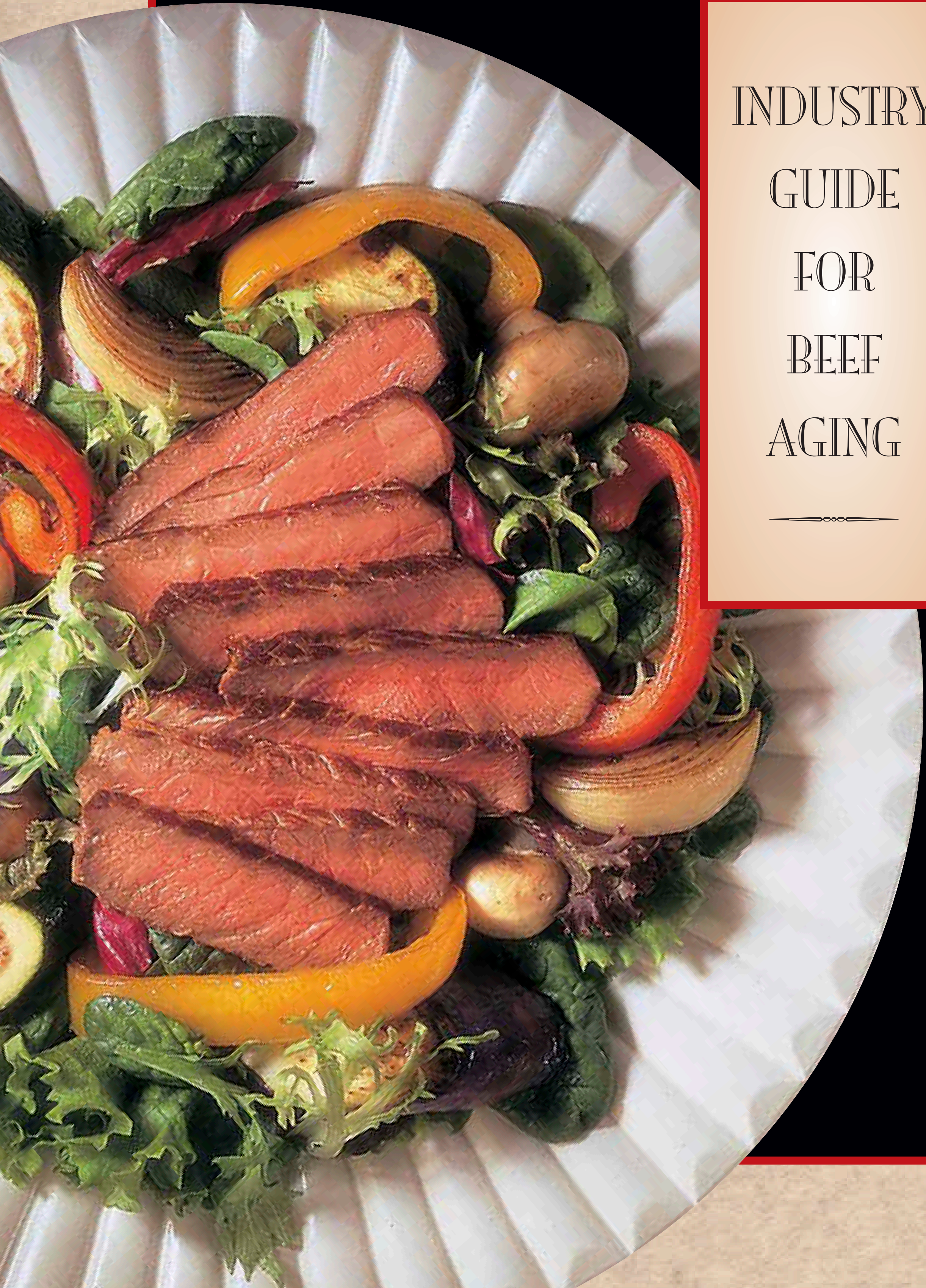

INDUSTRY GUIDE FOR BEEF AGING

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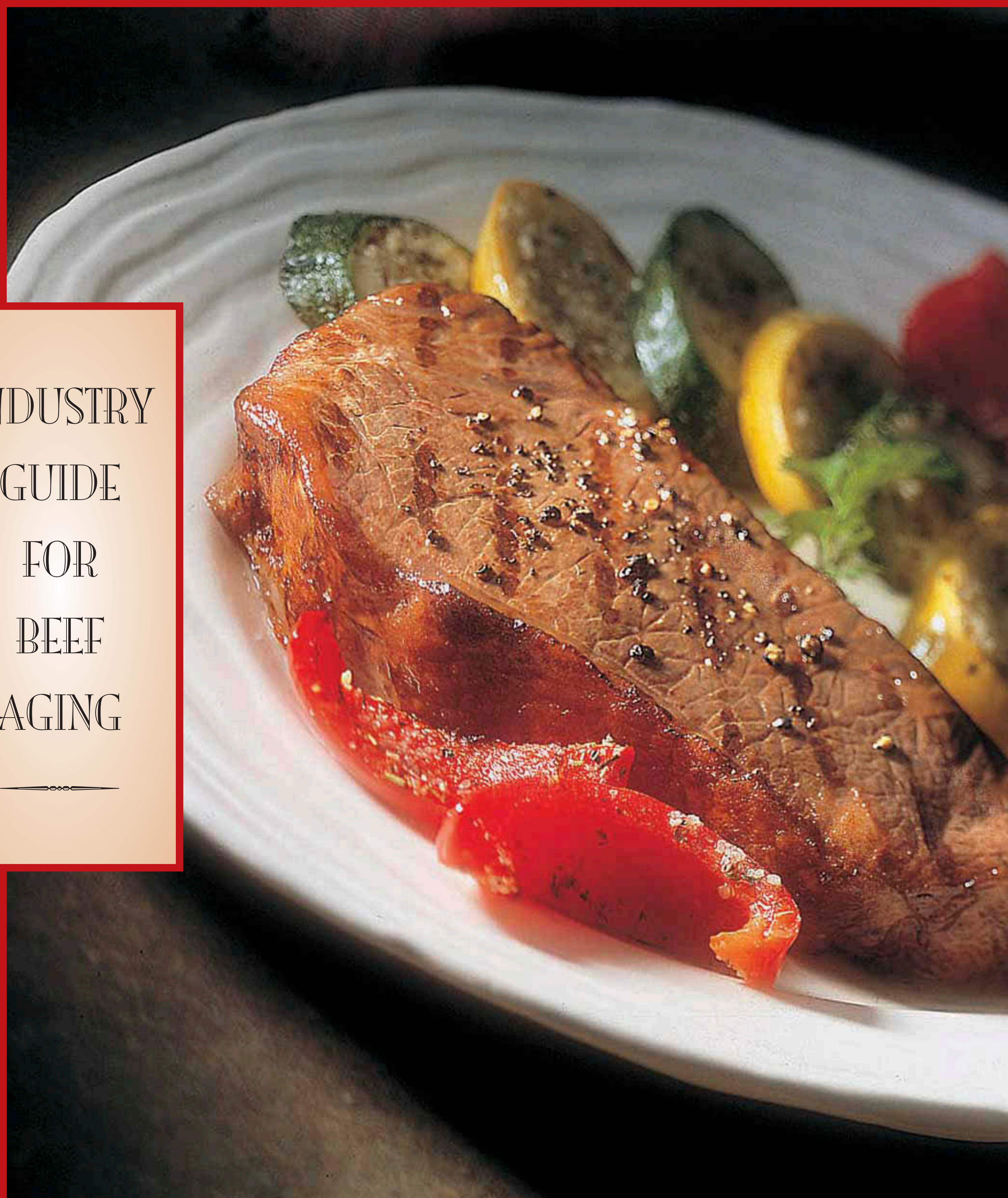
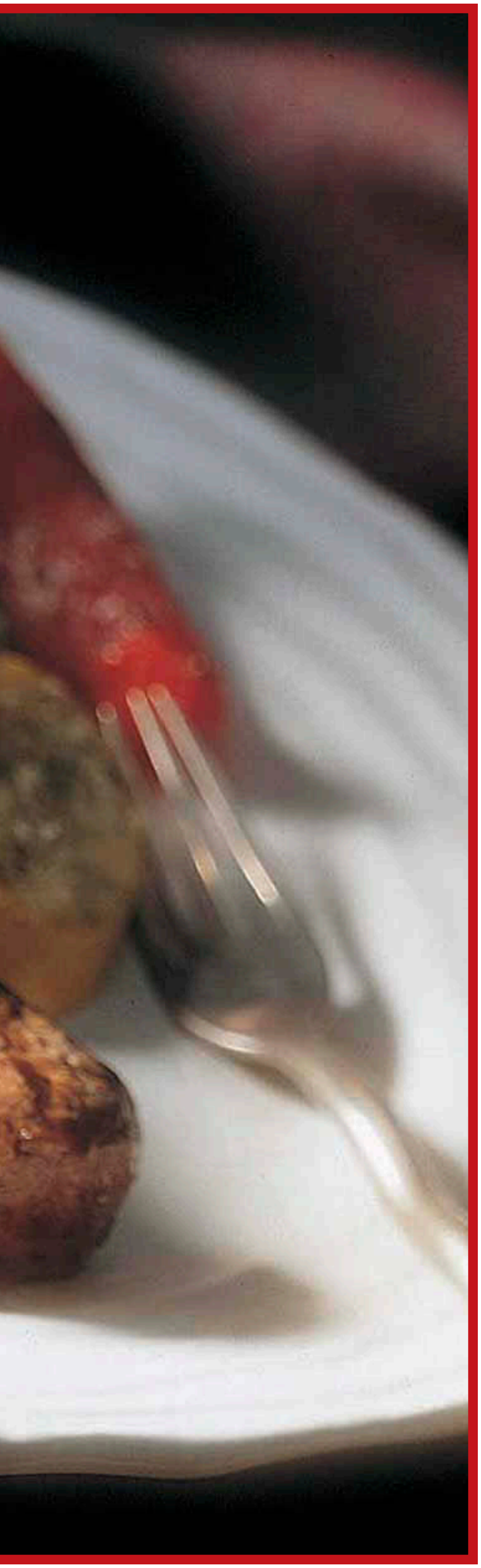




BACKGROUND

Postmortem aging is a critical management practice that can improve the consistency of beef tenderness (Tatum et al., 1999); however, the two most recent National Beef Tenderness Surveys revealed variability in length of postmortem aging time of beef cuts (Morgan et al., 1991; Brooks et al., 2000).

Previous studies have characterized improvements in tenderness associated with aging a variety of beef subprimals (Smith et al., 1978; Eilers et al., 1996). Researchers at Texas A&M University (Lorenzen et al., 1998), on behalf of the Texas Beef Council, developed an "aging index" that could be used by retailers for purposes of managing postmortem aging time of beef subprimal cuts to maximize beef palatability. That study recommended that ribeyes and shortloins be aged for at least 13 days; chuck rolls should be aged for at least 12 days; and bottom and top rounds should be aged at least 12 and 16 days, respectively. Researchers at Colorado State University (Mies et al., 1998), on behalf of the National Cattlemen's Beef Association (NCBA) and the Cattlemen's Beef Board, prepared a comprehensive review of scientific literature addressing the influence of postmortem aging time on beef tenderness for a number of different beef subprimals. They concluded that steaks from the rib be aged between 11 and 15 days; the chuck roll and clod for a minimum of 12 and 11 days, respectively; striploin and top sirloin cuts for at least 14 and 21 days, respectively; and top and bottom round cuts for a minimum of 16 and 12 days, respectively (Mies et al., 1998).

One of the key strategies employed by NCBA to increase beef demand has been to increase utilization of muscles from the chuck and round through value-added and further-processed beef products. To successfully promote use of chuck and round muscles, the National Cattlemen's Beef Association's muscle profiling research produced a complete database that characterizes the physical, chemical, and palatability traits of several individual beef muscles. That research has identified several individual muscles that possess desirable tenderness and/or flavor attributes and resulted in development of a product line of moderately priced cuts from the underutilized chuck and round (NCBA, 2000). In 2001, NCBA introduced the *Beef Value Cuts* program, involving use of 14 single-muscle cuts that offered easy preparation, greater consistency, and more lean-product options for beef consumers (CBB, 2003).

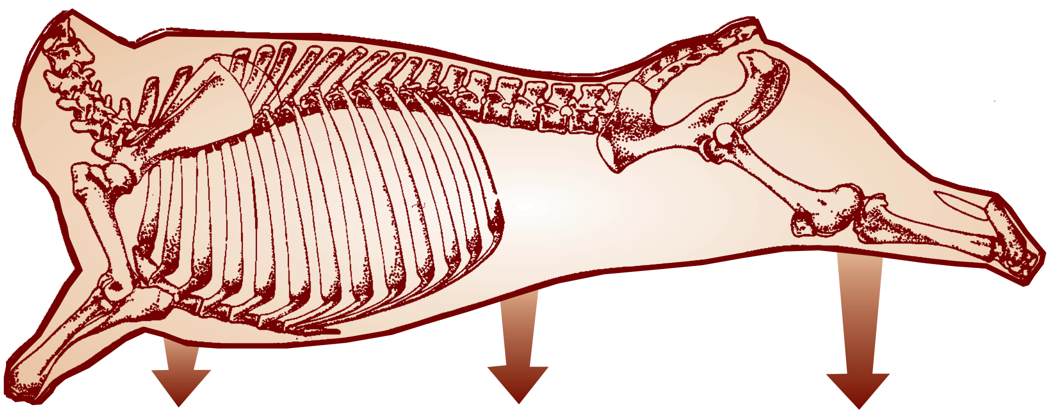
Current industry aging specifications are only applicable to beef subprimal cuts, not individual muscles within subprimal cuts and, to date, the effect of USDA Quality Grade on aging recommendations has not been determined.

