Declining Quality Grades: A Review of Factors Reducing Marbling Deposition in Beef Cattle.

Background

Marbling role in eating quality:
Three factors govern consumer acceptance of beef: tenderness, flavor and juiciness. All add to the eating experience in their own way. Consumers clearly want some tolerable level of tenderness, granting that preference varies somewhat by the individual. However, the overriding factor behind the desire to eat beef is its unique flavor.

Meat flavor has been an extensive basis for research, and the flavor profile by animal species is very well understood. In beef, the unique flavor and aroma derive from the carbonyl compounds found in marbling (Smith, 2005). Thus, as the USDA quality grade increases from Standard to Prime, the flavor profile intensifies and improves to create a more acceptable eating experience (Smith, 1990).

The problem:
Using USDA beef grading statistics, Figure 1 illustrates the change that has occurred in quality grade of harvested fed cattle (Robinson, *Western Livestock Journal*, 2006).

Figure 1. Historical Grading Percentages.

	1956	1966	1976	1986	1996	2005
% Prime	5.7	6.4	9.8	3.3	2.4	3.1
% Choice	57.1	76.1	79.5	93.6	60.4	57.2

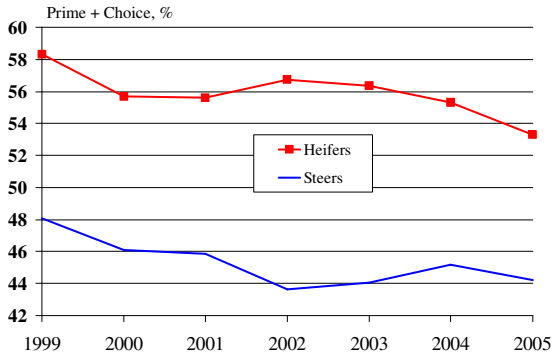
↑
USDA altered the grading standard expanding the Choice grade

In 1986, nearly 97 percent of the federally graded cattle were Choice or Prime, but in 2005 that had declined to 60 percent. Not surprisingly, the consumer demand for beef entered a 20-year decline, only reversed by the influence of premium brands and utilization of new cuts and products in the past eight years.

It should be noted that in the 1970s and '80s, only part of the cattle were graded; many carcasses that would be called Select today were not graded, and were called "No Rolls." Today, very few steer and heifer carcasses are not federally graded. The 2005 National Beef Quality Audit (BIF, 2006) made the USDA adjustment and still shows a 1 percentage-point decline in Prime and a 6.2 percentage-point decline in Choice, comparing 1975 to 2005.

Recent VetLife Benchmark data (courtesy of the VetLife Benchmark Performance Program) has shown the same decline for percent Prime and Choice in the past seven years.

Figure 2. Prime & Choice by Year: Steers & Heifers.



Certified Angus Beef® (CAB®) is the largest premium brand, requiring average Choice or higher marbling. As would be expected, the percentage of Angus-type cattle accepted into the Program has declined. The peak acceptance year, 1999, coincided with the lowest levels of Yield Grade 4 and 5 carcasses, which are not allowed into the brand. CAB® acceptance rates have declined significantly since then, partly due to the Yield Grade 4 and 5 increase, partly due to the decline in marbling.

Figure 3. Cattle Accepted Into the CAB® Brand.

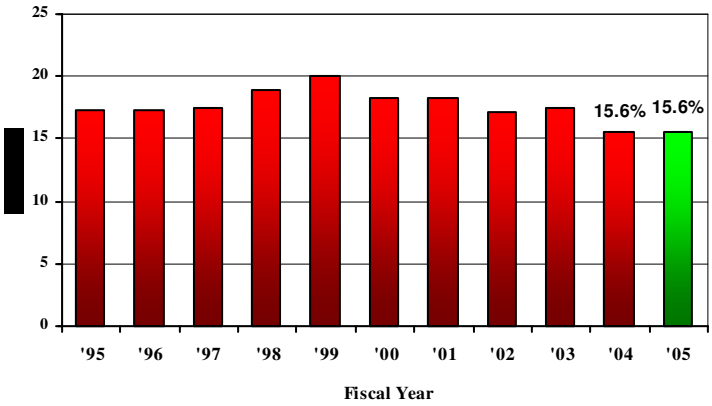
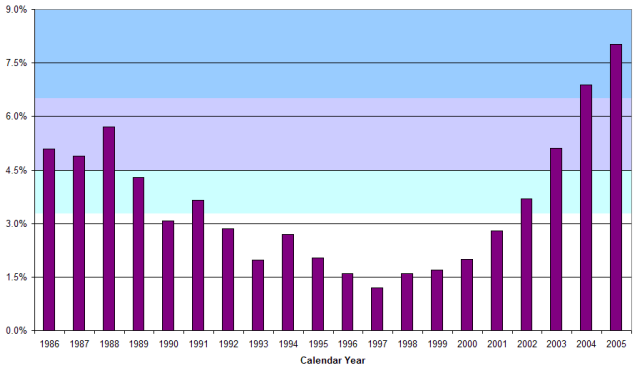
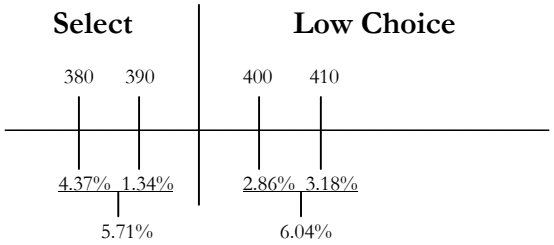


Figure 4. USDA Yield Grade 4 Beef – 1985-2004 (Percentage of Total Graded).



