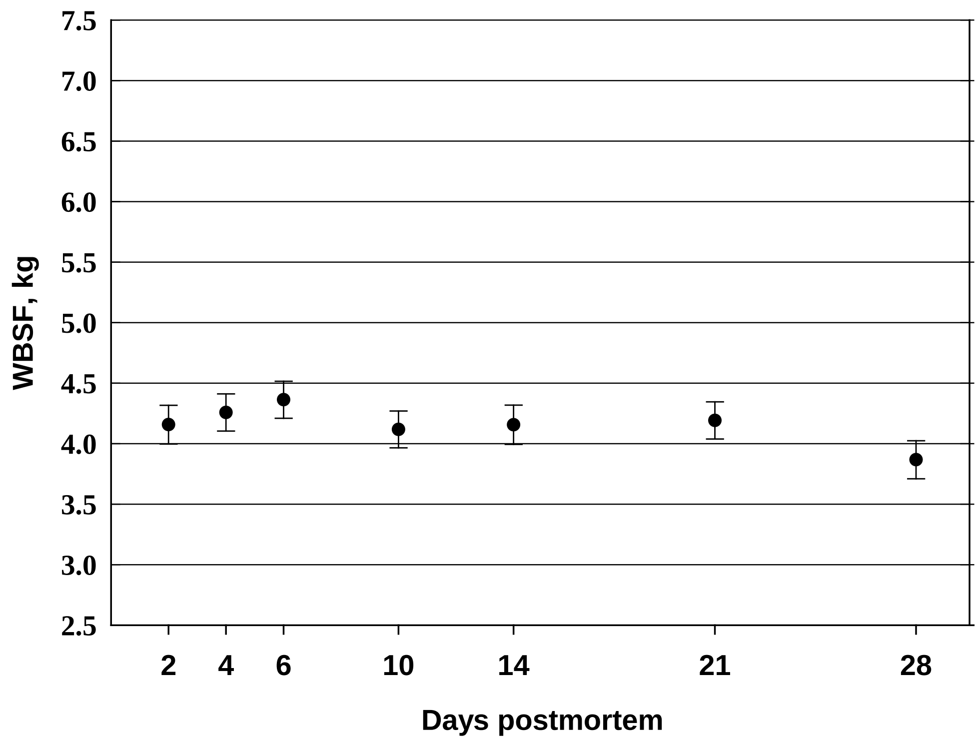

Figure 16. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *teres major* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable "age" is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