The success of single-muscle utilization has created the need to establish aging guidelines for individual muscles of different USDA Quality Grades. To identify these aging times, the National Cattlemen's Beef Association commissioned researchers at Colorado State University to conduct a study to characterize postmortem aging of fresh (never frozen) individual beef muscles of two different quality grades (upper 2/3 USDA Choice and USDA Select).

HOW THE STUDY WAS CONDUCTED

Over a seven-month period, researchers selected 40 USDA Select and 40 upper two-thirds USDA Choice (Premium Choice) beef carcasses from a packing plant located in Northeast Colorado. Two days after harvest (two days postmortem), ten subprimals were removed from each carcass during in-plant fabrication (Figure 1). Beef subprimals then were transported to the Colorado State University Meat Laboratory and fabricated into individual muscles (Figure 1). Each beef muscle was cut into seven one-inch thick steaks and each steak was assigned to one of the following postmortem aging periods: 2, 4, 6, 10, 14, 21 or 28 days. All steaks were vacuum-sealed and stored at 36°F (2°C) during aging. Following completion of the assigned aging period, steaks were removed from storage (never frozen), cooked on a double-sided electric grill to a peak internal temperature of 160°F (71°C) and, then, measured to determine Warner-Bratzler shear force (WBSF). Warner-Bratzler shear force assesses the tenderness of meat by measuring the amount of force in kilograms necessary to shear multiple 1/2 - inch core samples from each steak evaluated.

FIGURE 1: BEEF SUBPRIMALS AND INDIVIDUAL MUSCLES



CHUCK

Subprimal	IMPS
Chuck Roll	116 A
Shoulder Clod	114
Chuck Tender	116 B

LOIN

Subprimal	IMPS
Sirloin	181
Striploin	180
Tenderloin	189 A

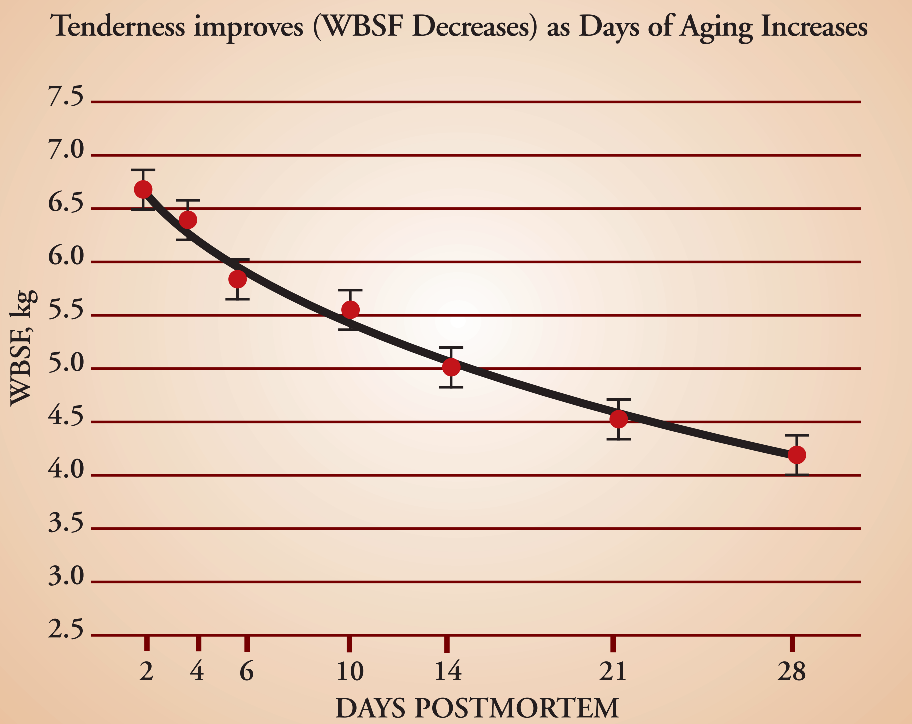
ROUND

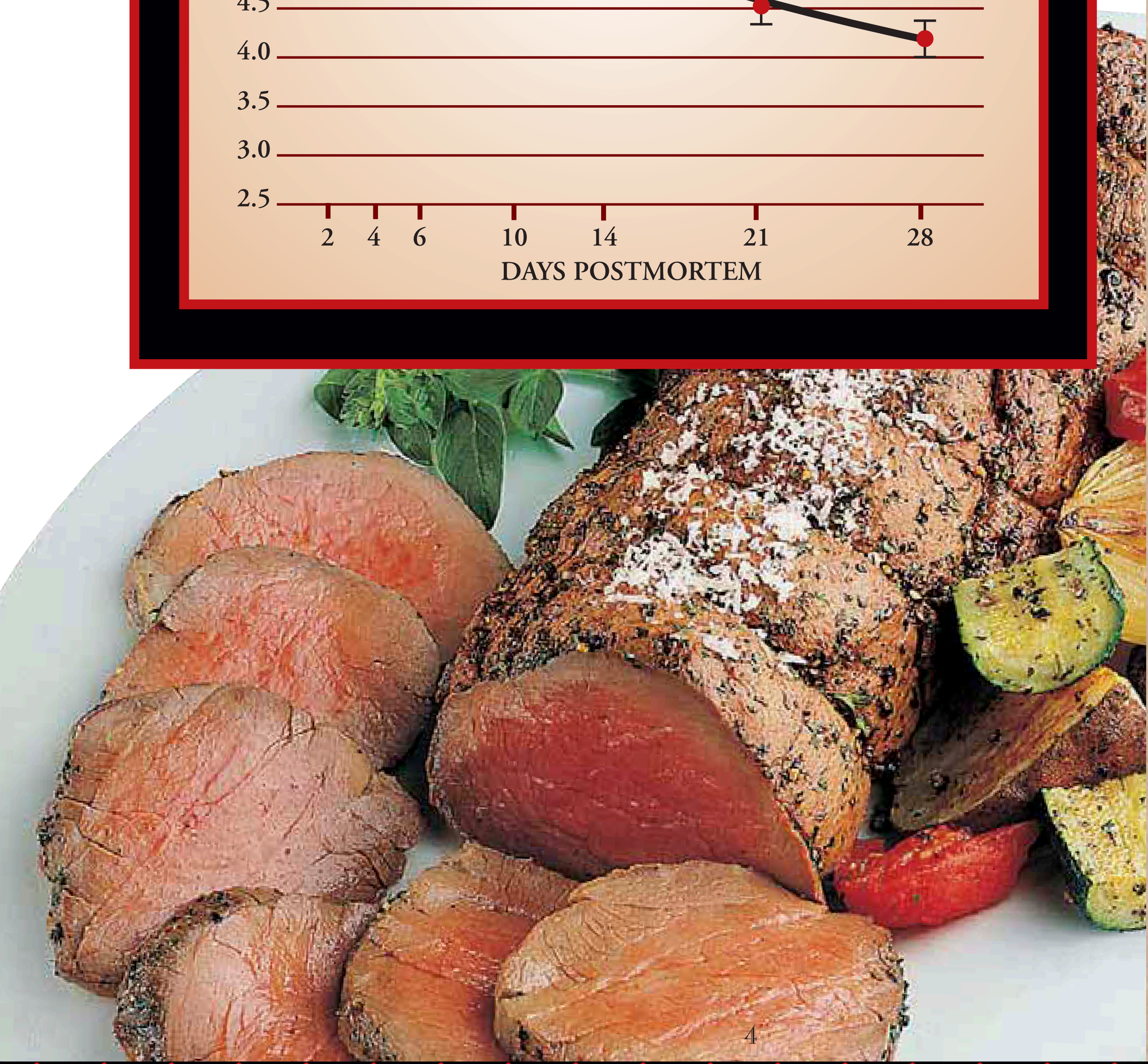
Subprimal	IMPS
Bottom Round	171 B
Top Round	169 A
Eye of Round	171 C
Knuckle	167

CHUCK	LOIN	ROUND
Chuck Roll 116 A Complexus (CP) Serratus ventralis (SV) Spinalis dorsi (SP)	Sirloin 181 Gluteus medius (GM) Tensor fasciae latae (Tri-tip) (TF)	Bottom Round 171 B Biceps femoris (BF)
Shoulder Clod 114 Infraspinatus (IF) Teres major (TM) Triceps brachii (TB)	Striploin 180 Longissimus dorsi (LD)	Top Round 169 A Semimembranosus (SM)
Chuck Tender 116 B Supraspinatus (SU)	Tenderloin 189 A Psoas major (PM)	Eye of Round 171C Semitendinosus (ST)
		Knuckle 167 Rectus femoris (RF) Vastus lateralis (VL) Vastus medialis (VM)

Differences in tenderness (WBSF values) caused by the effects of muscle, USDA Quality Grade, and length of postmortem aging period were evaluated using statistical models (PROC MIXED: SAS Inst. Inc., Cary, NC). To characterize the change in tenderness from 2 to 28 days postmortem, "aging curves" (Figure 2) were developed for each muscle within each of the two quality grades (PROC NLIN: SAS Inst. Inc., Cary, NC).

Figure 2: Aging Curve





Warner-Bratzler shear force assesses the tenderness of meat by measuring the amount of force in kilograms necessary to shear multiple 1/2 - inch core samples from each steak evaluated.

INITIAL FINDINGS

Researchers found that differences in postmortem tenderization are expressed as differences in:

1) **Initial Tenderness:** WBSF of the muscle before aging (2 days postmortem).

2) **Aging Response:** The overall change in WBSF that occurs during aging (from day 2 through day 28).

3) **Rate of Tenderization:** The daily change in WBSF during aging.

Initial tenderness values (2-day WBSF) and aging responses identify the improvement in tenderness that can be achieved through postmortem aging (Figure 3). Rate of tenderization characterizes the speed at which improvement in shear force is made. Warner-Bratzler shear force values at 2 days postmortem (initial tenderness) differed among muscles and between quality grades (Figure 3). Likewise, the changes in WBSF during aging (aging response and rate of aging) depended on both individual muscle and USDA Quality Grade (Figures 3 - 5). Correspondingly, both muscle and quality grade should be considered when developing beef aging protocols.

Figure 3: INITIAL TENDERNESS AND AGING RESPONSE

Muscle	Premium USDA Choice Initial tenderness[a]	Premium USDA Choice Aging response[b]	USDA Select Initial tenderness[a]	USDA Select Aging response[b]
Biceps femoris - long head	5.08	Low	5.86	Moderate
Complexus	5.39	Moderate	6.03	Moderate
Gluteus medius	5.39	Moderate	6.18	Moderate
Infraspinatus	4.48	Moderate	4.75	Moderate
Longissimus dorsi	5.63	Moderately high	6.66	High
Psoas major	4.28	Moderate	4.56	Moderate
Rectus femoris	4.92	Moderately low	5.33	Moderate
Semimembranosus	5.96	Moderate	7.34	High
Semitendinosus	6.10	Moderate	6.32	Moderate
Serratus ventralis	4.11	Moderately low	4.68	Moderately low
Spinalis dorsi	4.54	Moderately low	4.83	Moderate
Supraspinatus	5.83	Moderate	5.97	Moderate
Tensor fasciae latae	4.66	Moderately low	5.02	Moderate
Teres major	4.16	Moderately low	-[c]	-[c]
Triceps brachii - long head	5.29	Moderate	5.67	Moderate
Vastus lateralis	5.70	Moderate	6.18	Moderate
Vastus medialis	5.60	Moderately high	5.71	Moderately high

[a]Initial tenderness (kg) = WBSF 2 days postmortem. 1 kg = 2.2046 lb.
[b]Aging response = Change in WBSF from 2 to 28 days postmortem.
[c]Postmortem tenderization of the Select *Teres major* could not be characterized.