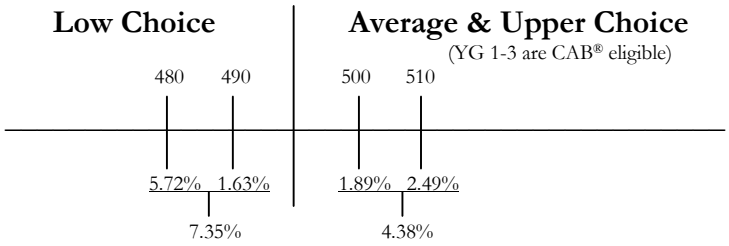
In 2004, Certified Angus Beef LLC (CAB) worked with all major packers to characterize Angus-type cattle in the slaughter mix. Marbling scores, to the nearest tenth, were determined on 26,707 carcasses (400=small Low Choice marbling, 500=modest marbling, etc.). It is interesting to note the high percentage of cattle that with a slight "tweak" from management, nutrition, health, genetics, etc., could easily improve grade and realize major economic consequences.

Figure 5. Percentage of Carcasses Falling Near Choice-Select Grade Breakpoint.



For example, 61.33 percent of all carcasses graded Choice, but 6.04 percent had a marbling score of 400 to 419, meaning they easily could have changed the portion grading Choice to 55 percent. However, nearly an equal percentage of Select grading cattle could easily become Choice with the right genetics and management. Of the Choice grading cattle, 7.35 percent were scored 480 to 499, meaning they could have become CAB® eligible, moving the current 15 percent acceptance rate to 22.5 percent. On the negative side, 4.38 percent were 500-519 implying CAB® acceptance rates were that close to being only 10 percent.

Figure 6. Percentage of Carcasses Falling Near the Choice-CAB® Grade Breakpoint.

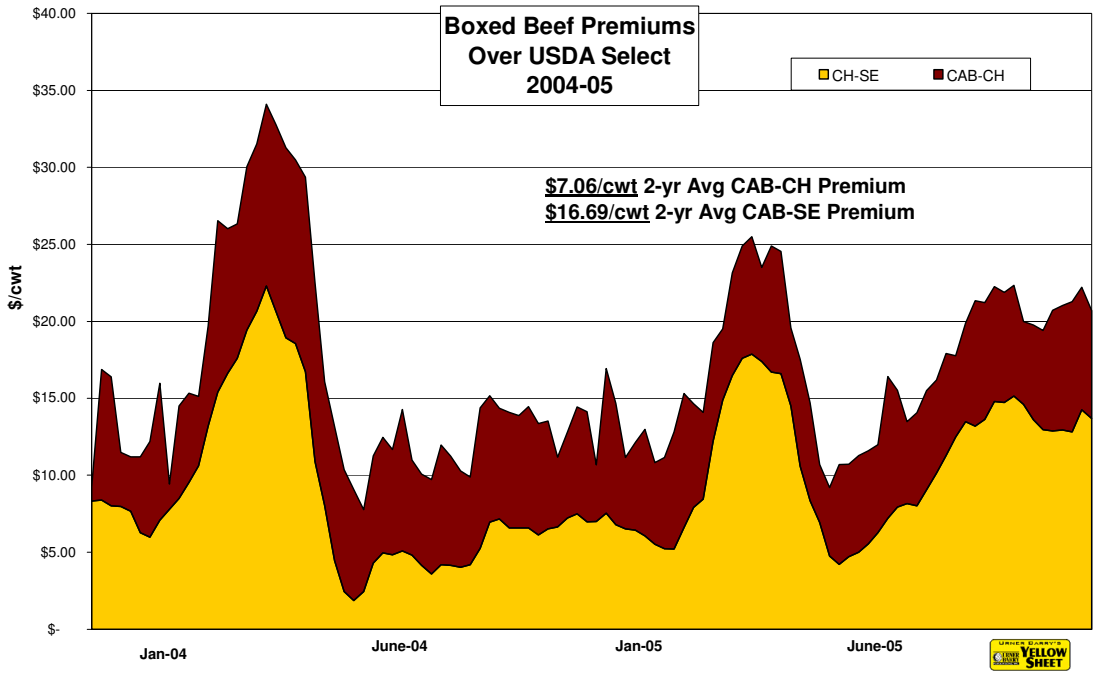


The economics:
In spite of an unprecedented increase in beef prices, consumer demand for an enjoyable eating experience has resulted in distinct price differentiation between quality grades.

The first economic manifestation of this is the dramatic spread between Choice and Select cutout values. In the early 1980s, that spread was typically $3-$4/hundredweight (cwt) of carcass. It increased to $6-$8/cwt in the '90s, and averaged near $10/cwt for 2004-05.

The evolution is further illustrated by the spread between Choice and CAB® as now reported by Urner-Barry and Cattle-Fax. That spread is very consistent (Figure 7) for the year, ranging from $6-$10/cwt of boxed beef. Figure 7 also illustrates the seasonal variation that occurs in percentage of cattle grading Choice.