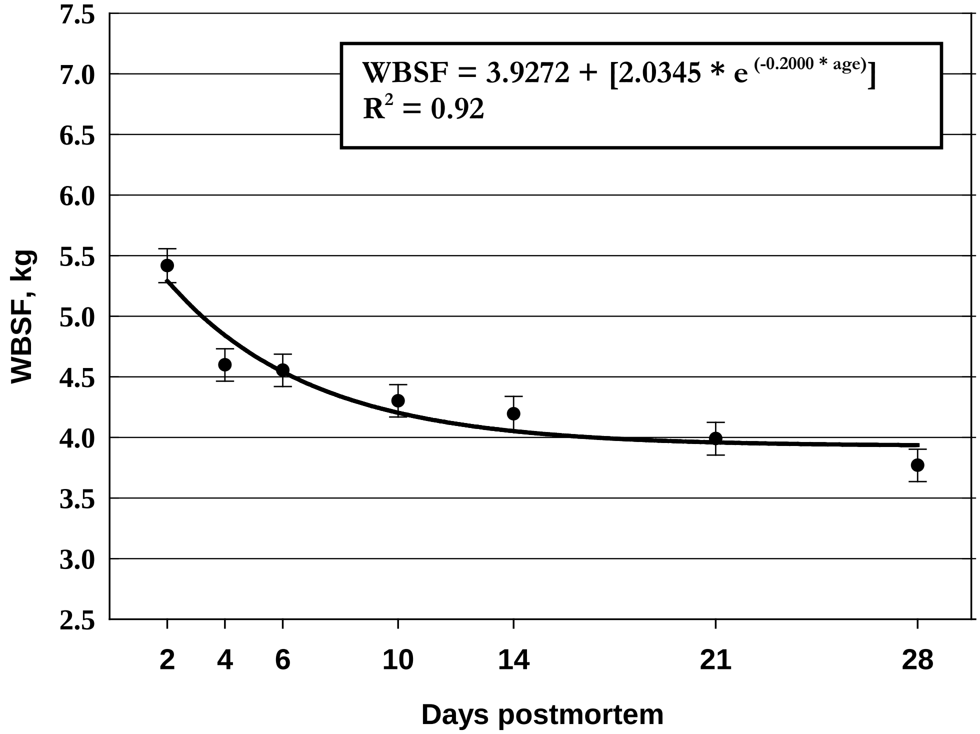

Figure 17. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for upper 2/3 Choice *triceps brachii* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable “age” is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

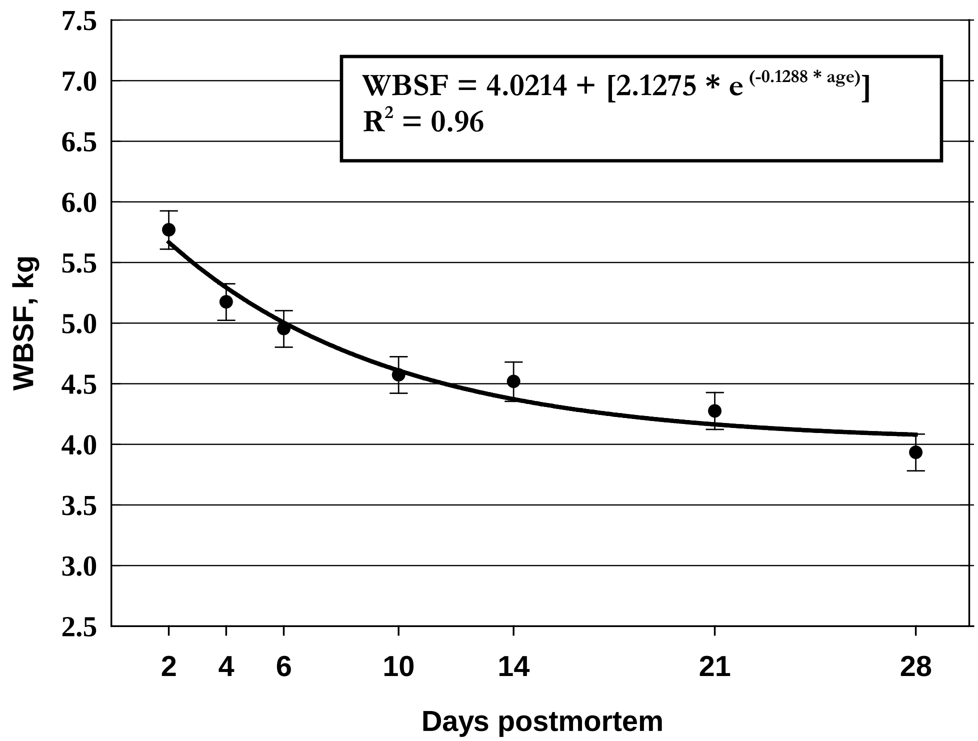

Figure 18. Least squares means ± standard error of the mean of Warner-Bratzler shear force (WBSF) for Select *triceps brachii* at 7 postmortem aging periods, and the non-linear regression model fit to these points. The variable “age” is the days of postmortem aging. The R^2 is the maximum proportion of total variability explained by the model. The constant "e" equals the base of the natural logarithm (2.718282).