KEY

High	Moderately high	Moderate	Moderately low	Low
≥ 2.2 kg	2.1 to 1.8 kg	1.7 to 1.1 kg	1.0 to 0.7 kg	≤ 0.6 kg

Categories established by standard deviations from the grand mean

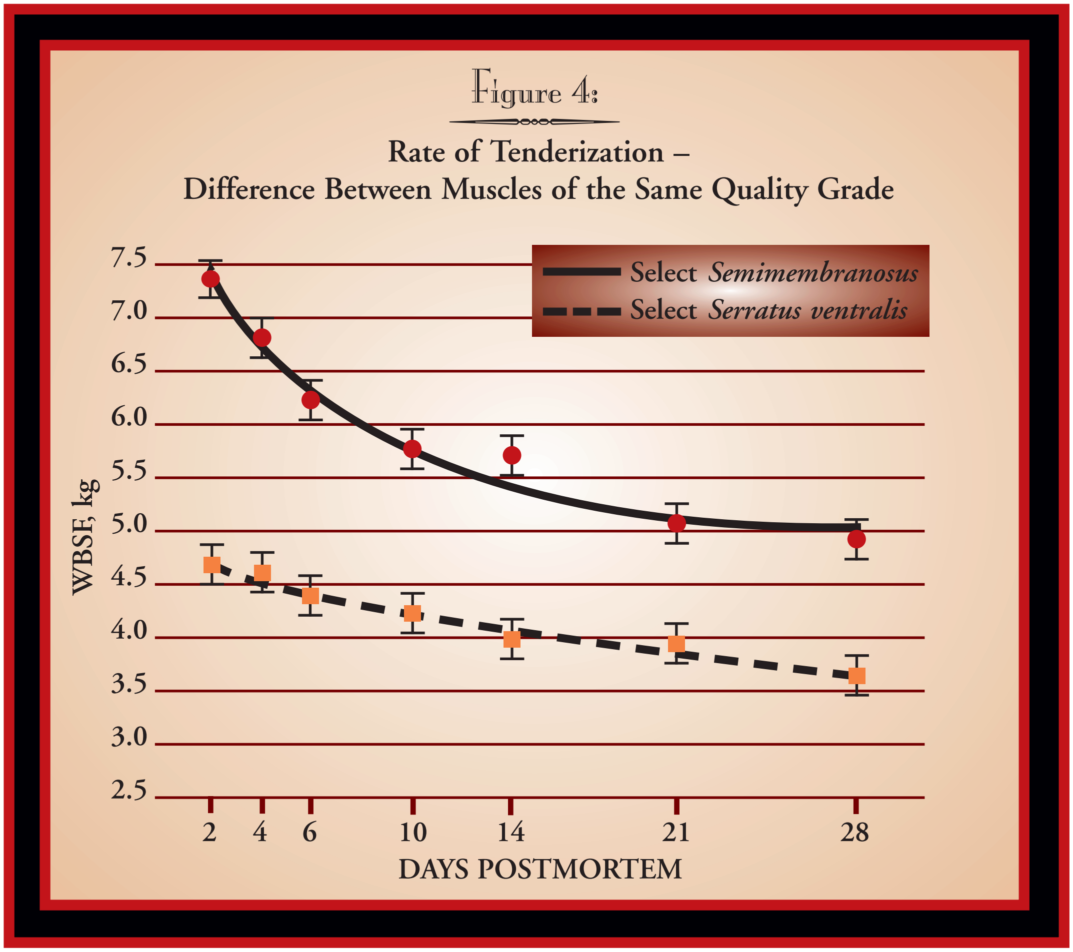


Figure 4:
Rate of Tenderization –
Difference Between Muscles of the Same Quality Grade
Select Semimembranosus
Select Serratus ventralis
WBSF, kg
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2
4
6
10
14
21
28
DAYS POSTMORTEM

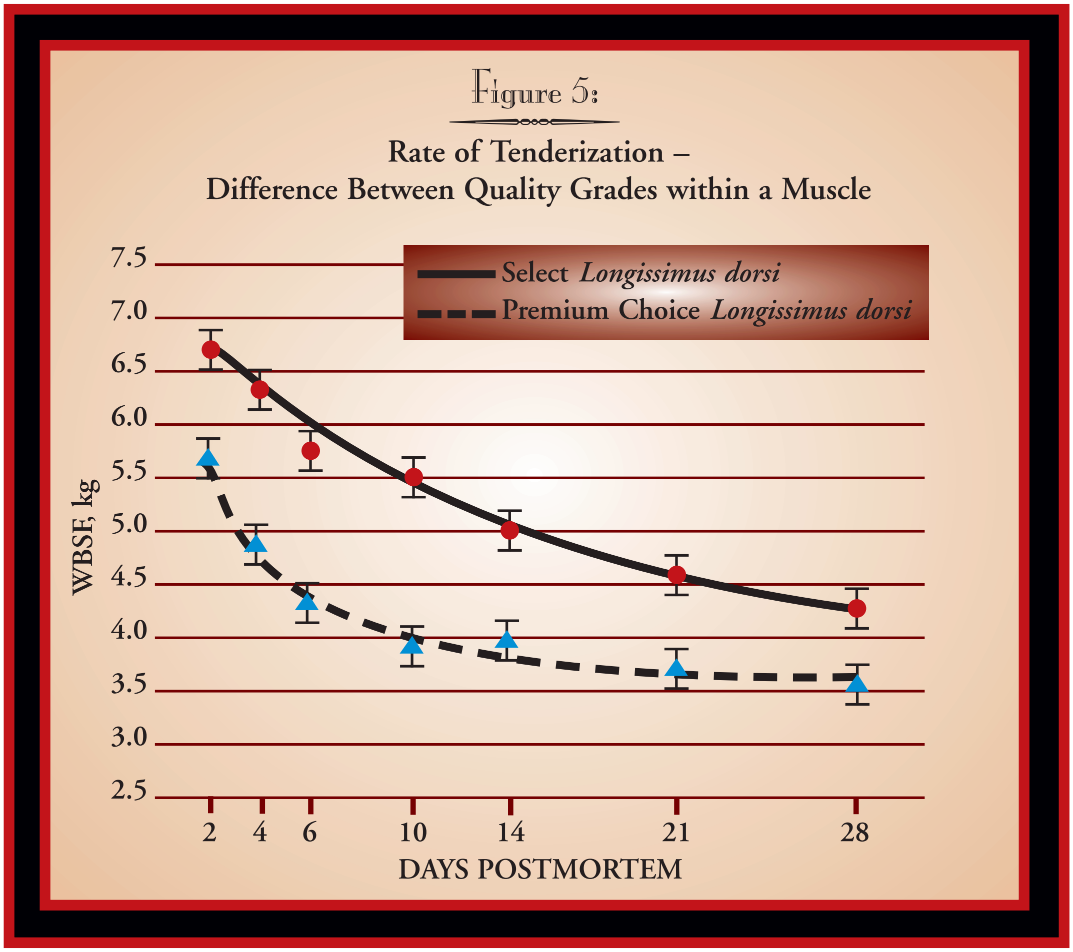


Figure 5:
Rate of Tenderization –
Difference Between Quality Grades within a Muscle
Select Longissimus dorsi
Premium Choice Longissimus dorsi
WBSF, kg
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2
4
6
10
14
21
28
DAYS POSTMORTEM

POSTMORTEM AGING MANAGEMENT

Postmortem aging periods can be established by:

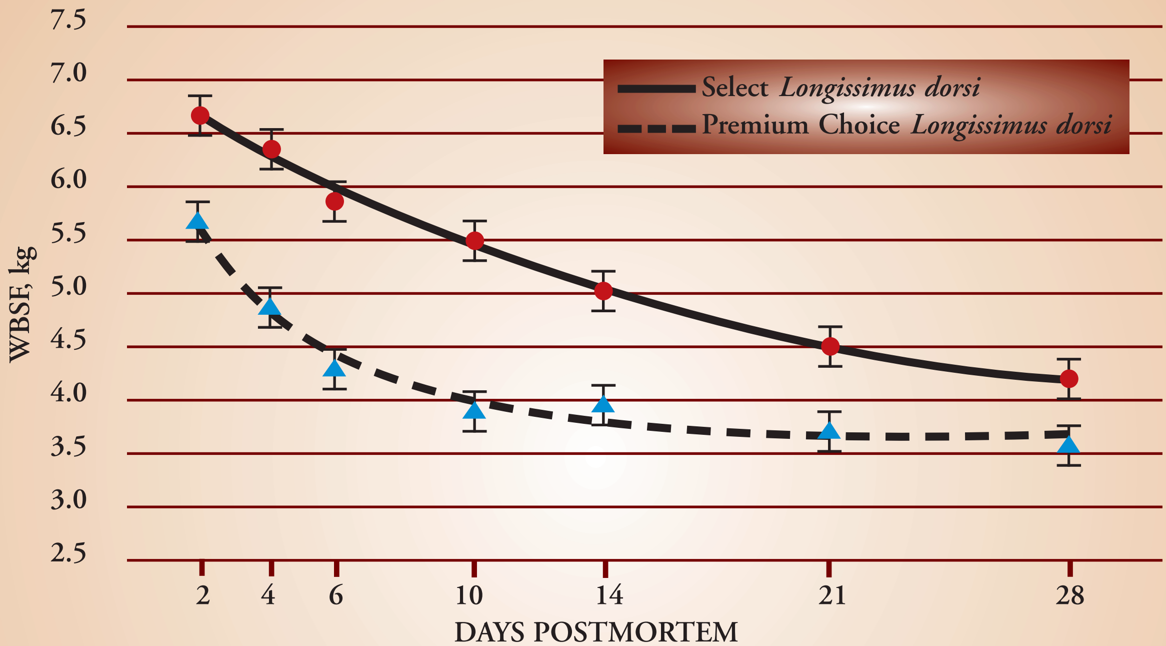
1) Determining the amount of time (days postmortem) required for a majority of the aging response to be completed.

2) Determining when a muscle has achieved a targeted WBSF value.

Considering both aging response and rate of tenderization, the time required for a majority of the aging response to be achieved was established for individual muscles of each quality grade (Figure 9). Based on this approach, the *Longissimus dorsi* requires substantially different aging periods depending on quality grade (Figure 6). A Select *Longissimus dorsi* will complete greater than 90% of its 2.5 kg aging response from 21 to 28 days

Figure 6:

Postmortem Tenderization – *Longissimus dorsi*

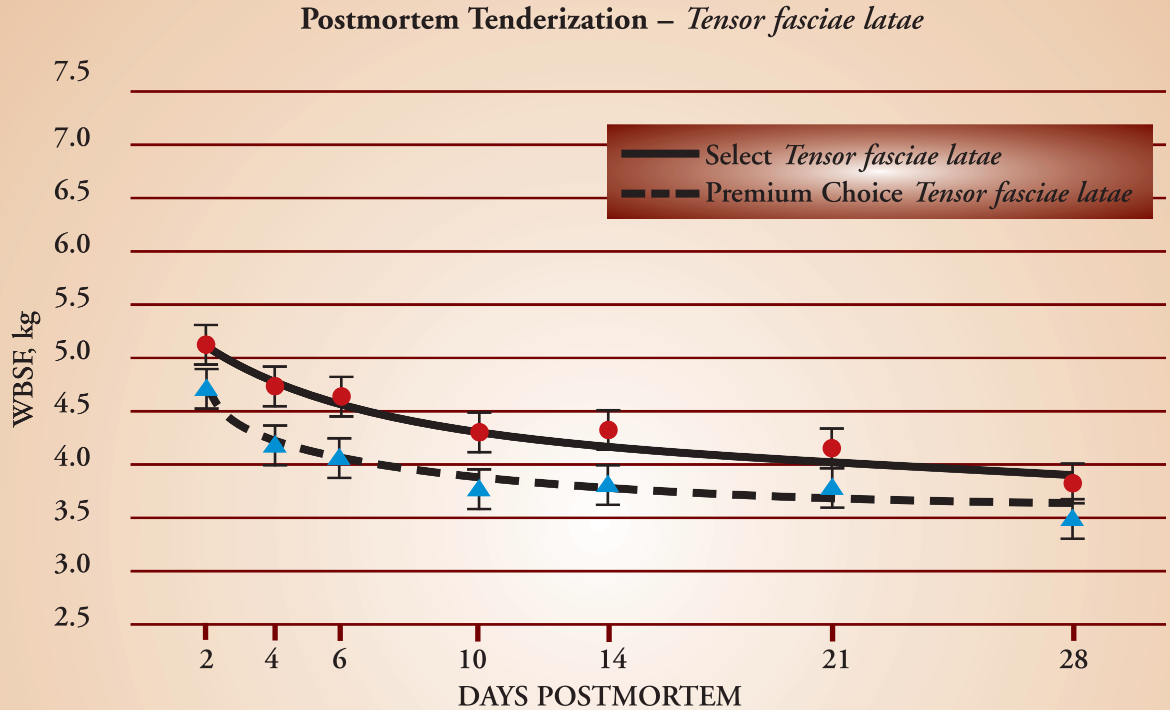


WBSF of *Longissimus dorsi* at 2-d postmortem, change in WBSF through 28-d postmortem, and the percentage of that change complete at each of 6 aging periods

Grade	2-d WBSF	Aging response (kg)	Days Postmortem					
			4	6	10	14	21	28
Select	6.66	2.5	14.7	27.6	49.1	65.8	86.6	100.0
Premium Choice	5.63	2.0	38.5	62.2	85.7	94.7	99.2	100.0

postmortem, while a Premium Choice *Longissimus dorsi* has completed approximately 95% of a 2.0 kg aging response by day 14. Like the *Longissimus dorsi,* the Select *Tensor fasciae latae* (Tri-tip) requires a longer aging period than a Premium Choice Tri-tip. Select and Premium Choice Tri-tips have similar aging responses (approximately 1.0 kg); however, almost 95% of this change in shear force is attained at 14 days postmortem for Premium Choice Tri-tips, whereas it takes greater than 21 days to attain a 95% change in shear force for Select Tri-tips (Figure 7). Although some Select muscles require longer aging periods than their Premium Choice counterparts, a muscle may require similar aging periods for both quality grades. The *Vastus lateralis* (from the knuckle) has an aging response of approximately 1.5 kg, and completed greater than 90% of this change in shear force by 21 days postmortem, regardless of quality grade (Figure 8).