Figure 7. Boxed Beef Premiums Over USDA Select, 2004-05.



As the percentage of cattle marketed on a grid increases, now at 40-50 percent and possibly moving to 70 percent (Cattle-Fax report), the economic importance of quality grade grows. Today, the spread between a Select and CAB® qualifying carcass of the same weight will be in the $150-200 range, making quality an important economic factor in profitability.

Why is this marbling trend occurring?

1. **Health problems in the cattle industry are increasing.**

   Iowa State University research (Busby et al., 2004) showed the striking effect health has on quality grade. Calves treated two or more times for bovine respiratory disease (BRD) had an 18 percent reduction in ability to grade Low Choice when compared to healthy calves. The impact was a 44 percent reduction in Prime and 33 percent fewer Premium Choice grading cattle.

   The preconceived notion or conventional wisdom today is that feedlot death loss is declining, thanks to improved technologies and more extensive preconditioning. The reality is just the opposite.

   A 13-year ('92-'04) evaluation of Kansas feedlots (Babcock et al., 2006) reported an annual trend of increased death loss in both steers and heifers. The summary showed a decrease in placement weight was associated with increased death loss. There also were consistent seasonal variations, with closeout months of April and May having the highest death loss.

These results are supported by data shared by the Vetlife Benchmark Performance Program (Figures 8 and 9). This information shows a seven-year increase in veterinary medicine costs per head—and mortality percentage—with only 2002 showing a break from the upward trend.

Figure 8. Vet Med $ by Year: Steers & Heifers.

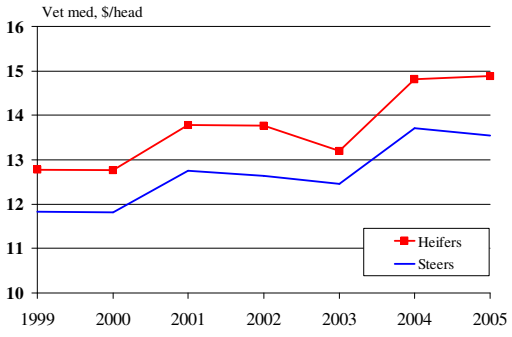
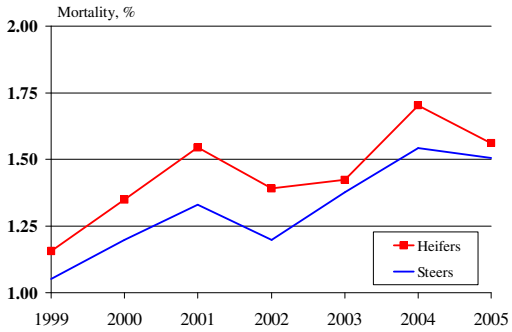


Figure 9. Mortality % by Year: Steers & Heifers.



Why is this occurring?
The only documented evidence is lighter placement weights and the consistent annual trend of feeding younger cattle. But to compound this, as the feeding industry becomes more consolidated, the labor-to-cattle ratio in the larger feedyards becomes reduced. That suggests health management of calves in particular may be compromised.

2. Increased use of ethanol co-products by feedlots.

From a small cottage industry in 1980 producing 175 million gallons, the ethanol industry has grown dramatically, producing 3.9 billion gallons in 2005. Since 1999, there has been a 265 percent growth in ethanol production, with much of it centered in Nebraska, South Dakota, and Iowa. By 2015, the industry estimates production will grow to 9.8 billion gallons. The National Corn Growers Association documents that 14.6 percent of the 2005 corn crop was used for ethanol production.

As this industry has grown, so has the availability of ethanol co-products such as distiller's dried grains, corn gluten meal, and wet distilled feeds. Consultants and industry analysts say over 80 percent of Nebraska feedlots with more than 2,000-head capacity are feeding some ethanol co-product. Average dietary inclusion is said to exceed 20 percent (DM basis) in most feedlots.

So how is this trend affecting quality grade?
Dr. Chris Reinhardt, Kansas State University Extension Feedlot Specialist, summarized 13 studies that included wet or dry distiller's grain at varying levels. Using ANOVA statistical procedures, with yield grade as a covariate, the results were as follows:

Distiller's Grain Level (DM basis)	Marbling Score	Calculated YG Score
None	5.55[a]	2.96[a]
1-15%	5.49[a]	3.08[b]
16-29%	5.46[a, b]	3.05[b]
Over 29%	5.35[b]	3.06[b]

[a, b] Differing superscript in same row (P<.05)

The reason for this decline in marbling may be associated with the reduced level of starch availability in distilled products as compared to corn. Although feedlot cattle performance is generally not reduced, the lower level of starch digestibility (Pingel and Trenkle, 2006) could affect marbling adipocyte differentiation.

3. Structural and management changes in the feeding industry.

The past 35 years have seen a complete relocation of the cattle feeding industry and a distinct change in the size of feedlots. In 1970, 40 percent of the cattle were fed in Iowa, Minnesota, Illinois, and Indiana, while Texas fed 14.4 percent. Today, the four Midwest states feed 16 percent and Texas feeds 26.1 percent.