Table 5. Categorization of muscles by responsiveness to postmortem aging

Muscle	Upper 2/3 USDA Choice Aging response[a]	USDA Select Aging response[a]
Biceps femoris - long head	Low	Moderate
Gluteus medius	Moderate	Moderate
Infraspinatus	Moderate	Moderate
Longissimus dorsi	Moderately low	High
Psoas major	Moderate	Moderate
Rectus femoris	Moderately low	Moderate
Tensor fascia latae	Moderately low	Moderate
Teres major	Moderately low	-[b]
Triceps brachii - long head	Moderate	Moderate

[a]Change in WBSF from two to 28 days postmortem. High = $\geq$ 2.3 kg; Moderately high = 2.2 to 1.8 kg; Moderate = 1.7 to 1.1 kg; Moderately low = 1.0 to 0.7 kg; Low = $\leq$ 0.6 kg.
[b]Regression line was unable to be fit to Select *teres major*, therefore aging response cannot be measured.

Table 6. Warner-Bratzler shear force (WBSF) for upper 2/3 Choice muscles at 2 days postmortem (kg), the change in shear force through 28 days postmortem, and the percentage (%) of that change completed at each of 6 postmortem aging periods

			Days postmortem					
Muscle	2-Day WBSF[a]	Aging response (kg)[b]	4	6	10	14	21	28
Biceps femoris - long head	5.08	0.5	40.3	64.3	87.3	99.8	99.9	100.0
Gluteus medius	5.39	1.1	23.0	40.9	65.7	80.7	94.3	100.0
Infraspinatus	4.48	1.4	29.4	50.2	75.63	88.3	97.3	100.0
Longissimus dorsi	5.96	2.0	38.5	62.2	85.7	94.7	99.2	100.0
Psoas major	4.28	1.1	15.1	28.4	50.1	66.8	87.2	100.0
Rectus femoris	4.92	1.0	30.3	51.5	76.8	89.1	97.6	100.0
Tensor fascia latae	4.67	1.0	36.9	60.3	84.3	93.9	99.0	100.0
Teres major	4.16	0.7	19.4	35.3	59.1	75.2	91.7	100.0
Triceps brachii - long head	5.29	1.4	33.2	55.4	80.3	91.4	98.3	100.0

[a]WBSF at two days postmortem predicted by non-linear regression model.
[b]Aging response = Predicted WBSF day 2 – Predicted WBSF day 28.

Table 7. Warner-Bratzler shear force (WBSF) for Select muscles at 2 days postmortem (kg), the change in shear force through 28 days postmortem, and the percentage (%) of that change completed at each of 6 postmortem aging periods

			Days postmortem					
Muscle	2-Day WBSF[a]	Aging response (kg)[b]	4	6	10	14	21	28
Biceps femoris - long head	5.86	1.1	11.9	22.9	42.4	59.0	82.3	100.0
Gluteus medius	6.18	1.6	9.6	18.9	36.4	52.5	77.9	100.0
Infraspinatus	4.75	1.4	14.1	268	48.0	64.7	85.9	100.0
Longissimus dorsi	6.66	2.5	14.7	27.6	49.1	65.8	86.6	100.0
Psoas major	4.56	1.3	9.2	18.2	35.2	51.3	77.0	100.0
Rectus femoris	5.33	1.3	14.8	27.9	49.5	66.2	86.8	100.0
Tensor fascia latae	5.02	1.1	21.9	39.3	63.9	79.2	93.7	100.0
Teres major	-	-	-	-	-	-	-	100.0
Triceps brachii - long head	5.67	1.6	23.5	41.7	66.7	81.5	94.7	100.0

[a]WBSF at two days postmortem predicted by non-linear regression model.
[b]Aging response = Predicted WBSF day 2 – Predicted WBSF day 28.