Figure 7:



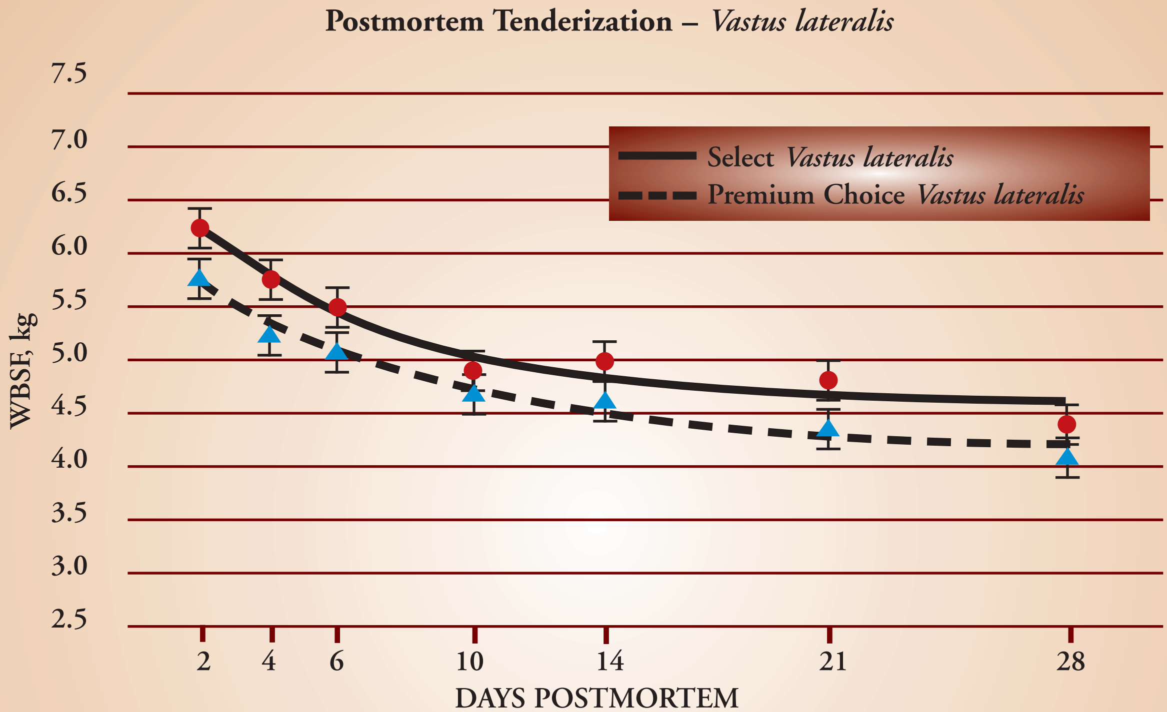
WBSF of *Tensor fasciae latae* at 2-d postmortem, change in WBSF through 28-d postmortem, and the percentage of that change complete at each of 6 aging periods

			Days Postmortem					
Grade	2-d WBSF	Aging response (kg)	4	6	10	14	21	28
Select	5.02	1.1	21.9	39.3	63.9	79.2	93.7	100.0
Premium Choice	4.67	1.0	36.9	60.3	84.3	93.9	99.0	100.0

Aging times that ensure that a majority of the aging response has been achieved are listed for individual muscles of each quality grade in Figure 9. These aging periods are based on the percentage of aging response that has been completed. Aging times (days post-mortem) for muscles with high, moderately high, moderate, moderately low, and low aging responses correspond to the day that at least 96%, 95%, 94%, 90%, and 85% of the aging response is complete, respectively. Aging periods longer than those identified (up to 28 days) in Figure 9 will result in an additional ≤ 0.1 kg decrease in WBSF.

Aging periods displayed in Figure 9 ensure that a majority of the aging response has been achieved for an individual muscle, regardless of initial tenderness; however, information regarding postmortem tenderization of individual muscles obtained from this study (Figures 11- 13) may also be used to manage the length of aging time by determining

Figure 8:



WBSF of *Vastus lateralis* at 2-d postmortem, change in WBSF through 28-d postmortem, and the percentage of that change complete at each of 6 aging periods

			Days Postmortem					
Grade	2-d WBSF	Aging response (kg)	4	6	10	14	21	28
Select	6.18	1.6	25.5	44.7	69.9	84.1	95.7	100.0
Premium Choice	5.70	1.5	22.9	40.8	65.6	80.7	94.0	100.0

when a muscle has achieved a targeted WBSF value. To determine the amount of postmortem aging that will be required for a muscle to reach a targeted shear force value, initial tenderness, aging response, and rate of tenderization must all be considered. For example, if a WBSF value of 4.4 kg is established as a desirable endpoint for the Select *Longissimus dorsi*, 23 days of postmortem aging will be required to achieve a 2.3 kg decrease in WBSF (2-d WBSF = 6.7 kg; target WBSF = 4.4 kg)(Figure 10). Several research studies have attempted to examine the impact of differences in WBSF on consumer acceptance of steaks (Miller et al., 2001; Lorenzen et al., 2003). Platter et al. (2003) reported that the predicted probability of consumers finding a *Longissimus* steak acceptable 50 and 68% of the time was at approximate WBSF values of 4.4 and 3.7 kg, respectively. Although these values can be used to help establish optimal endpoints for

Figure 9:

Postmortem Aging Periods

Muscle	Associated Name	Premium USDA Choice		USDA Select	
		Aging Response[a]	Aging Period[b]	Aging Response[a]	Aging Period[b]
Round					
Biceps femoris - long head	Bottom/outside round, flat	0.5	6	1.1	26
Rectus femoris	Round tip center	1.0	15	1.3	25
Semimembranosus	Top/inside round	1.4	16	2.3	23
Semitendinosus	Eye of round	1.4	18	1.6	23
Vastus lateralis	Round tip side	1.5	21	1.6	20
Vastus medialis	Round tip bottom	1.8	21	1.9	25
Loin					
Gluteus medius	Top sirloin	1.1	21	1.6	27
Longissimus dorsi	Striploin	2.0	15	2.5	26
Psoas major	Tenderloin	1.1	25	1.3	27
Tensor fasciae latae	Tri-tip	1.0	12	1.1	22
Chuck					
Complexus	-	1.5	23	1.7	27
Infraspinatus	Top blade, flat iron	1.4	18	1.4	25
Serratus ventralis	Chuck under blade	0.9	25	1.0	24
Spinalis dorsi	-	1.0	13	1.3	23
Supraspinatus	Chuck/mock tender	1.4	14	1.6	23
Teres major	Shoulder/petite tender	0.7	21	-	-
Triceps brachii - long head	Clod heart, shoulder center	1.4	16	1.6	21

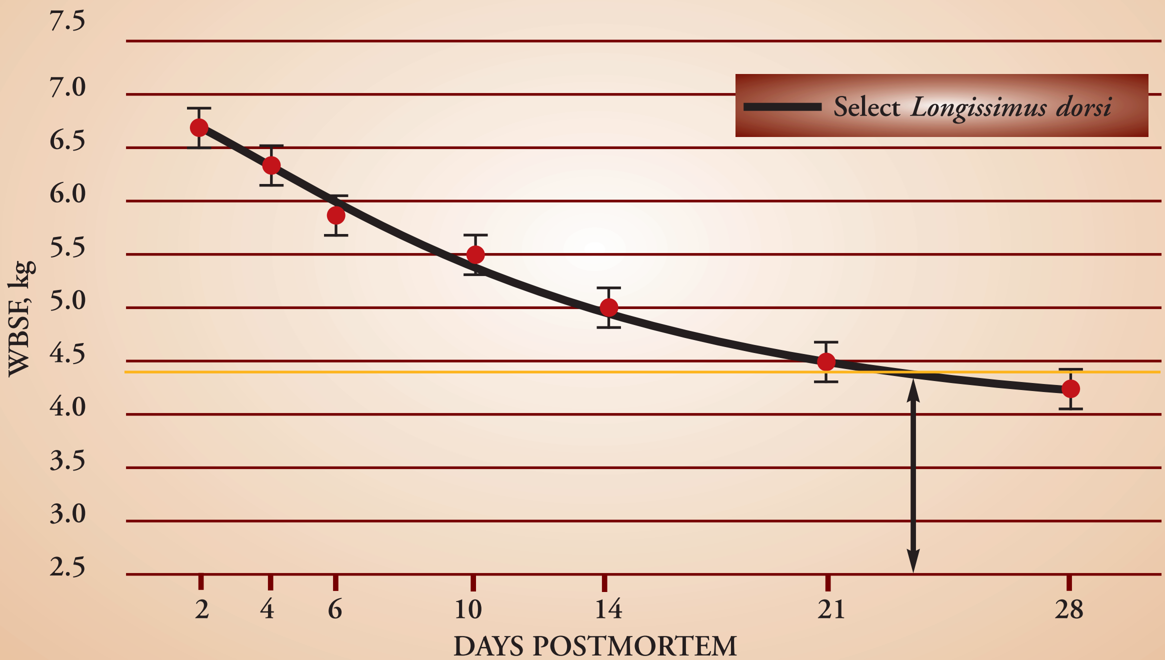
[a]Aging response (kg) = WBSF at 2 d postmortem - WBSF at 28 d postmortem; 1 kg = 2.2046 lb.
[b]Aging periods correspond to the day that a majority of the aging response is complete. Aging times (days postmortem) for muscles with aging responses ≥ 2.2 kg, 2.1 to 1.8 kg, 1.7 to 1.1 kg, 1.0 to 0.7 kg, and ≤ 0.6 kg correspond to the day that at least 96%, 95%, 94%, 90%, and 85% of the aging response is complete, respectively.

Longissimus dorsi muscles, it is unknown if these WBSF values accurately reflect consumer acceptance of steaks derived from other beef muscles.

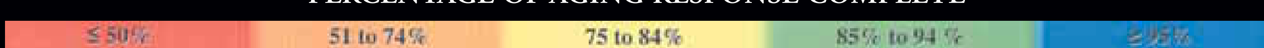
In addition to allowing the description of postmortem aging patterns for differing beef muscles, information from this study regarding the relative tenderness (WBSF values) of individual muscles of differing quality grades may be used to determine appropriate uses for specific muscles and to identify muscles that would be suitable for an intended use (Beef Muscle User Guide). Again, the impact of differences in WBSF on consumer acceptability has been investigated extensively for *Longissimus* steaks, but it is unknown if these changes in WBSF would affect consumer acceptance similarly within and among different muscles. Platter et al. (2003) suggested that differences in WBSF of 0.2 kg and 0.5 kg would result in changes of 4 to 5% and 9 to 12 % of consumer acceptance, respectively.

Figure 10:

Postmortem Aging Periods – Achieving Targeted WBSF Values



KEY-
PERCENTAGE OF AGING RESPONSE COMPLETE



Muscle	Quality Grade	2-d WBSF	Aging Response	Days of Postmortem Aging: 4 6 10 14 21 28
LD	Select	6.66	2.5	

90.4% – percentage of aging response needed to reach 4.4 kg.

Figures 11, 12 and 13:

Postmortem Tenderization of Muscles from the Round, Loin and Chuck

Warner-Bratzler shear force (WBSF) at two days postmortem (kg), the change in shear force through 28 days postmortem (aging response), and a color corresponding to the percentage (%) of that change complete at each of six postmortem aging periods

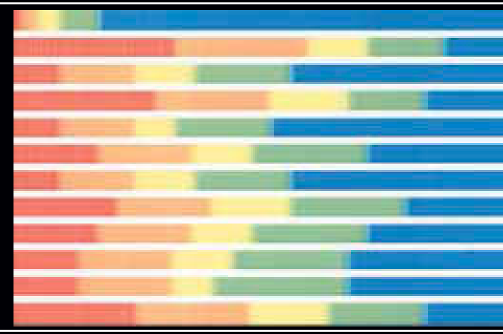
KEY-PERCENTAGE OF AGING RESPONSE COMPLETE

≤ 50% | 51 to 74% | 75 to 84% | 85% to 94 % | ≥ 95%

MUSCLES FROM THE ROUND

Muscle[a]	Quality Grade	2-d WBSF[b]	Aging Response[c]
BF	Premium Choice	5.08	0.5
BF	Select	5.86	1.1
RF	Premium Choice	4.92	1.0
RF	Select	5.33	1.3
SM	Premium Choice	5.96	1.4
SM	Select	7.34	2.3
ST	Premium Choice	6.10	1.4
ST	Select	6.32	1.6
VL	Premium Choice	5.70	1.5
VL	Select	6.18	1.6
VM	Premium Choice	5.60	1.8
VM	Select	5.71	1.9

Days of Postmortem Aging: 4 6 10 14 21 28



[a]BF = Biceps femoris; RF = Rectus femoris; SM = Semimembranosus; ST = Semitendinosus; VL = Vastus lateralis; VM = Vastus medialis.
[b]2 d WBSF (kg); 1 kg = 2.2046 lb. [c]Aging response = WBSF at 2 d postmortem – WBSF at 28 d postmortem.