Besides location, size has increased. Ten years ago, a 60,000-head feedyard was rare. Today, numerous feedlots of that size exist, and those with more than 32,000-head capacity are feeding 2 percent more cattle each year. They already account for more than half of all cattle fed (Mintert, 2006).

So how does this relate to quality grade?
Utilizing the CAB Feedlot Licensing Program (FLP) database and classifying the feedyards by size provides insight. Yards with more than 20,000-head one-time capacity had a 41 percent reduction in CAB® acceptance rate (15.8 vs. 27 percent acceptance). There also was a 17-20 percentage-point reduction in cattle grading Choice or higher.

Size Classification	No. Cattle	Percent Choice and Above	Percent CAB® Accepted
Under 10,000	41,078	77	27
10,000 - 20,000	21,030	74	27.8
Over 20,000	77,518	57.8	15.8

Why the difference?
In the previous table, feedlots with less than 20,000-head capacity are located in Iowa and Nebraska, and tend to focus on higher quality, Northern cattle. The larger yards are often located in Kansas and Texas, and typically aim to "upgrade" Southern cattle. It should be noted that cattle in the table above were of a relative quality that warranted requests for detailed carcass data.

A more logical reason may relate to larger feedyards almost exclusively using steam-flaked grain. Smaller yards use rolled or cracked grain and almost always feed corn.

A review of 552 studies by Owens and Gardner (1999, ASAS Proceedings) showed the significant effect of flaking on quality grade; grain type also had an effect.

Table 1. Effect of Grain Processing Method on Performance and Carcass Traits.

	Whole Grain	Dry Rolled	Steam Flaked
ADG, lb.	3.15[a]	3.12[b]	3.48[b]
HCW, lb.	708[b]	713[b]	737[a]
Feed/Gain[c], lb.	6.37	6.37	5.43
Marbling Score	512[a, b]	524[a]	482[b]
REA, sq. in.	12.3[c]	12.6[b]	13.1[a]
Yield Grade	2.75[a, b]	2.69[b]	2.85[a]

Differing superscript in same row (P<.05)
Quality Grade: 400 = slight marbling, 500 = small marbling, etc.
[c] Recalculated from the authors' Gain/Feed for consistency in this paper

Table 2. Effect of Grain Type on Performance and Carcass Traits.

	Corn	Milo	Wheat
ADG, lb.	3.26[a]	3.15[a]	3.26[a]
Feed/Gain[c], lb.	6.06[a]	6.49[b]	5.65[a]
Marbling Score	512[a]	499[a]	498[a]
Yield Grade	2.72[b]	2.92[a]	2.86[a, b]

Differing superscript in same row (P<.05)
Quality Grade: 400 = slight marbling, 500 = small marbling, etc.
[c] Recalculated from the authors' Gain/Feed for consistency in this paper

Owens and Gardner suggested the effect of flaking on performance and carcass trait differences may relate to a shift in the site of digestion. The yield grade change may be due to less ruminal escape of dietary starch, while reduced quality grade for cattle fed milo may be related to lower starch availability. The effect of steam flaking on marbling is not fully understood. More ruminal starch digestion should increase the organic acids that are later converted to glucose and glucose is a precursor for marbling. In the review, steam flaking increased ribeye area though not relative to carcass weight. It is hypothesized that this increased muscle area has a diluting effect on marbling (Owens communication). With increased daily gains achieved through steam flaking, days on feed are reduced, and that could also reduce marbling.

What would be the result if both distiller's co-products and flaked grain were included in the same ration? Work at the University of Nebraska (Vander Pol et al., 2006) used feed rations containing 30 percent (DM basis) wet distiller's grain and were then varied by grain processing method for the rest of the ration corn (61.4 percent DM basis). The results suggest combination use may be very detrimental to marbling deposition.

Table 3. Effect of Corn Processing Methods in Finishing Diets Containing Wet Distiller's Grains on Cattle Performance.

	Grain Processing Method		
Trait	**Dry rolled**	**Whole**	**Steam Flaked**
ADG, lb./day	4.05[a]	3.85[b]	3.59[c]
Feed/gain, lb./lb.	5.68[a]	6.07[b]	5.76[a]
Quality Grade			
% Choice or Higher	63.5	60	48.3
% Premium Choice	29.4[a]	23.3[a]	6.7[b]
Marbling Score*	540[a]	534[a]	496[b]
Yield Grade	3.62[a]	3.49[a]	3.22[b]

* Marbling Score: 400=slight, 500=small, etc.
Differing superscript in same row (P<.05)

4. Marbling development is a lifetime event.

The long-held myth in cattle production was that marbling deposition occurred only during the feedlot phase of an animal's life.

Where marbling begins:
As cells proliferate in early fetal development, they start to differentiate into either muscle or fat cells. Numerous endocrine physiological factors control this process, but androgen or androgen-like endocrine factors exert a great influence. Singh et al., 2003 documented that androgens promoted muscle conversion and inhibited adipose conversion. It is likely that genetic and nutritional factors also play a part in this early process.

Upon birth, these cells continue to specialize with many extrinsic factors contributing to the process. The earliest adipocyte (fat) cells, preadipocytes really, further differentiate into subcutaneous fat and intramuscular (marbling) fat cells. Nutritional substrate affects the outcomes. If the diet contributes high levels of acetate, subcutaneous fat cells develop, while propionate/glucose availability stimulates marbling cell formation. For those animals destined for harvest, this process ultimately determines the quality grade of the carcass.