Table 8. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at two days of postmortem aging, and an index value of individual muscle tenderness at two days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Teres major*	4.16^{z}	0.16	160
2	*Psoas major*	4.49^{yz}	0.16	148
3	*Infraspinatus*	4.79^{xy}	0.16	139
4	*Tensor fascia latae*	5.07^{wx}	0.16	131
5	*Rectus femoris*	5.27^{w}	0.16	126
6	*Triceps brachii* - long head	5.77^{v}	0.16	115
7	*Biceps femoris* - long head	6.01^{v}	0.16	110
8	*Gluteus medius*	6.12^{v}	0.16	109
9	*Longissimus dorsi*	6.64^{u}	0.16	100

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[u,v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 9. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at four days of postmortem aging, and an index value of individual muscle tenderness at four days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Teres major*	4.26^{z}	0.15	149
2	*Psoas major*	4.47^{yz}	0.15	142
3	*Infraspinatus*	4.51^{yz}	0.15	141
4	*Tensor fascia latae*	4.73^{y}	0.15	135
5	*Triceps brachii* - long head	5.17^{x}	0.15	123
6	*Rectus femoris*	5.22^{x}	0.15	122
7	*Biceps femoris* - long head	5.67^{w}	0.15	112
8	*Gluteus medius*	6.29^{v}	0.15	101
9	*Longissimus dorsi*	6.36^{v}	0.15	100

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 10. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at six days of postmortem aging, and an index value of individual muscle tenderness at six days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	4.35[z]	0.15	136
2	*Teres major*	4.36[z]	0.15	135
3	*Psoas major*	4.48[z]	0.15	132
4	*Tensor fascia latae*	4.60[yz]	0.15	128
5	*Triceps brachii* - long head	4.95[y]	0.15	119
6	*Rectus femoris*	4.96[y]	0.15	119
7	*Biceps femoris* - long head	5.45[x]	0.15	108
8	*Gluteus medius*	5.68[wx]	0.15	104
9	*Longissimus dorsi*	5.91[w]	0.15	100

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 11. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at 10 days of postmortem aging, and an index value of individual muscle tenderness at 10 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Psoas major*	3.94[z]	0.15	140
2	*Teres major*	4.12[z]	0.15	134
3	*Infraspinatus*	4.14[z]	0.15	133
4	*Tensor fascia latae*	4.19[yz]	0.15	131
5	*Triceps brachii* - long head	4.57[xy]	0.15	121
6	*Rectus femoris*	4.67[x]	0.15	118
7	*Biceps femoris* - long head	5.32[w]	0.15	104
8	*Gluteus medius*	5.48[w]	0.15	101
9	*Longissimus dorsi*	5.50[w]	0.15	100

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 12. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at 14 days of postmortem aging, and an index value of individual muscle tenderness at 14 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	3.78^{z}	0.16	133
2	*Psoas major*	3.88^{z}	0.16	129
3	*Teres major*	4.16^{yz}	0.16	121
4	*Tensor fascia latae*	4.30^{y}	0.16	117
5	*Rectus femoris*	4.46^{y}	0.16	112
6	*Triceps brachii* - long head	4.52^{y}	0.16	111
7	*Longissimus dorsi*	5.01^{x}	0.16	100
8	*Biceps femoris* - long head	5.46^{w}	0.16	92
9	*Gluteus medius*	5.50^{w}	0.16	91

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 13. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at 21 days of postmortem aging, and an index value of individual muscle tenderness at 21 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Psoas major*	3.57^{z}	0.15	126
2	*Infraspinatus*	3.67^{z}	0.15	123
3	*Tensor fascia latae*	4.06^{y}	0.15	111
4	*Rectus femoris*	4.16^{xy}	0.15	108
5	*Teres major*	4.19^{xy}	0.15	108
6	*Triceps brachii* - long head	4.27^{xy}	0.15	106
7	*Longissimus dorsi*	4.52^{x}	0.15	100
8	*Gluteus medius*	4.96^{w}	0.15	91
9	*Biceps femoris* - long head	4.98^{w}	0.15	91