MUSCLES FROM THE LOIN

Muscle[a]	Quality Grade	2-d WBSF[b]	Aging Response[c]
GM	Premium Choice	5.39	1.1
GM	Select	6.18	1.6
LD	Premium Choice	5.63	2.0
LD	Select	6.66	2.5
PM	Premium Choice	4.28	1.1
PM	Select	4.56	1.3
TF	Premium Choice	4.66	1.0
TF	Select	5.02	1.1

Days of Postmortem Aging: 4 6 10 14 21 28

[a]GM = Gluteus medius; LD = Longissimus dorsi; PM = Psoas major; TF = Tensor fasciae latae. [b]2 d WBSF (kg); 1 kg = 2.2046 lb.
[c]Aging response = WBSF at 2 d postmortem – WBSF at 28 d postmortem.

MUSCLES FROM THE CHUCK

Muscle[a]	Quality Grade	2-d WBSF[b]	Aging Response[c]
CP	Premium Choice	5.39	1.5
CP	Select	6.03	1.7
IF	Premium Choice	4.48	1.4
IF	Select	4.75	1.4
SP	Premium Choice	4.54	1.0
SP	Select	4.83	1.3
SU	Premium Choice	5.83	1.4
SU	Select	5.97	1.6
SV	Premium Choice	4.11	0.9
SV	Select	4.68	1.0
TB	Premium Choice	5.29	1.4
TB	Select	5.67	1.6
TM	Premium Choice	4.16	0.7
TM[d]	Select	–	–

Days of Postmortem Aging: 4 6 10 14 21 28

[a]CP = Complexus; IF = Infraspinatus; SP = Spinalis dorsi; SU = Supraspinatus; SV = Serratus ventralis; TB = Triceps brachii; TM = Teres major.
[b]2 d WBSF (kg)=2.2046 lb. [c]Aging response = WBSF at 2 d postmortem – WBSF at 28 d postmortem.
[d]Tenderization of Select *Teres major* could not be characterized.

Aging periods determined from this study are intended to be used as guidelines for postmortem management of individual muscles. The WBSF values displayed for individual muscles at various postmortem aging intervals were predicted based on averages of the samples evaluated in this trial; therefore, actual shear force values (for individual samples) were both higher and lower than those reported, and this should be considered when determining appropriate aging times. Tenderization of beef may also be affected by a multitude of factors such as biological cattle type, electrical stimulation techniques, and carcass chilling procedures. The preceding discussion regarding management of postmortem aging solely concerns changes in WBSF values (tenderness), but the effects of aging on beef flavor attributes and product shelf-life should also be evaluated when establishing postmortem aging periods.

CONCLUSIONS

Tenderness of cooked beef was affected by individual muscle, USDA Quality Grade, and length of postmortem aging period.

To improve the consistency of beef tenderness, postmortem aging should be managed with respect to both individual muscle and USDA Quality Grade.

In general, USDA Select beef muscles had higher WBSF values at 2 days postmortem, had an equal or greater decrease in WBSF through 28 days postmortem (aging response), and required longer postmortem aging periods to complete a majority of an aging response when contrasted with comparable muscles from Premium USDA Choice beef.

USDA Select beef muscles required approximately 20 days or more of postmortem aging to complete a majority of the aging response.

Management of postmortem aging with respect to both individual muscle and USDA Quality Grade can result in identification of appropriate uses for specific muscles, and identification of muscles suitable for an intended use (Beef Muscle User Guide).

REFERENCES

Brooks, J. C., J. B. Belew, D. B. Griffin, B. L. Gwartney, D. S. Hale, W. R. Henning, D. D. Johnson, J. B. Morgan, F. C. Parrish, Jr., J. O. Reagan, and J. W. Savell. 2000. National Beef Tenderness Survey-1998. J. Anim. Sci. 78:1852-1860.

CBB. 2003. Beef Value Cuts. *New Opportunities for the Beef Industry.* Cattlemen's Beef Board. Centennial, CO.

Eilers, J. D., J. D. Tatum, J. B. Morgan, and G. C. Smith. 1996. Modification of early-postmortem muscle pH and use of postmortem aging to improve beef tenderness. J. Anim. Sci. 74:790-798.

Lorenzen, C. L., B. H. Weatherly, and J. W. Savell. 1998. Determination of an aging index. Final Report to the Texas Beef Council. Department of Animal Science, Texas Agricultural Experiment Station, Texas A&M University, College Station, TX.

Lorenzen, C. L., R. K. Miller, J. F. Taylor, T. R. Neeley, J. D. Tatum, J. W. Wise, M. J. Buyck, J. O. Reagan, and J. W. Savell. 2003. Beef Customer Satisfaction: Trained sensory panel ratings and Warner-Bratzler shear force values. J. Anim. Sci. 81:143-149.

Mies, P. D., K. E. Belk, J. D. Tatum, and G. C. Smith. 1998. Effects of postmortem aging on beef tenderness, and aging guidelines to maximize tenderness of different beef subprimal cuts. Beef Program Report, Program in Meat Science, Colorado State University, Fort Collins, CO.

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.

Morgan, J. B., J. W. Savell, D. S. Hale, R. K. Miller, D. B. Griffin, H. R. Cross, and S. D. Shackelford. 1991. National Beef Tenderness Survey. J. Anim. Sci. 69:3274-3283.

NCBA. 2000. Muscle Profiling. National Cattlemen's Beef Association, Centennial, CO.

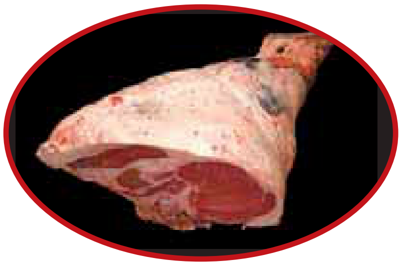
Platter, W. J., J. D. Tatum, K. E. Belk, P. L. Chapman, J. A. Scanga, and G. C. Smith. 2003. Relationships of consumer sensory ratings, marbling score, and shear force value to consumer acceptance of beef strip loin steaks. J. Anim. Sci. 81:2741-2750.

Smith, G. C., G. R. Culp, and Z. L. Carpenter. 1978. Postmortem aging of beef carcasses. J. Food Sci. 43:823-826.

Tatum, J. D., K. E. Belk, M. H. George, and G. C. Smith. 1999. Identification of quality management practices to reduce the incidence of retail beef tenderness problems: Development and evaluation of a prototype quality system to produce tender beef. J. Anim. Sci. 77: 2112-2118.

BEEF MUSCLE USER GUIDE

BEEF ROUND IMPS 158



Bottom Round 171B	Top Round 169 A	Eye of Round 171C	Knuckle 167

Biceps femoris (BF)

Semimembranosus (SM)

Semitendinosus (ST)

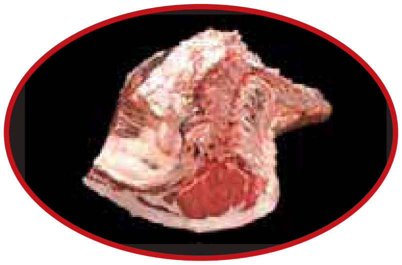
Rectus femoris (RF)
Vastus lateralis (VL)
Vastus medialis (VM)

				Premium USDA Choice			USDA Select		
Wholesale Cut	IMPS	Muscle	Weight	Aging Response[a]	Aging Time[b], d	WBSF at Aging Time, kg	Aging Response[a]	Aging Time[b], d	WBSF at Aging Time, kg
Bottom Round	171 B	*Biceps femoris*	8.6 - 13.3	Low	6	4.64	Moderate	26	4.85
Top Round	169 A	*Semimembranosus*	7.6 - 11.0	Moderate	16	4.63	High	23	5.09
Eye of Round	171 C	*Semitendinosus*	3.7 - 5.4	Moderate	18	4.75	Moderate	23	4.82
Knuckle	167	*Rectus femoris*	2.3 - 3.3	Moderately low	15	4.04	Moderate	25	4.08
		Vastus lateralis	2.9 - 4.2	Moderate	21	4.32	Moderate	20	4.67
		Vastus medialis	0.8 - 1.3	Moderately high	21	3.84	Moderately high	25	3.93

[a]Aging response: High = ≥ 2.2 kg;
Moderately high = 2.1 to 1.8 kg;
Moderate = 1.7 to 1.1 kg;
Moderately low = 1.0 to 0.7 kg;
Low = ≤ 0.6 kg.

[b]Aging time corresponds to the day that at least 96%, 95%, 94%, 90%, and 85% of the aging response is complete for muscles with high, moderately high, moderate, moderately low, and low aging responses, respectively.

Beef Loin IMPS 172



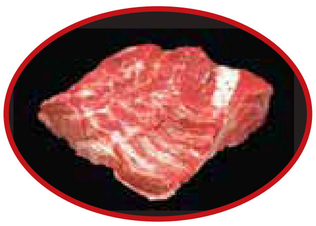
Sirloin 181	Striploin 180	Tenderloin 189 A
		
Gluteus medius (GM) Tensor fasciae latae (Tri-tip) (TF)	Longissimus dorsi (LD)	Psoas major (PM)

			Premium USDA Choice			USDA Select		
Wholesale Cut	IMPS	Muscle	Aging Response[a]	Aging Time[b], d	WBSF at Aging Time, kg	Aging Response[a]	Aging Time[b], d	WBSF at Aging Time, kg
Sirloin	181	*Gluteus medius*	Moderate	21	4.33	Moderate	27	4.65
		Tensor fasciae latae	Moderately low	12	3.77	Moderate	22	3.98
Striploin	180	*Longissimus dorsi*	Moderately high	15	3.75	High	26	4.28
Tenderloin	189A	*Psoas major*	Moderate	25	3.26	Moderate	27	3.26

[a]Aging response: High = ≥ 2.2 kg;
Moderately high = 2.1 to 1.8 kg;
Moderate = 1.7 to 1.1 kg;
Moderately low = 1.0 to 0.7 kg;
Low = ≤ 0.6 kg.

[b]Aging time corresponds to the day that at least 96%, 95%, 94%, 90%, and 85% of the aging response is complete for muscles with high, moderately high, moderate, moderately low, and low aging responses, respectively.

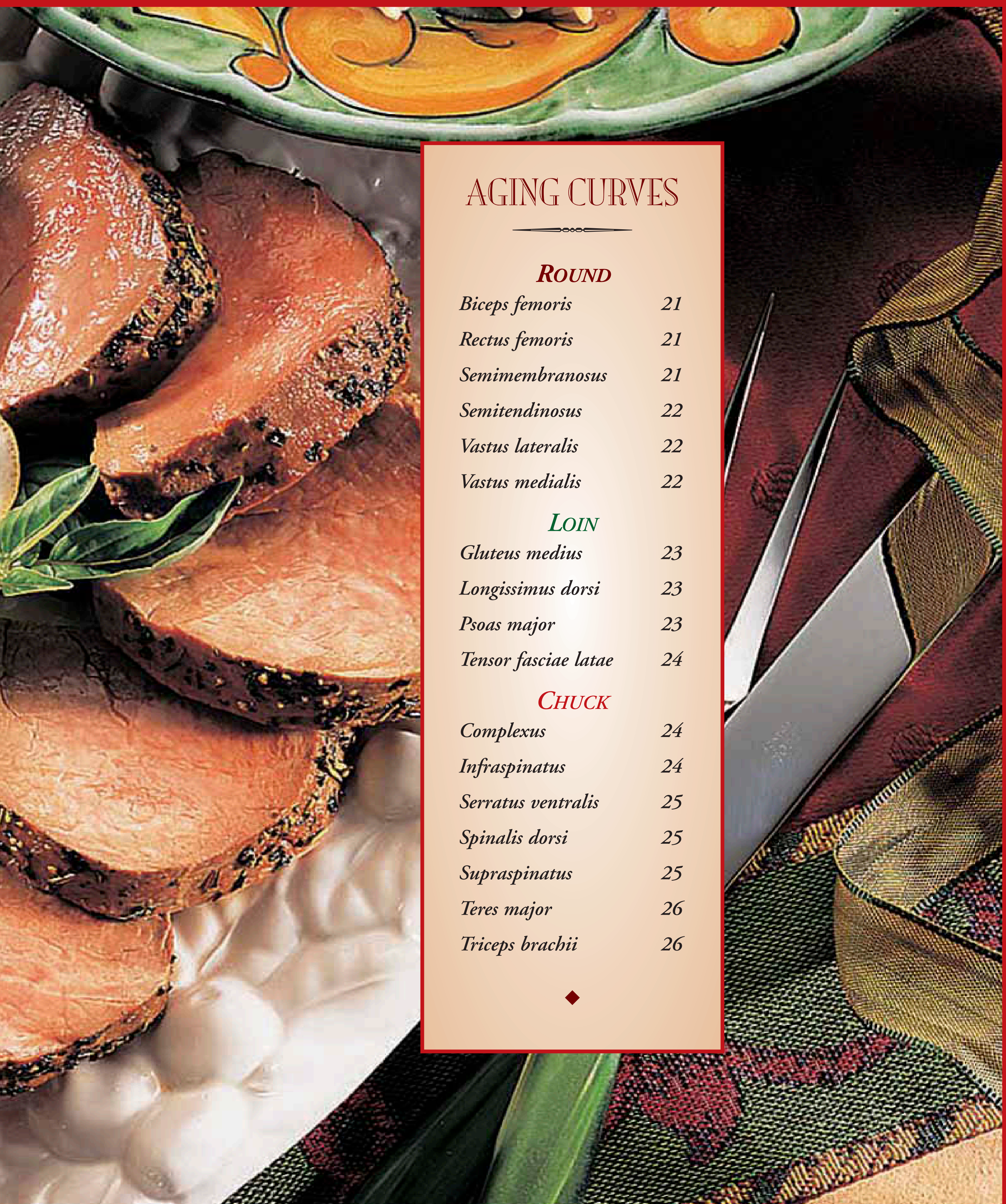
BEEF CHUCK, SQUARE-CUT IMPS 113

Chuck Roll 116 A	Shoulder Clod 114	Chuck Tender 116 B
		
Complexus (CP) Serratus ventralis (SV) Spinalis dorsi (SP)	Infraspinatus (IF) Teres major (TM) Triceps brachii (TB)	Supraspinatus (SU)