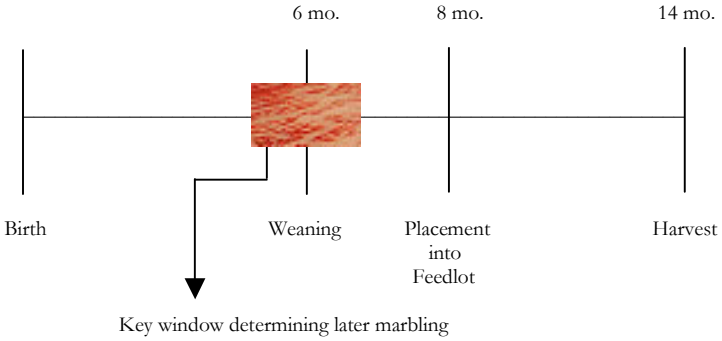
Is there an ideal marbling/yield grade carcass endpoint?
Most cattle are marketed at a compositional endpoint of .4 to .8 inch of external fat cover to target optimization of quality and yield grades. Based on results on nearly 140,000 cattle in the FLP database, marketing below .5-inch fat cover reduces marbling level and CAB® acceptance rates.

Table 4. Level of External Carcass Fat Cover.

	.1	.2	.3	.4	.5	.6	.7	.8	.9
Marbling Score	368	392	409	430	450	460	470	478	477
Choice and Prime, %	28.3	42.4	50.4	60.1	69.2	73.6	75.4	79.8	79.6
CAB® Acceptance Rate, %	2.2	4.5	9	13.2	17.7	22	21.4	17.4	12.7
Yield Grade, % 4 and 5's	.7	.2	.3	.7	2	5.6	18.8	35.2	56.1

Marbling Window:
Recent research (Berger and Faulkner, 2005; Bruns and Pritchard, 2005; and Fluharty et al., 2005) suggests that marbling development is a lifetime event. Moreover, the time period near weaning seems to be an especially critical period in a calf's life because of the management events occurring.

Figure 10. Marbling Window – "Window of Opportunity"



Management strategies during this time period—early weaning, creep feeding, delayed implanting, and maintaining health—all contribute to the subsequent quality grade and level of CAB® acceptance.

5. Timing, number, and potency of implant regime.

Utilization of growth-promoting implants is one of the most economical management practices used by beef producers. Equally well documented is the negative impact implanting has on quality grade. Research studies (Bruns and Pritchard, 2005; Mader, 1994) have shown that the percentage of cattle grading Choice and higher can be reduced by 15-20 percent, with the percentage of CAB®-accepted cattle reduced by 8-10 percent in aggressive implant programs. Increased feeder calf cost and high break-even prices have likely increased the implant frequency and/or potency used in the beef industry over the last several years.

Can the implant effect be at least partially offset? Extensive research work offers possibilities.

Delay Implanting. A number of research studies suggest that delaying implant usage offers potential to improve marbling levels while still capturing the implant's performance benefit. The work suggests that implant usage early in the feedlot

phase, at the start of the growing period, or even pre-weaning may impact the cellular differentiation process, reducing marbling adipocyte formation and/or growth (Bruns and Pritchard, 2006; Mader, 1993; Johnson, 2006).

One opportunity is to delay implanting by 30-50 days at the start of the feedlot phase. Research by Bruns and Pritchard (2006) suggests that delayed implanting improves quality grade without significant effects on growth rate and economic feedlot breakevens.

Another opportunity is delaying implant usage during the growing phase, or avoiding usage completely. Research (Brandt et al., 1991; Mader, 1994) suggests that deferring initial implant usage to the feedlot phase had little or no effect on an animal's total weight gain (growing and feedlot), while improving marbling potential.

Yet another opportunity to delay implant usage is avoiding implant usage during the pre-weaning phase. Research (Mader et al., 1985) suggests that implanting at this stage may also depress later weight gain responses to implants during the growing and feedlot phases. The effect of pre-weaning implants on subsequent marbling levels and quality grades has been variable. Some studies (Mader, 1994) show no effect while other studies (Mader et al., 1994) show some reduction in marbling levels, especially in heifers.

Reduce number of times cattle are implanted. There are a couple of ways to avoid the negative implant effect on carcass quality, yet receive the positive implant benefits on growth. As previously discussed, limiting or avoiding use during the pre-weaning and growing phases is one way. Another is limiting the number of times implanted during the feedlot phase to a single time and possibly delaying the timing of that implant administration.

Utilizing the FLP database, the number of implants administered may affect CAB® acceptance rates.

CAB Acceptance Rate	Number of Times Implanted
.1 to 9.9%	1.24[a, b]
10.0 to 19.9%	1.29[a, b]
20-29.9%	1.42[a]
Over 30%	.91[b]

[a, b] Differing superscripts are different at P<.05

Reduce the aggressiveness (potency) of implant programs. Yet another method of reducing the implanting effect is to use a less aggressive implanting strategy. Classifying the implant potency into varying categories (Reinhardt, 2006) had a great impact on CAB® acceptance rates.