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 14. Rank of USDA Select beef muscles by Warner-Bratzler shear force (WBSF) at 28 days of postmortem aging, and an index value of individual muscle tenderness at 28 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Psoas major*	3.21[z]	0.15	131
2	*Infraspinatus*	3.31[z]	0.15	127
3	*Tensor fascia latae*	3.83[y]	0.15	110
4	*Teres major*	3.87[y]	0.16	109
5	*Triceps brachii* - long head	3.93[y]	0.15	107
6	*Rectus femoris*	4.04[y]	0.15	104
7	*Longissimus dorsi*	4.21[xy]	0.15	100
8	*Gluteus medius*	4.59[wx]	0.15	92
9	*Biceps femoris* - long head	4.76[w]	0.15	88

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 15. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at two days of postmortem aging, and an index value of individual muscle tenderness at two days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Teres major*	4.18[z]	0.14	135
2	*Psoas major*	4.30[yz]	0.14	131
3	*Infraspinatus*	4.62[xy]	0.14	122
4	*Tensor fascia latae*	4.70[wx]	0.14	120
5	*Rectus femoris*	5.03[vw]	0.14	112
6	*Biceps femoris* - long head	5.08[uv]	0.14	111
7	*Triceps brachii* - long head	5.42[tu]	0.14	104
8	*Gluteus medius*	5.45[t]	0.14	103
9	*Longissimus dorsi*	5.64[t]	0.14	100

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[t,u,v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 16. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at four days of postmortem aging, and an index value of individual muscle tenderness at four days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	3.77^{z}	0.13	130
2	*Teres major*	4.04^{yz}	0.13	121
3	*Psoas major*	4.11^{yz}	0.13	119
4	*Tensor fascia latae*	4.23^{xy}	0.13	116
5	*Rectus femoris*	4.52^{wx}	0.13	109
6	*Triceps brachii* - long head	4.60^{w}	0.13	107
7	*Biceps femoris* - long head	4.72^{vw}	0.13	104
8	*Longissimus dorsi*	4.90^{uv}	0.13	100
9	*Gluteus medius*	5.05^{u}	0.13	97

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[u,v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 17. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at six days of postmortem aging, and an index value of individual muscle tenderness at six days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Teres major*	3.81^{z}	0.13	113
2	*Infraspinatus*	3.89^{z}	0.13	111
3	*Psoas major*	3.96^{y}	0.13	109
4	*Tensor fascia latae*	4.05^{xy}	0.13	106
5	*Rectus femoris*	4.25^{wxy}	0.13	101
6	*Longissimus dorsi*	4.31^{wx}	0.13	100
7	*Triceps brachii* - long head	4.55^{vw}	0.13	94
8	*Biceps femoris* - long head	4.66^{uv}	0.13	92
9	*Gluteus medius*	4.89^{u}	0.13	88

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[u,v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 18. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at ten days of postmortem aging, and an index value of individual muscle tenderness at ten days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	3.57[z]	0.13	111
2	*Psoas major*	3.74[yz]	0.14	105
3	*Tensor fascia latae*	3.84[yz]	0.13	103
4	*Teres major*	3.91[y]	0.13	101
5	*Longissimus dorsi*	3.94[y]	0.13	100
6	*Rectus femoris*	4.30[x]	0.14	92
7	*Triceps brachii* - long head	4.30[x]	0.13	92
8	*Gluteus medius*	4.64[w]	0.13	85
9	*Biceps femoris* - long head	4.70[w]	0.13	84

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 19. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at 14 days of postmortem aging, and an index value of individual muscle tenderness at 14 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	3.25[z]	0.14	112
2	*Teres major*	3.55[yz]	0.15	112
3	*Psoas major*	3.57[yz]	0.14	111
4	*Tensor fascia latae*	3.84[xy]	0.14	103
5	*Longissimus dorsi*	3.97[wx]	0.14	100
6	*Triceps brachii* - long head	4.19[vw]	0.14	95
7	*Rectus femoris*	4.32[vw]	0.15	92
8	*Biceps femoris* - long head	4.48[v]	0.15	89
9	*Gluteus medius*	4.53[v]	0.14	88