				Premium USDA Choice			USDA Select		
Wholesale Cut	IMPS	Muscle	Weight	Aging Response[a]	Aging Time[b], d	WBSF at Aging Time, kg	Aging Response[a]	Aging Time[b], d	WBSF at Aging Time, kg
Chuck Roll	116 A	*Complexus*	2.0 - 3.2	Moderate	23	3.98	Moderate	27	4.37
		Serratus ventralis	5.0 - 7.6	Moderately low	25	3.31	Moderately low	24	3.76
		Spinalis dorsi	1.0 - 1.4	Moderately low	13	3.62	Moderate	23	3.65
Shoulder Clod	114	*Infraspinatus*	3.2 - 4.6	Moderate	18	3.19	Moderate	25	3.44
		Teres major	0.7 - 1.0	Moderately low	21	3.54	-	-	-
		Triceps brachii	5.7 - 8.3	Moderate	16	4.01	Moderate	21	4.16
Chuck Tender	116 B	*Supraspinatus*	2.2 - 3.1	Moderate	14	4.49	Moderate	23	4.48

[a]Aging response: High = ≥ 2.2 kg;
Moderately high = 2.1 to 1.8 kg;
Moderate = 1.7 to 1.1 kg;
Moderately low = 1.0 to 0.7 kg;
Low = ≤ 0.6 kg.

[b]Aging time corresponds to the day that at least 96%, 95%, 94%, 90%, and 85% of the aging response is complete for muscles with high, moderately high, moderate, moderately low, and low aging responses, respectively.