Table 5. Implant Classification

Low (1)	Ralgro, Synovex C, Component EC, Encore, Compudose
Medium (2)	Synovex S & H; Component ES, EH
Medium High (3)	Finaplix S,H; Revalor IS, IH; Synovex Choice; Component TE-IS and RE-IH
High (4)	Revalor S,H; Component TE-S and TE-H
Aggressive (5)	Synovex Plus, Revalor 200

Table 6. Effect of Implant Potency on CAB® Acceptance Rates.

CAB Acceptance Rate	Total Implant Potency Score*
0	5.25[a]
.1 to 19.9%	4.16[a]
20-29.9%	4.17[a]
Over 30%	2.53[b]

[a, b] Differing superscripts are different at P<.05

* Total Implant Potency Score is the number of times an animal is implanted, multiplied by the mean implant potency score

Other Contributing Factors

1. **Genetics**

Any discussion of marbling levels must, of course, include the genetic influence. Marbling is a very heritable trait (Herring, 2006), allowing genetic selection to have a significant effect on quality grade and CAB® acceptance rates. Both genetic selection within breed and differences between breeds will dramatically impact marbling levels.

Table 7. Genetic Selection Within the Angus Breed

	Top 10%	Bottom 10%
No. Sires	110	110
% Choice and Higher	94.4	44.2
% Standard	.1	16.7
% CAB® Acceptance Rate	48	13
Fat Cover	.49	.54
$B Value	> $43	< $9

Source: OSU data report – Schutte et al., 1998

Table 8. Feedlot and Carcass Traits by Percentage of Angus in Cattle

	Less than 25%	26-75%	Above 75%
Feedlot gain, lb./day	3.05	3.12	3.29
Morbidity rate, %	24.2	17.8	14.1
Quality Grade			
% Prime	.4	1.0	3.1
% Premium Choice	9.7	19.4	34.3
% Low Choice	46.0	52.2	50.2
% Select	38.3	25.0	11.7
% Standard	5.6	2.4	.8
Yield Grade			
% 4 & 5	1.0	1.5	3.0

Source: Iowa Tri-County Steer Carcass Futurity, 2005
Feedlot gain, morbidity rate, quality and yield grade value all different at P<.02

2. Early Weaning

Calves are traditionally weaned at 6-8 months of age, but weaning earlier—as early as 3-4 months—has shown dramatic positive effects on quality grade and CAB® acceptance rates (Berger and Faulkner, 2005). In these studies, early-weaned calves often graded 50 to 75 percent or more Average Choice and above, up to twice as many qualifying for added premiums when compared to traditionally weaned calves. Early and steady use of a high grain ration, preferably corn, was the key to success. The mode of action likely relates to high grain diets yielding more propionate, a gluconeogenic precursor, resulting in greater marbling deposition.

3. Creep Feeding

During times of lower calf prices, and because of logistical challenges in some production systems, creep feeding is seldom used. Research has, however, clearly shown that when calves are placed in an accelerated production system, resulting in harvesting at 13-15 months of age, creep feeding accentuates marbling potential. Research at the University of Illinois and the Ohio State University has shown that grain-, usually corn-based, creep feeding increases marbling levels, with 100 days of such feed capable of raising final marbling by a full score. As previously shown, corn is ideal because it increases starch absorption in the small intestine.

4. Disposition

Often overlooked is the impact poor disposition has on marbling potential. Recent Iowa research (Busby et al., 2006) showed that cattle displaying aggressive behavior had greatly reduced quality grades.

Table 9. Effect of Disposition on Quality Grade.

	Docile	Restless	Aggressive
% CAB® Accepted*	29.1	22.8	14.3
% Select and Standard*	19.8	25.1	37

* Percent CAB® accepted and % Select/Standard different at <.001

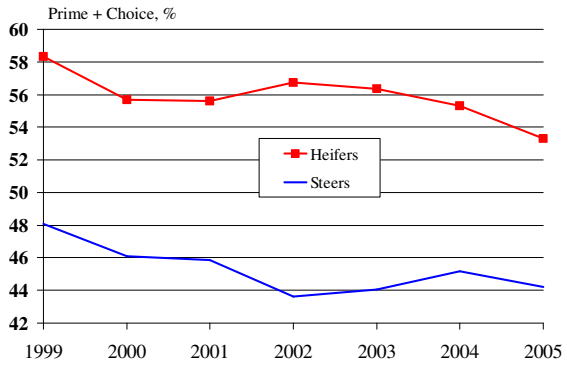
5. Vitamin A Levels

Both United States and Japanese research (Pyatt and Berger, 2005) suggests that high levels of Vitamin A may negatively impact marbling deposition. The mode of action is such that marbling-related adipocyte development could be reduced by increasing dietary fat-soluble Vitamin A. The results have been variable in research studies, and the authors have recommended further research.

6. Gender of Animals

Numerous studies have shown that heifers consistently out-grade steers by 8-10 percentage points in Choice levels, with CAB® acceptance rates 6-8 percentage points higher in heifers. The cattle cycle and the resulting percent of heifers in the harvest mix influences grade and CAB® acceptance rates. A 1-point change in the heifer harvest percentage correlates to a 0.1-point change in CAB® acceptance percentage.

Figure 10. Prime & Choice by Year: Steers & Heifers*.