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 20. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at 21 days of postmortem aging, and an index value of individual muscle tenderness at 21 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	3.26^{z}	0.13	113
2	*Psoas major*	3.38^{yz}	0.13	109
3	*Teres major*	3.61^{xy}	0.14	102
4	*Longissimus dorsi*	3.67^{wxy}	0.13	100
5	*Tensor fascia latae*	3.77^{wx}	0.13	97
6	*Rectus femoris*	3.82^{wx}	0.13	96
7	*Triceps brachii* - long head	3.99^{w}	0.13	92
8	*Gluteus medius*	4.44^{v}	0.13	83
9	*Biceps femoris* - long head	4.56^{v}	0.13	81

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 21. Rank of upper 2/3 USDA Choice beef muscles by Warner-Bratzler shear force (WBSF) at 28 days of postmortem aging, and an index value of individual muscle tenderness at 28 days postmortem (*Longissimus dorsi* = 100)

Rank	Muscle	WBSF (kg)	SEM	Tenderness index[a]
1	*Infraspinatus*	2.99^{z}	0.13	119
2	*Psoas major*	3.19^{yz}	0.13	111
3	*Teres major*	3.45^{xy}	0.13	103
4	*Tensor fascia latae*	3.51^{x}	0.13	101
5	*Longissimus dorsi*	3.55^{x}	0.13	100
6	*Triceps brachii* - long head	3.77^{wx}	0.13	94
7	*Rectus femoris*	3.90^{vw}	0.13	91
8	*Gluteus medius*	4.15^{v}	0.13	86
9	*Biceps femoris* - long head	4.58^{u}	0.13	78

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* / Mean WBSF (kg) of the individual muscle} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle.
[u,v,w,x,y,z]Means in the same column lacking common superscript letters differ ($P < 0.05$).

Table 22. Index value[a] of individual muscle tenderness for upper 2/3 Choice muscles at 7 postmortem aging periods (14 day Upper 2/3 Choice *Longissimus dorsi* = 100)

	Days postmortem						
Muscle	2	4	6	10	14	21	28
Biceps femoris - long head	78	84	85	84	89	87	87
Gluteus medius	73	79	81	86	88	89	96
Infraspinatus	86	105	102	111	122	122	133
Longissimus dorsi	70	81	92	101	100	108	112
Psoas major	92	97	100	106	111	117	124
Rectus femoris	79	88	93	92	92	104	102
Tensor fascia latae	84	94	98	103	103	105	113
Teres major	95	98	104	102	112	110	115
Triceps brachii - long head	73	86	87	92	95	99	105

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* at 14 days postmortem/ Mean WBSF (kg) of the individual muscle at each respective aging period} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle at 14 days postmortem.

Table 23. Index value[a] of individual muscle tenderness for Select muscles at 7 postmortem aging periods (14 day Select *Longissimus dorsi* = 100)

	Days postmortem						
Muscle	2	4	6	10	14	21	28
Biceps femoris - long head	83	88	92	94	92	101	105
Gluteus medius	82	80	88	91	91	101	109
Infraspinatus	105	111	115	121	133	137	151
Longissimus dorsi	75	79	85	91	100	111	119
Psoas major	112	112	112	127	129	140	156
Rectus femoris	95	96	101	107	112	120	124
Tensor fascia latae	99	106	109	120	117	123	131
Teres major	120	118	115	122	120	120	129
Triceps brachii - long head	87	97	101	110	111	117	127

[a]Tenderness Index = {Mean WBSF (kg) of the *longissimus dorsi* at 14 days postmortem/ Mean WBSF (kg) of the individual muscle at each respective aging period} * 100. Tenderness index values greater than 100 indicate more desirable values for tenderness than the *longissimus dorsi* muscle at 14 days postmortem.

For more information contact:
National Cattlemen's Beef Association
9110 East Nichols Avenue
Centennial, Colorado 80112-3450
(303) 694-0305