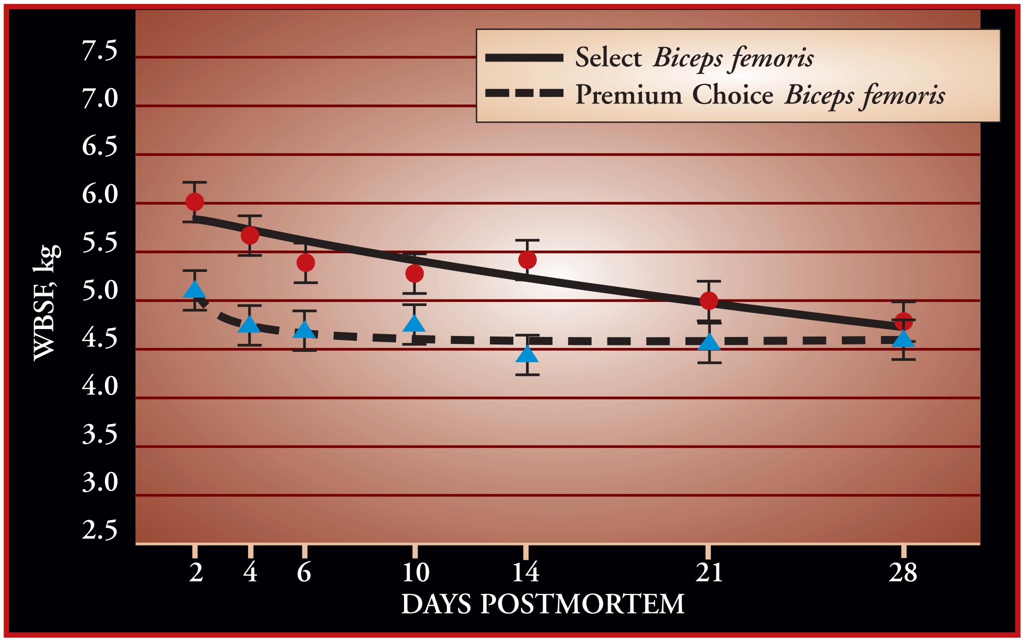
AGING CURVES

ROUND

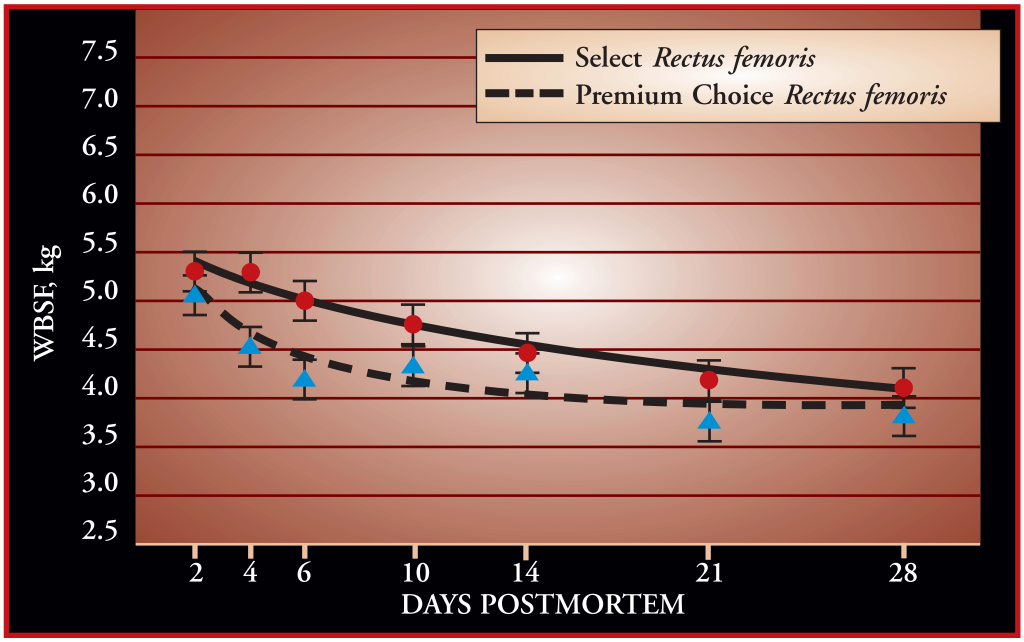
LOIN

CHUCK

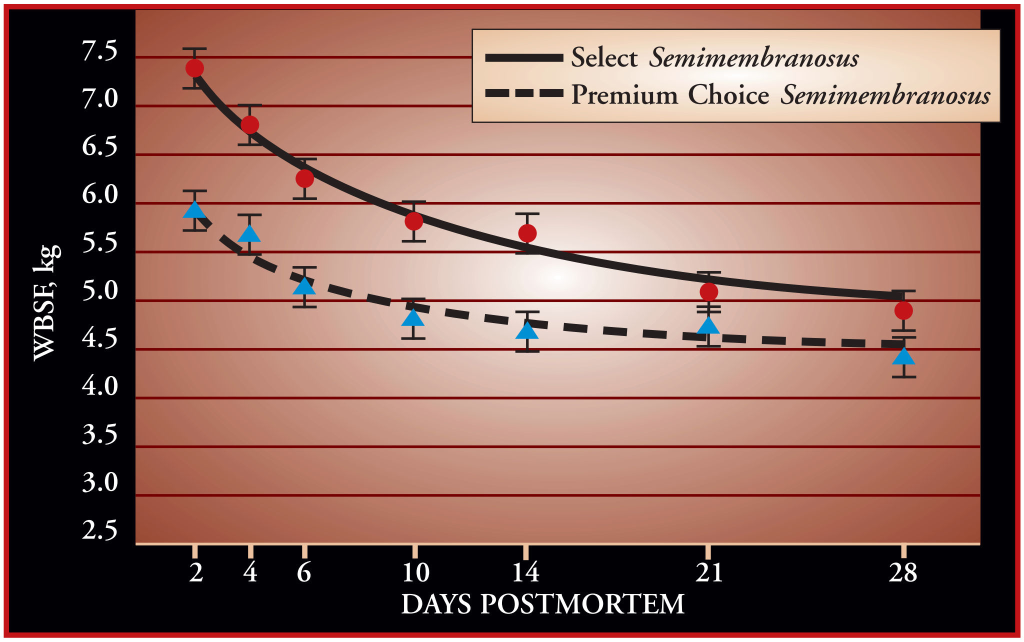
Biceps femoris

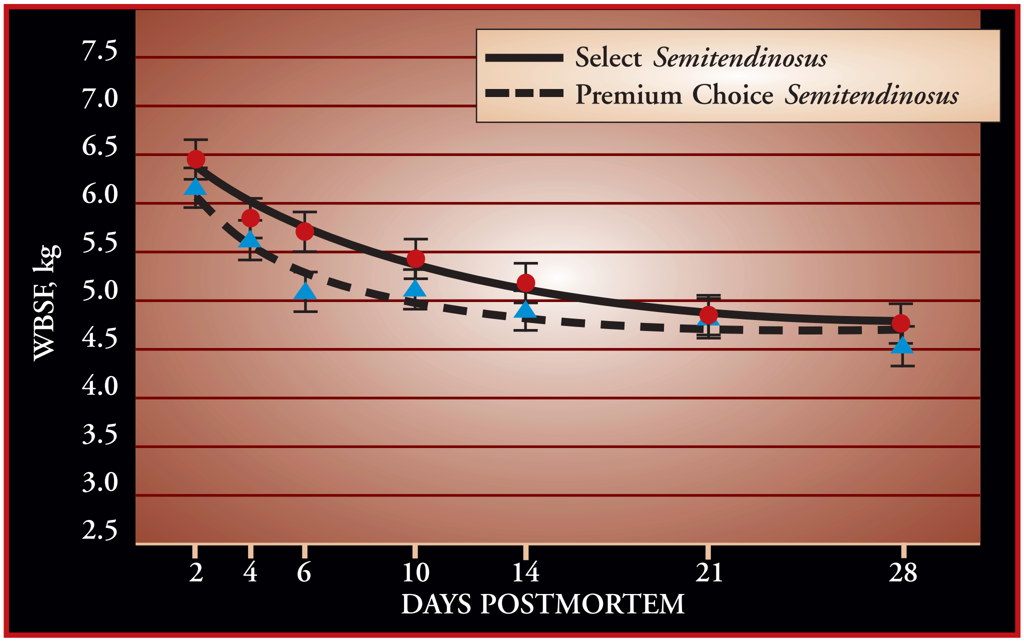


Rectus femoris

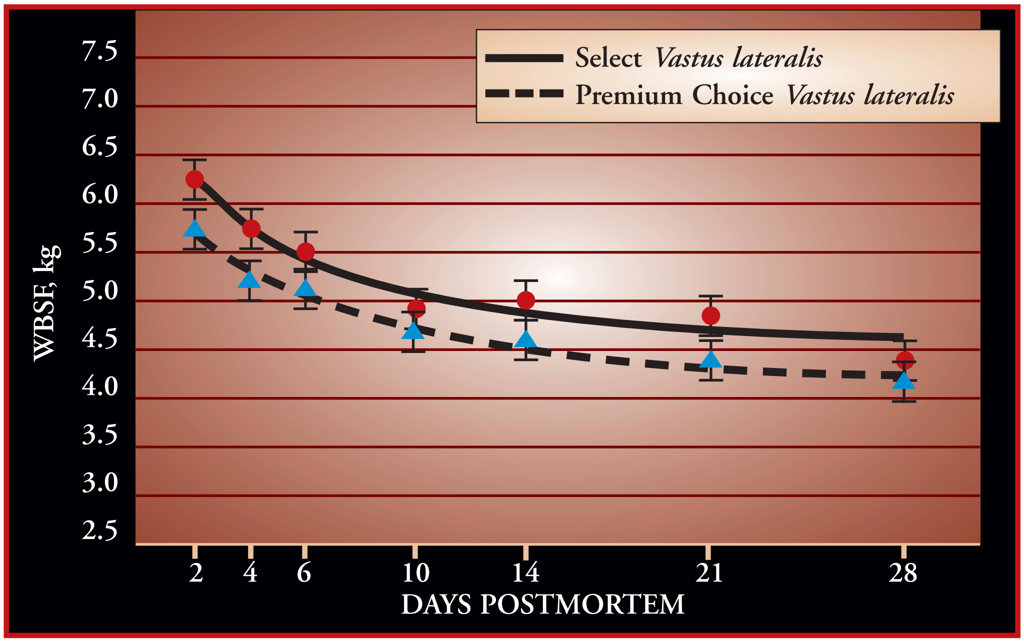


Semimembranosus

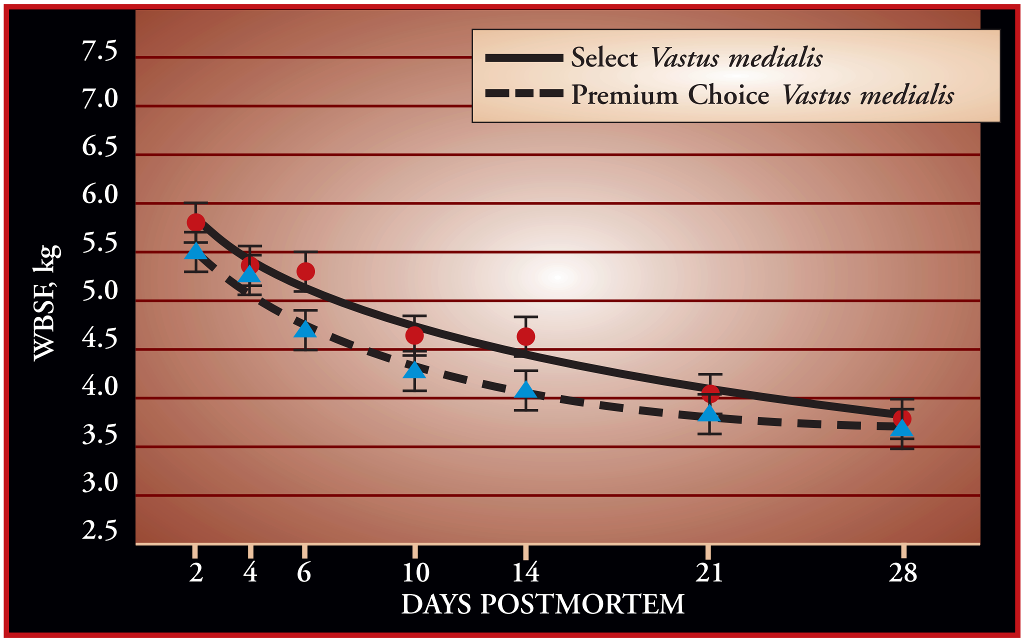




Semitendinosus

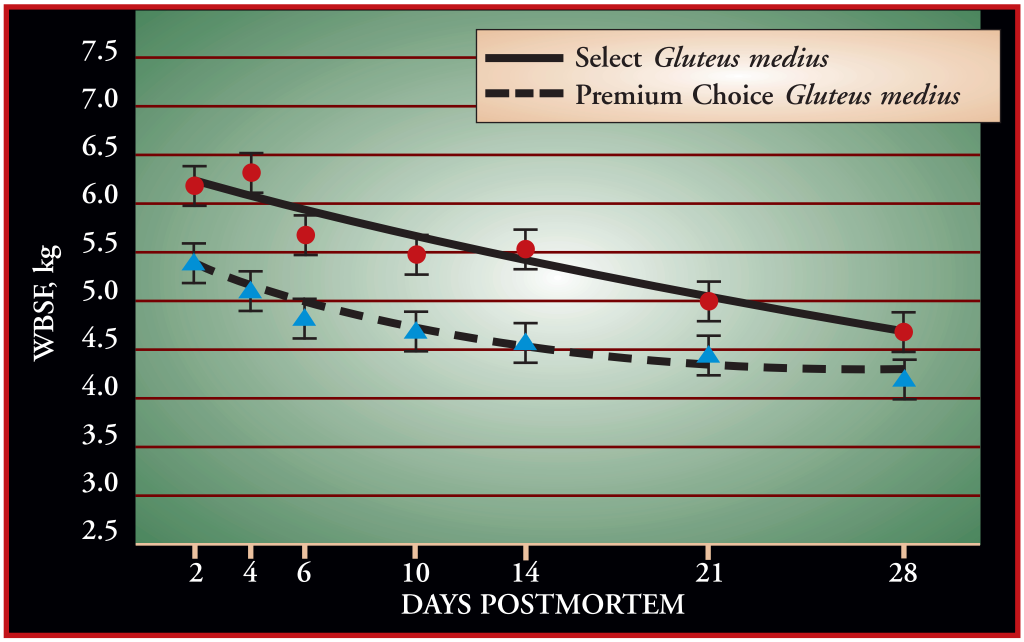


Vastus lateralis

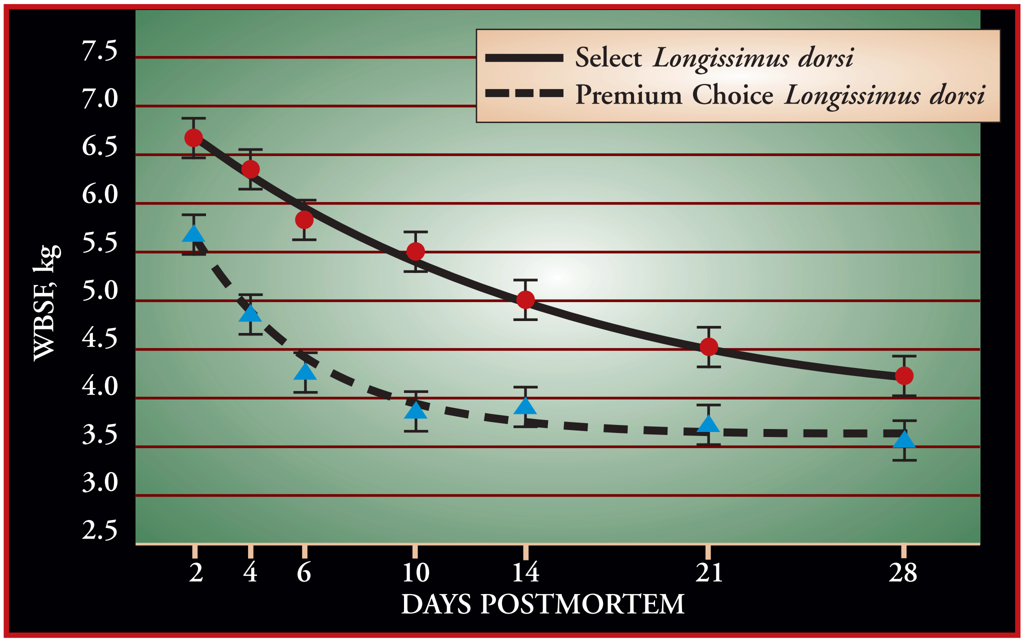


Vastus medialis

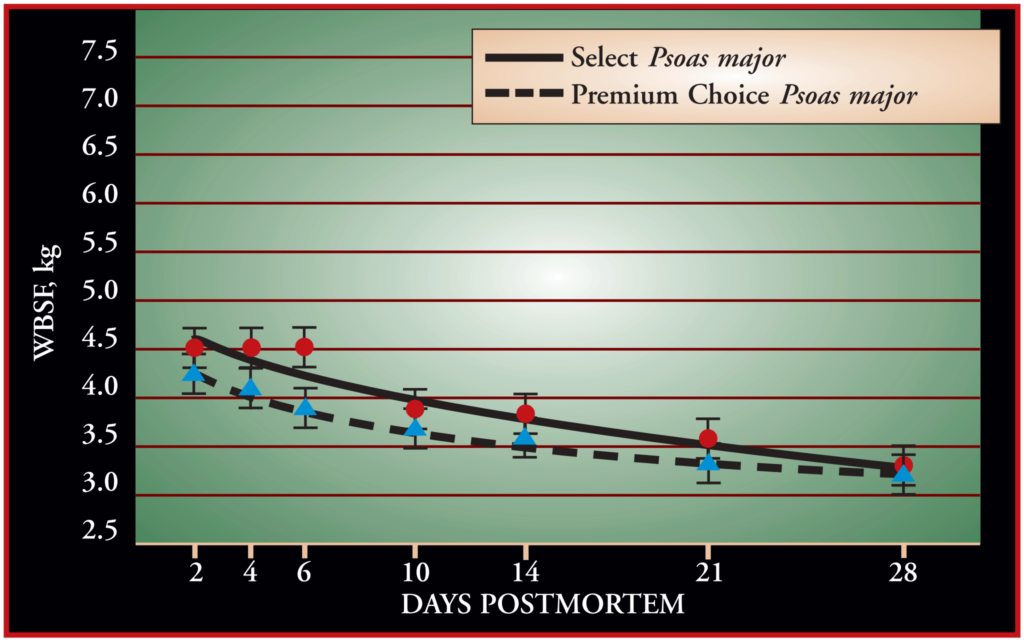
Gluteus medius

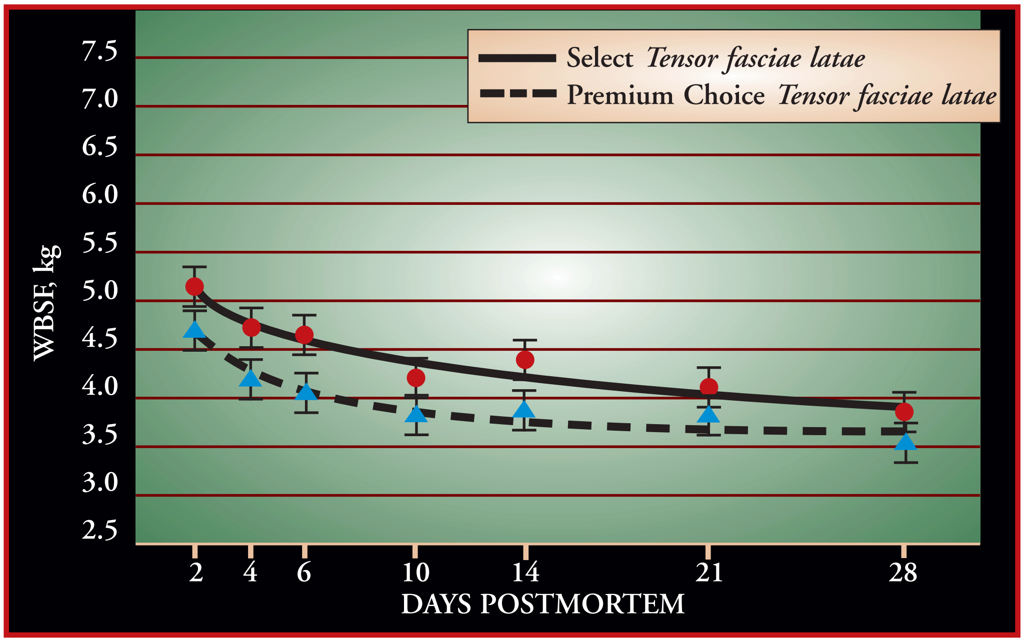


Longissimus dorsi

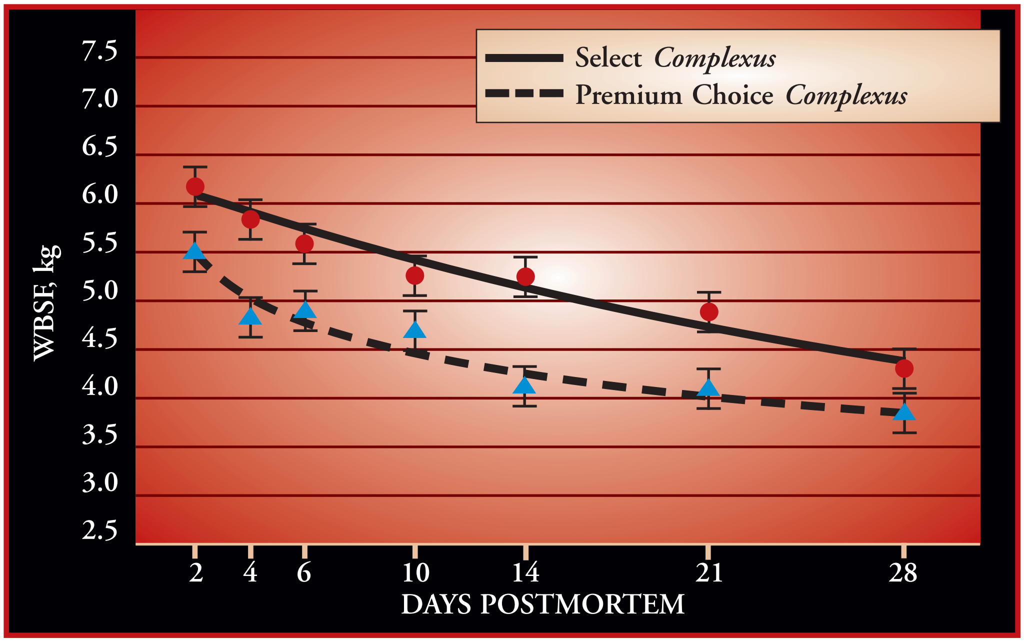