* Source: Courtesy VetLife Benchmark Performance Program (2006) data

7. Calves vs. Yearlings

Traditionally, the average age at harvest has been 18-20 months. However, because of short cattle supplies and widespread drought conditions, age has decreased in recent years. A Nebraska research report (Brewer et al., 2004) suggests 30-35 percent of all cattle are placed on feed as calves, which likely relates to Northern and Midwest cattle rather than all fed cattle.

The widely held industry belief is that yearlings out-grade calves, but that is likely influenced by the production system. A Nebraska study (Vander Pol et al., 2006) showed that calves of common genetics split at weaning had drastically different quality grades based on the production system. The calf feds had 32.5 percent grade Prime and Premium Choice versus only 1.2 percent for the yearlings that were placed

on a winter growing diet where gains were only 1.16 lb./day for 197 days. Equally important, 19 percent of the yearling carcasses were classified as "tough" by a sensory panel versus zero for the calf feds.

The CAB FLP data suggests calves may now slightly out-grade yearlings. In the 2005 FLP data, calves averaged 13.9 percent CAB® acceptance rate while yearlings were at 13.0 percent.

8. Sorting of Feedlot Cattle

Numerous reports have suggested quality grade can be improved if cattle are sorted during the feedlot period, but solid research data is not available. To support this claim, the FLP data on 32,187 cattle suggests limited value from sorting. Only yield grade appeared to benefit.

Table 10. Effect of Number of Times Sorted on Quality Grade.

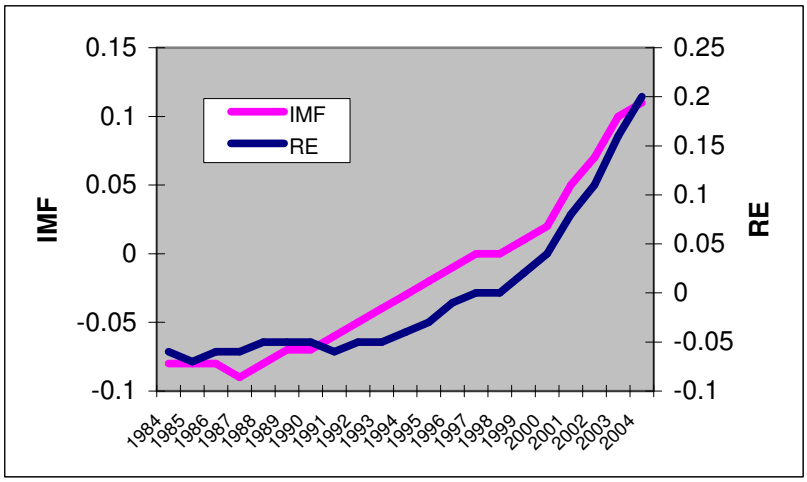
	Sort Number		
	0	**1**	**2 or more**
Quality Grade			
% Prime	.9	.9	.9
% CAB®	22.7	25.1	24.2
% Low Choice	47.2	48.4	48.0
% Select	28.2	24.8	26.3
Yield Grade			
% 4	11.9	11.8	10.3
% 5	1.4	1.3	.8

CAB® acceptance rate, % Low Choice, and % Select different at P<.05

9. Antagonistic Genetic Selection Traits

Our analysis of numerous databases finds the correlation between marbling and ribeye area is -0.2 (negative), inferring genetic selection for muscling could reduce marbling levels. However, the potential likely exists for selective breeding to overcome this antagonism. Just as random genetic selection for yearling weight increases birth weight, strategic genetic selection can increase yearling weight while holding birth weight constant. The same logic may be applied to selection for marbling and ribeye area. Using the Angus breed as an example, Figure 11 shows the improvement that has simultaneously been made over the last 20 years for both marbling and ribeye area.

Figure 11. Angus Intramuscular Fat (IMF) and Ribeye (RE) EPD Trends



Source: American Angus Association

Summary

It is clear that no one factor is solely contributing to the decline in marbling, but numerous factors are having an effect. Because of this trend, the economic value received for cattle sold through a value-based marketing system is affected and, on a large scale, the demand for beef threatened.

White paper compiled by Larry Corah and Mark McCully

Appreciation goes out to the following individuals for their assistance with the white paper:

Pete Anderson, Vetlife, Inc.
Rob Cooper, Cattlemen's Nutrition Services, LLC
Jim Drouillard, Kansas State University
Francis Fluharty, The Ohio State University
Brad Johnson, Kansas State University
D.J. Jordan, Cattlemen's Nutrition Services, LLC
Terry Mader, University of Nebraska
Robbi Pritchard, South Dakota State University
Chris Reinhardt, Kansas State University
Steve Smith, Texas A&M University

Work Cited

American Angus Association. 2005. Sire Evaluation Report.

Anderson, P.T. 2006. VetLife Summary: Health and morbidity data on feedlot cattle. Personal communication.

Anderson, P.T. 2006. VetLife Summary: Quality grade in feedlot heifers and steers. Personal communication.

Anderson, R.V., J.R. Rasby, T.J. Klopfenstein and R.T. Clark. 2005. An evaluation of production and economic efficiency of two beef systems from calving to slaughter. J. Anim. Sci. 83:694-704.

Babcock, A., R. Jones and M. Langemeier. 2006. Examining death loss in Kansas feedlots. KSU Beef Research Report of Progress 959.

Beef Improvement Federation (Smith, et al.). 2006. Proceedings.

Berger, L.L. and N.A. Pyatt. 2005. Nutritional and management factors affecting marbling deposition. Certified Angus Beef white paper.

Berger, L.L. and D.B. Faulkner. 2005. Lifetime impacts of management on beef carcass quality and profitability.. Proc. Plains Nut. Conf.

Brandt, Jr., R.T., R.J. Grant and R.S. Pope. 1991. Evaluation of Revalor implants for stocker-finishing cattle. KSU Beef Research Report of Progress 623. Pg 85-88.

Brewer, P.S., C.R. Calkins, R.J. Rasby, T.J. Klopfenstein and R.V. Anderson. 2004. Carcass traits and palatability attributes of herdmates finished as calves or yearling steers. 2004 Nebr. Beef Research Report. Pg 92-94.

Bruns, K.W. and R.H. Pritchard. 2006. Delay implants, increase beef quality. CAB *Black Ink Basics* Fact Sheet.

Bruns, K.W., R. H. Pritchard and D.L. Boggs. 2004. The relationships among body weights, body composition, and intramuscular fat content in steers. J. Anim. Sci. 82:1315-1322.

Busby, W.D., D. Strohbehn, P. Beedle and L.R. Corah. 2004. Effect of postweaning calf health on feedlot gain and quality grade. J. Anim. Sci. (Suppl. 2): 83. (Abstr.)

Busby, W.D., D. Strohbehn, P. Beedle, L.R. Corah and J.F. Stika. 2005. Effect of disposition on feedlot gain and quality grade. J. Anim. Sci. (Suppl. 2): 83. (Abstr.)

Busby, W.D., D. Strohbehn, P. Beedle, and M.E. King. 2006. Effect of disposition on feedlot gain and quality grade. Iowa State Univ. Animal Industry Research Report R2070.

Cattle-Fax Quarterly Report. 2006. Percentage of cattle grid marketed.

Dinneen, R. 2006. Ethanol has arrived. Proc. Nat. Ethanol Conf.

Fluharty, F.L. 2005. Factors influencing marbling deposition. Personal communication.

Herring, A.D. 2006. Genetics aspects of marbling in beef carcasses. Certified Angus Beef white paper.

Johnson, B.J. 2006. Cellular aspects of marbling deposition in cattle. Personal communication.

Mader, T.L. 1994. Effect of implant sequence and dose on feedlot cattle performance. J. Anim. Sci. 72:277-282.

Mader, T.L. 1994. Effect of sequential implanting with Synovex on steer and heifer performance. J. Anim. Sci. 72:1095-1100.

Mader, T.L., D. C. Clanton, J.K. Ward, D.E. Pankaskic and G.H. Deutscher. 1985. Effect of pre-and post weaning Zeranol implant on steer calf performance. J. Anim. Sci. 61:546-551.

Mintert, J. 2006. Larger feedlots gaining market share. *Feedlot* publication March/April 2006. Pg 14-15.

National Corn Growers Association. 2006 Annual Report.

Owens, F.N. 2006. Effect of muscle area on intramuscular fat levels. Personal communication.

Owens, F.N. and B.A. Gardner. 2000. A review of the impact of feedlot management and nutrition on carcass measurements of feedlot cattle. Proc. Amer. Soc. of Anim. Sci.

Pingel, D. and A. Trenkle. 2006. Digestibility of diets with corn grain and urea replaced with corn distiller's grains and solubles. Iowa State Univ. Beef Res. Report R2069.

Pyatt, N.A. and L.L. Berger. 2005. Review: Potential effects of Vitamins A and D on marbling deposition in beef cattle. Prof. Anim. Scientist. 21:174-181.

Reinhardt, C.D. 2006. A review: Effect of distilling byproducts on marbling scores in feedlot cattle. Personal communication.

Reinhardt, C.D. 2006. Classifying implant potency into categories. Personal communication.

Robinson, J. 2006. Quality beef demand outstrips supply. West. Live. J. March 13 and 20 weekly issues.

Singh, J.J. et al. 2003. Effect of androgen levels on cellular differentiation. J. Anim. Sci. (Suppl. 2). 82: (Abstract).

Smith, G.C. 2002. Effect of marbling levels on undesirable eating experience. Canadian Beef Palatability Enhancement Workshop.

Smith, G.C. 2005. Why people eat beef. NCBA Proc. Cattlemen's College.

Smith, G.C., J.W. Savell, J.B. Morgan and T.E. Lawrence. 2006. Report of June-Sept, 2005 National Beef Quality Audit: A new benchmark for the U.S. beef industry. 2006 Beef Imp. Fed. Proc. Pg 6-11.

USDA APHIS Report. 2000. Highlights: Changes in the U.S. feedlot industry, 1994-1999.

Vander Pol, K.J., G.E. Erickson, T.J. Klopfenstein, M.A. Greenquist and T. Robb. 2006. Effect of dietary inclusion of wet distiller's grain on feedlot performance of finishing cattle and energy value relative to corn. U. of Nebr. Beef Research Report MP88A. Pg. 51-53.