Psoas major

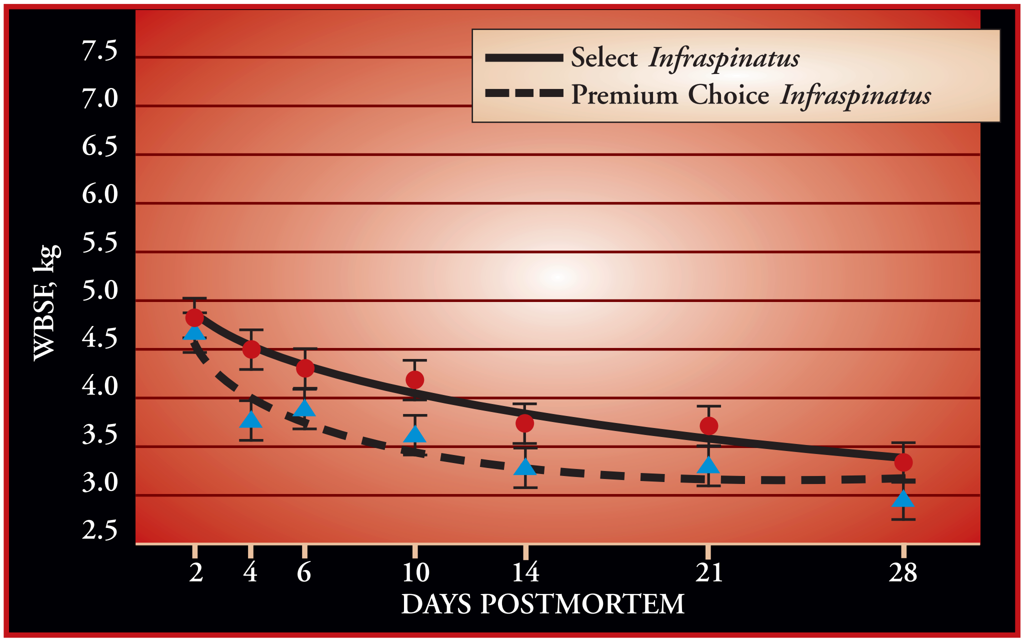




Tensor fasciae latae

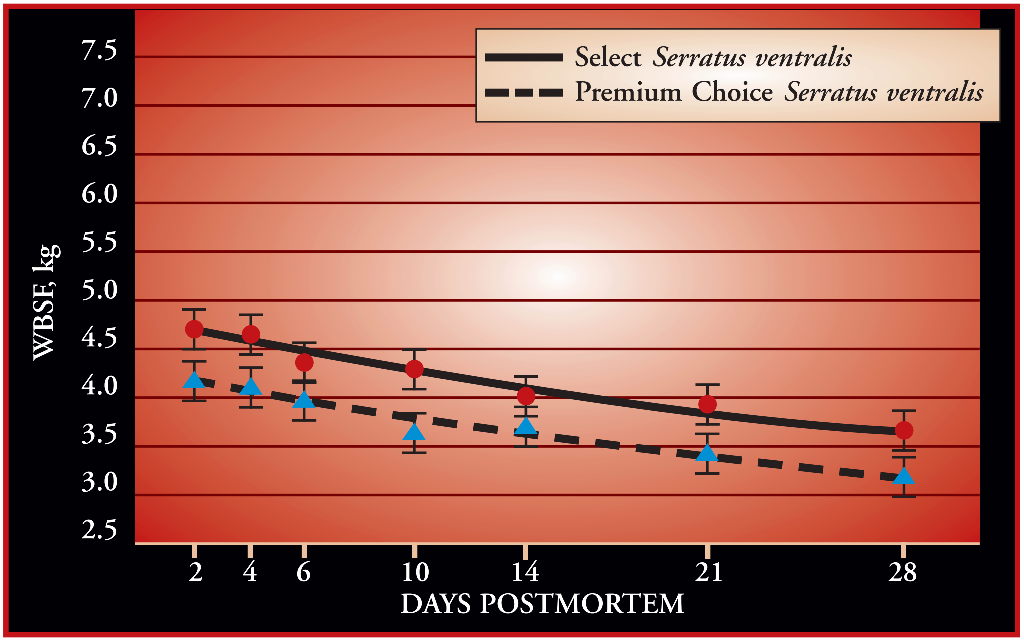


Complexus

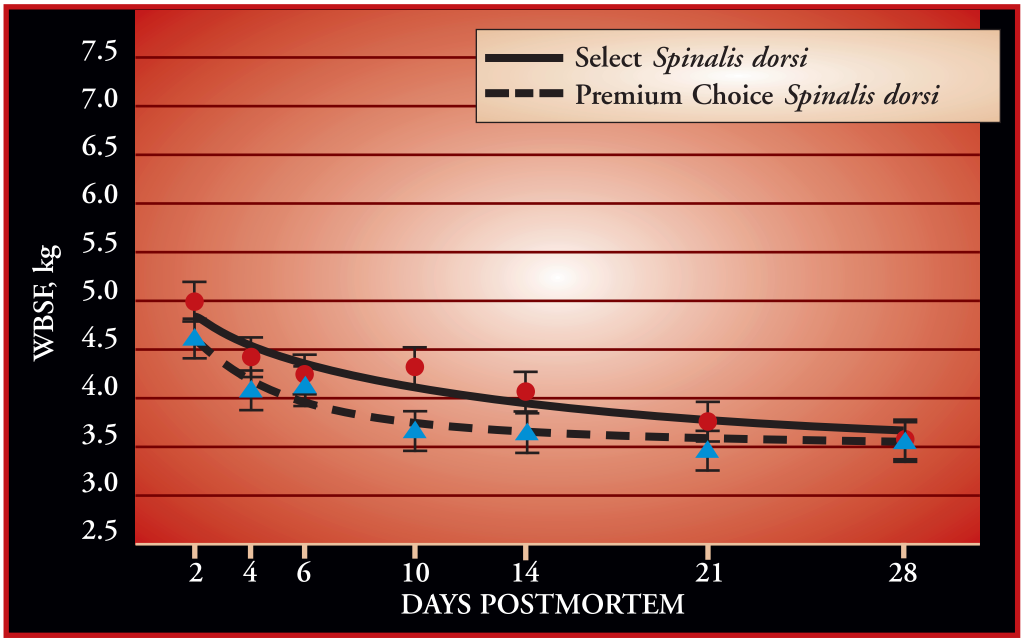


Infraspinatus

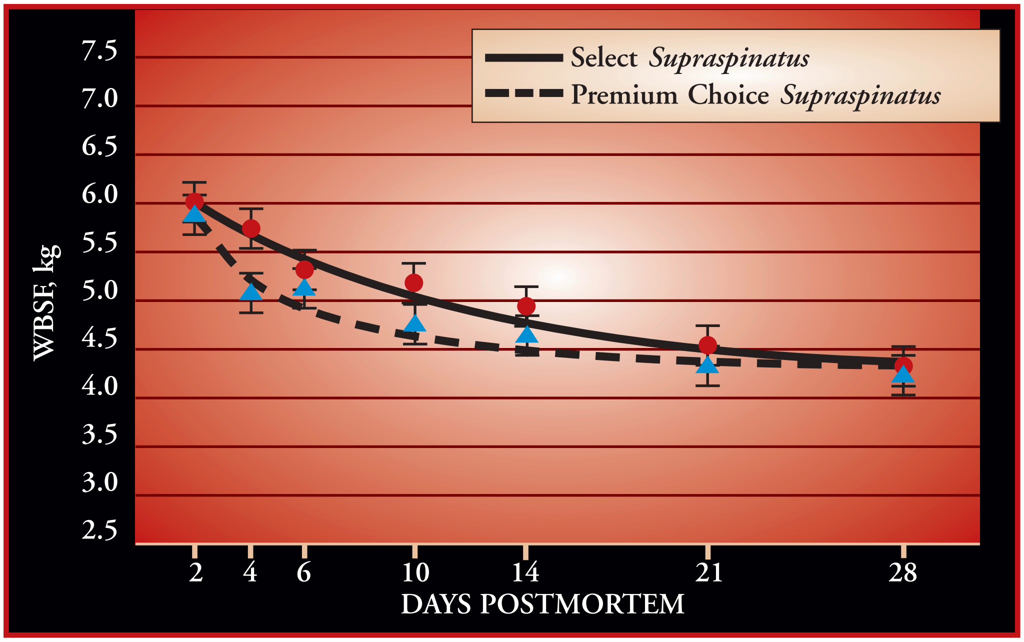
Serratus ventralis

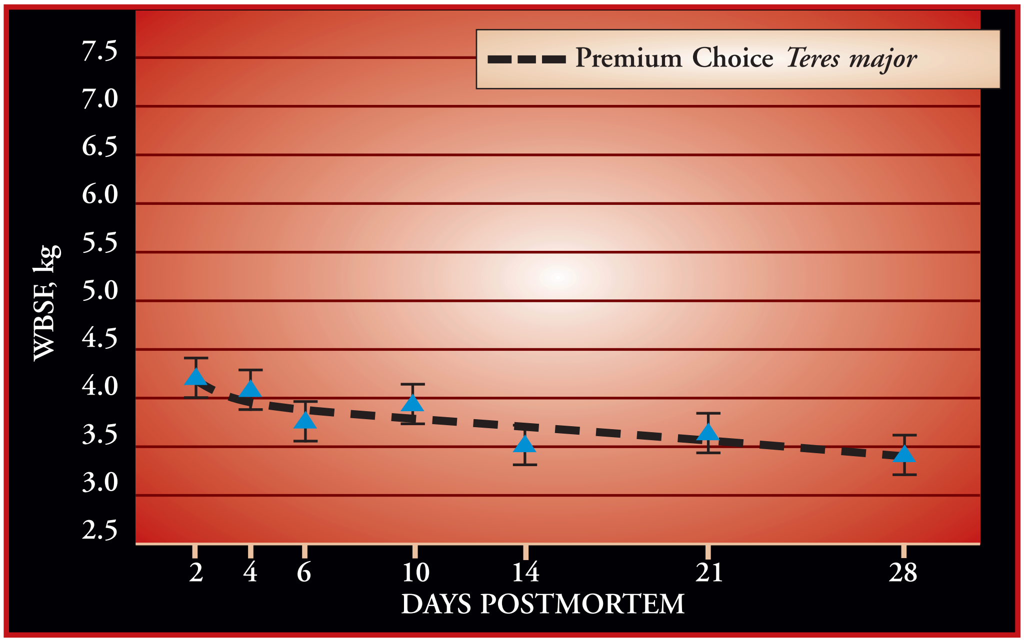


Spinalis dorsi

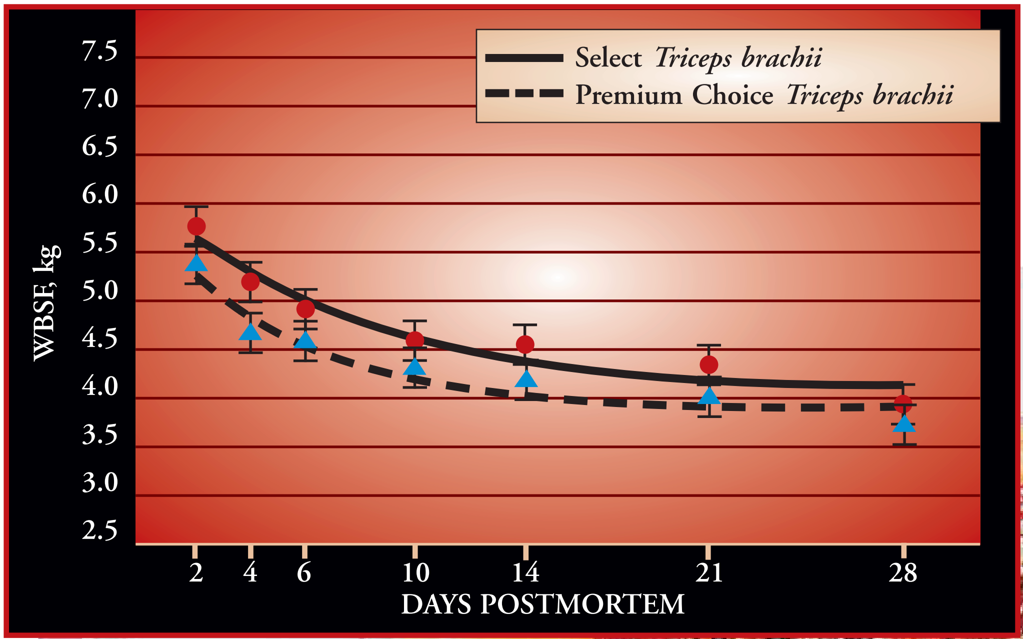


Supraspinatus





Teres major



Triceps brachii

Study Performed by Colorado State University

S. L. Gruber, K. E. Belk, J. D. Tatum, J. A. Scanga, G. C. Smith

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 PRINTED IN U.S.A. 4-2006 2,000 ITEM#12810